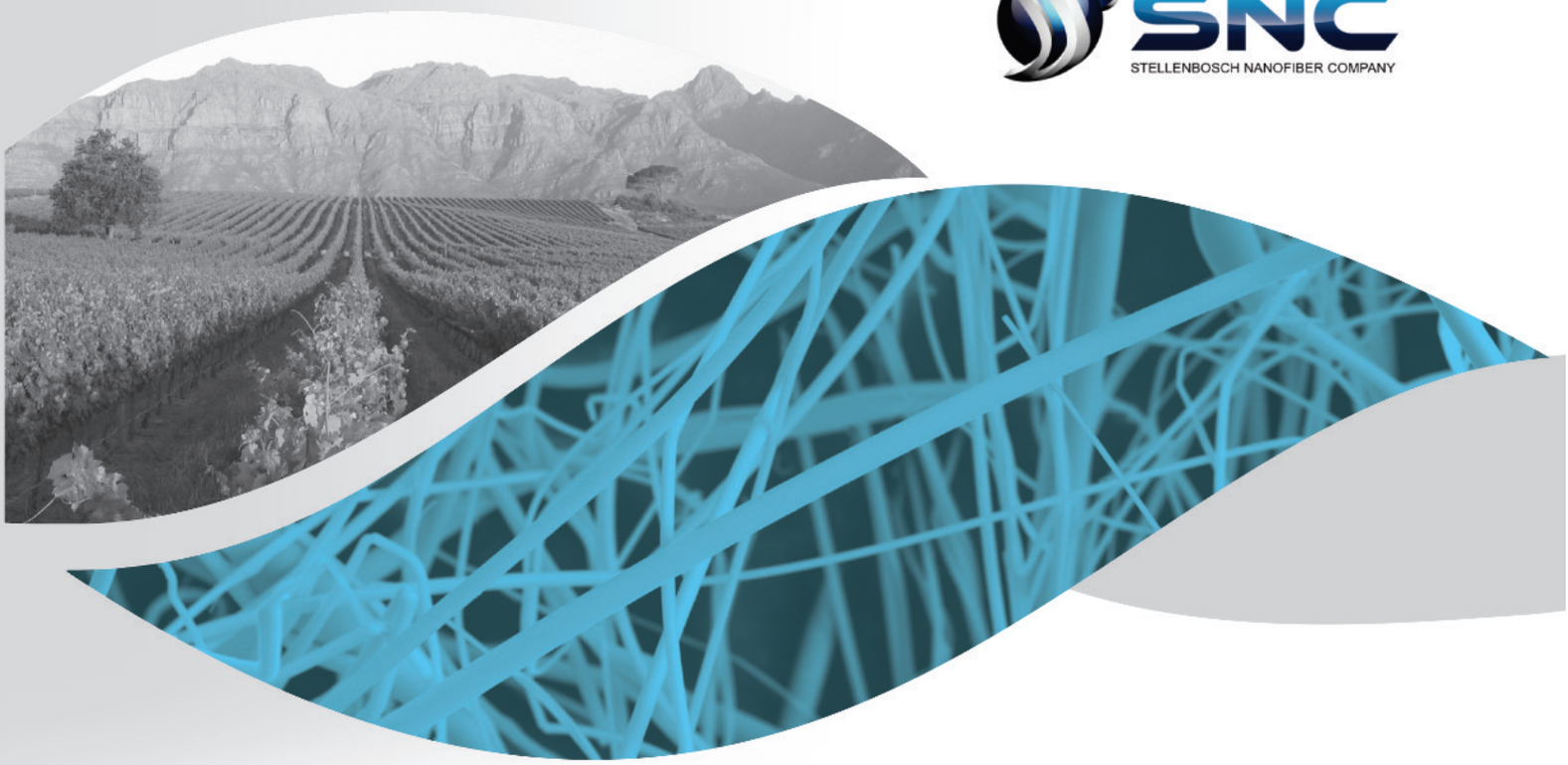


ELECTROSPIN2018
INTERNATIONAL CONFERENCE

16th to 18th January 2018

Wallenberg Research Centre at Stias

Stellenbosch, South Africa

Hosted by The Stellenbosch Nanofiber Company

TABLE OF CONTENTS

WELCOME

from the Electrospin2018 Conference Chair

Eugene Smit

Welcome to Stellenbosch in January. After the long December summer holiday, this is usually the time of year when there is a palpable excitement in the air. When students young and old return to the oak-lined avenues of one of South Africa's iconic historical towns to start a new academic year. This is the time of year when new visions are put in motion. When anything can happen!

It is hard to believe that it's already been eight years since the first Electrospin2010 conference was held in Melbourne. While that seems recent, some significant changes have occurred in the field of electrospinning since then. We've seen highly successful conferences in Jeju, San Francisco and Otranto, which have helped to define our international scope and raise the standard of this biennial event. While in 2010 there were only a handful of companies supplying electrospinning equipment, and most electrospun fiber products were essentially "concepts with great potential", today the commercial electrospinning landscape boasts more than 40 companies that offer ranges of products and services based on electrospun fibers. At the same time, our understanding of many of the fundamental aspects of electrospinning is being refined and continues to attract new approaches and hypotheses. At this conference you will find these efforts and advances addressed by leaders from around the globe.

I would like to thank the International Advisory Committee for their support in creating awareness of this conference, and especially the chairs of the previous Electrospin conferences for their support and advice. Also, thanks to our sponsors and exhibitors for their financial support and endorsement of this important event. A very special thanks to Jolandi and the team at Onscreen Events for doing a tremendous job in putting together what will be a memorable Electrospin2018 International Conference. Finally, I thank you the participants for enriching this international conference with your presence. I hope you will enjoy all the content, be inspired with new ideas and make new connections to turn those new ideas into revolutionary products.

Enjoy Stellenbosch – take part in as much of the conference program as you can, but also take some time to explore the treasures of a town that has been crowned as the 'Food, Wine & Art Capital of South Africa'.

Best regards,

Eugene Smit

CEO - The Stellenbosch Nanofiber Company (Pty) Ltd

PLENARY SPEAKERS

Prof. Andreas Greiner

Andreas Greiner received his Ph D. degree in Chemistry from the University of Marburg in 1988. In 1989 he joined University of California as postdoc, Santa Barbara, USA. He was appointed associate professor for organic chemistry and macromolecular chemistry at the University of Mainz and became head of the TransMIT Center for Plastic Science and Nanotechnology in 1999. In 2000 he became full professor for polymer chemistry and technology at the University of Marburg and joined in 2012 University of Bayreuth as distinguished professor for macromolecular chemistry. He is board member of Dechema Nanotechnology section and is heading the business unit Future Solution of New Materials Bayreuth GmbH. Present research topics are functional biobased polymer synthesis, electrospinning of polymer nanofibers, polymer-functionalized nanoparticles, poly(p-xylylene)s, functional polymer dispersions, polymers for coatings, filtration, textiles, medicine, pharmacy, and agriculture.

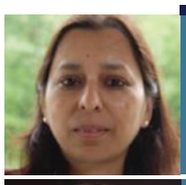
Prof. Il-Doo Kim

Prof. Il-Doo Kim received his Ph.D. degree (2002) from KAIST. From 2003 to 2005, he was a postdoctoral fellow with Prof. Harry L. Tuller at MIT. He returned to Korea Institute of Science and Technology as a senior research scientist. In Feb. 2011, he joined at KAIST as a faculty member in Department of Materials Science and Engineering. The Il-Doo Kim group' research work is focused on novel synthesis of inorganic nanomaterials optimized for application in ultra-sensitive chemical sensors (exhaled breath gas analysis for disease diagnosis), highly efficient energy storage devices (Li-ion batteries), and functional nano-electronics including nanofiber-based transparent electrodes. Our research works aim at developing new synthetic methods that relies on a modified electrospinning to produce unique nano-building blocks such as highly porous nanofibers and nanotubes. Kim's research group also develops multi-dimensional catalyst-functionalized nanofibers, i.e., oxide and nitride materials, as cost-effective and highly efficient nano-catalysts, especially optimized for Li-O_2 batteries. Prof. Kim has published over 194 articles, 5 book chapters, and holds 186 international patents. Moreover, a number of patents related with nanofiber synthesis and applications have been successfully licensed to 6 companies. Prof. Kim is a Deputy Editor of the Journal of Electroceramics, a member of Young Korea Academy Science and Technology (YKAST), and an associate member of Korea Academy Science and Technology (KAST).

Prof. Eyal Zussman

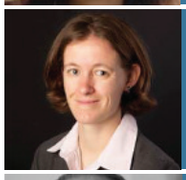
Dr. Eyal Zussman is the Winograd Professor in the Department of Mechanical Engineering at the Technion – Israel institute of Technology. He holds a DSc degree from the Technion in mechanical engineering. He held postdoctoral appointment at Technical University in Berlin, Germany. Since joining the faculty at the Technion, he has served as Director of the NanoEngineering Group. His group research is in the area of molecular engineering of soft matter, in particular the development of process-structure-property relationships, through the use of simulations and experiments, and the development of functional electrospun fibers. He was Visiting Professor at the Northwestern University (2003), and at the National University of Singapore (2010-2015). He has published over 130 peer-reviewed journal articles.

INVITED SPEAKERS



Prof. Seema Agarwal

Universität Bayreuth, Germany

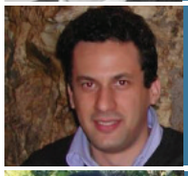


Prof. Jennifer Andrew

Associate Professor in the Department of Materials

Prof. Deon Bezuidenhout

Strait Access Technologies, South Africa

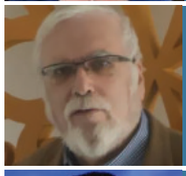


Dr. Andrea Camposeo

University of Pisa, Italy

Prof. You-Lo Hsieh

University of California, Davis

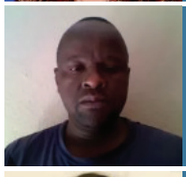


Prof. Geoffrey Mitchell

Polytechnic Institute Leiria in Portugal

Prof. Xiumei MO

Donghua University, China

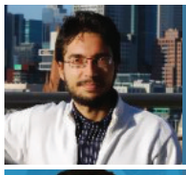


Prof. Makwena Moloto

Vaal University of Technology, South Africa

Dr. Luana Persano

CNR-Nanoscience Institute



Prof. Dario Pisignano

University of Pisa

Dr. Brendan Robb

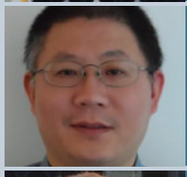
Electrospinning Company, UK

Prof. Bert Klumperman

Stellenbosch University, South Africa

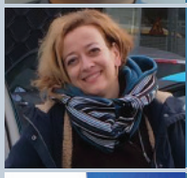
Prof. Tae-Woo Lee

Seoul National University, Korea



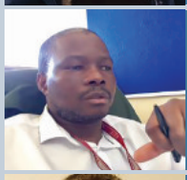
Prof. Tong Lin

Deakin University, Australia



Dr. Antonella Macagnano

CNR, Italy



Dr. Phillemon Matabola

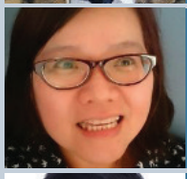
MINTEK, South Africa

Dr. Marc Simonet

University of Applied Sciences, Switzerland

Prof. Zenixole R. Tshentu

Nelson Mandela University, South Africa



Dr. Yen Truong

CSIRO, Australia

Prof. Jianhua Yan

Donghua University, China

Prof. Alexander Yarin

University of Illinois at Chicago, USA

PROGRAMME

MONDAY, 15 JANUARY 2018

4:30 PM – 8:00 PM	**WELCOME RECEPTION AND REGISTRATION**

TUESDAY, 16 JANUARY 2018

OPENING REMARKS AND PLENARY SESSION 1

8:50 AM **Welcome and Conference Opening**

9:10 AM **Ultralight polymer sponges from short electrospun fibers (Plenary)**
Andreas Greiner
Universität Bayreuth, Germany

10:00 AM – 10:30 AM	**BREAK**	
	Room 1: Energy, Catalysis, Electronics and Sensors	**Room 2: Medical Applications, Biotechnology and Tissue Engineering**
10:30 AM	**Electrospun nanofibers of organic semiconductors and hybrid materials: novel flexible light sources with enhanced photon emission** (Invited) Andrea Camposeo,[1] Luana Persano,[1] Maria Moffa,[1] Vito Fasano[2] and Dario Pisignano[2] *[1] NEST, Istituto Nanoscienze-CNR, Italy* *[2] Università del Salento, Italy*	**Electrospun cardiovascular devices: scaffolds for blood vessel and heart valve prostheses** (Invited) Deon Bezuidenhout *Strait Access Technologies, South Africa*
10:50 AM	**Electrospun nanofiber membranes for energy, environmental and biomaterial applications** (Invited) Ilias Louis Kyratzis and Yen Bach Truong *CSIRO Manufacturing, Australia*	**Electrospun 3D porous nanofiber scaffolds for tissue engineering** (Invited) Xiumei Mo *Donghua University, China*
11:10 AM	**Air purification by nanostructured electrospun membranes: different strategies for enhancing the performance of nanocomposite photocatalysts** Martina Roso, Carlo Boaretti, Alessandra Lorenzetti and Michele Modesti *University of Padova, Italy*	**Novel poly(ε-caprolactone)/gelatin wound dressings prepared by emulsion electrospinning with controlled release capacity of Ketoprofen anti-inflammatory drug** A.O. Basar,[1] S. Torres-Giner,[2] S. Castro,[3] Turkoglu Sasmazel[1] and Jose M. Lagaron[2] *[1] Atilim University, Turkey* *[2] CSIC, Spain* *[3] Bioinicia S.L., Spain*

11:25 AM	**Conjugates of platinum nanoparticles with gallium tetra – (4-carboxyphenyl) porphyrin and their use in photodynamic antimicrobial chemotherapy when in solution or embedded in electrospun fiber** Muthumuni Managa and Tebello Nyokong *Rhodes University, South Africa*	**Bead-on-string electrospun nanocomposite fibrous system for tissue engineering** Chiara Rinoldi, Ewa Kijeńska, Adrian Chlanda, Emilia Choinska and Wojciech Swieszkowski *Warsaw University of Technology, Poland*
11:40 AM	**MOF-templated synthesis of Co_3O_4 on SnO_2 nanofibers as superior anodes for lithium-ion batteries** Jun Young Cheong, Won Tae Koo, Chanhoon Kim, Ji-Won Jung, Su-Ho Cho and Il-Doo Kim *KAIST, Republic of Korea*	**Improved healing of electrospun tissue engineering scaffolds by increased porosity and drug delivery** Wian van den Bergh, Anel Oosthuysen, Thomas Franz, Peter Zilla and Deon Bezuidenhout *University of Cape Town, South Africa*
11:55 AM	**Laser induced photocatalytic degradation of Orange G using halogenated bodipy dyes embedded in polystyrene nanofibers** Augustus Lebechi, Tebello Nyokong and John Mack *Rhodes University, South Africa*	**Electrospun polyacrylamide hydrogel nanofibers: from nanocarriers to stimuli responsive nanomaterials** Sylwia Pawlowska, P.Nakielski and F. Pierini *Polish Academy of Sciences, Poland*
12:10 PM – 1:40 PM LUNCH		
	Room 1: Energy, Catalysis, Electronics and Sensors	**Room 2: Medical Applications, Biotechnology and Tissue Engineering**
1:40 PM	**Highly aligned printed nanofibers for flexible electronics and neuromorphic artificial synaptic electronics** (Invited) Tae-Woo Lee *Seoul National University, Republic of Korea*	**Tailoring electrospinning techniques for regenerative medicine** (Invited) Marc Simonet *IME Technologies, Netherlands*
2:00 PM	**Design of eco-friendly and sustainable nanofibrous sensors for detecting environmental pollutants** (Invited) Antonella Macagnano,[1] F. De Cesare,[1,2] E. Zampetti,[1] A. Bearzotti,[1] G. Scarascia-Mugnozza[2] and N. Pirrone[1] *[1] IIA-CNR, Italy* *[2] University of Tuscia, Italy*	**Advanced nanostructured fabrics for low burden protection** (Invited) Yen Bach Truong,[1,6] Jacinta Poole,[1,6] Ilias Louis Kyratzis,[1,6] Josh Ince,[1,6] Jurg Schutz,[1,6] Lucy Cotter,[1,6] Yvonne Douglas,[1,6] Shadi Houshyar,[2,6] David Nielsen,[3,6] Liberty Wagner,[4,6] Gareth Beckermann[5,6] and Deepak Ganga[6] *[1] CSIRO-Manufacturing, Australia* *[2] RMIT University, Australia* *[3] Defence Science and Technology Group, Australia* *[4] Bruck Textiles, Australia* *[5] Revolution Fibres, New Zealand* *[6] DMTC Ltd, Australia*

2:20 PM	**Catalyst comprising dual bio-templates assisted WO_3 nanotube toward exceptionally selective and sensitive H_2S sensors** Dong-Ha Kim,[1] Ji-Soo Jang,[1] Won-Tae Koo,[1] Seon-Jin Choi,[2] Hee-Jin Cho,[1] Min-Hyeok Kim,[1] Sang-Joon Kim[1] and Il-Doo Kim[1] *[1] KAIST, Republic of Korea* *[2] Harvard Medical School, USA*	**Nanofibrous scaffolds loaded with neurotrophin for peripheral nerve tissue engineering** Ewa Kijeńska and Wojciech Swieszkowski *University of Technology, Poland*
2:35 PM	**Electrospinning of polythiophene with pendant fullerene nanofibers for single-material organic solar cells** Filippo Pierini,[1] M. Lanzi,[2] P. Nakielski,[1] S. Pawlowska,[1] O. Urbanek[1] and T.A. Kowalewski[1] *[1] Polish Academy of Sciences, Poland* *[2] University of Bologna, Italy*	**Electrospun antimicrobial wound dressings as drug delivery systems-design and development** L. Preem,[1] G.-M. Lanno,[2] M. Putrinš,[2] T. Tenson[2] and K. Kogermann[1] *[1] Institute of Pharmacy, University of Tartu, Estonia* *[2] Institute of Technology, University of Tartu, Estonia*
2:50 PM	**Electrospun PMMA polymer blend nanofibrous membrane: electrospinnability, surface morphology and mechanical response** Jacky Jia Li Lee, Bee Chin Ang, Andri Andriyana, Md Islam Shariful, and M. A. Amalina *University of Malaya, Malaysia*	**Electrospinning of collagen with nanocapsules of PLGA for delivery of paclitaxel in drug-eluting stents** Liliana Maria Agudelo,[1,2] Jesus Antonio Carlos Cornelio,[2] Luis Fernando Rodriguez,[1,2] Isabel Cristina Ortiz,[1] Lina Marcela Hoyos[1,2] and Gabriel Jaime Colmenares[1,2] *[1] Universidad Pontificia Bolivariana, Colombia* *[2] Nanomat S.A.S, Colombia*
3:05 PM	**Laser induced photodegradation of Orange G using phthalocyanine - cobalt ferrite magnetic nanoparticle conjugates electrospun in polystyrene nanofibers** Sivuyisiwe Mapukata and Tebello Nyokong *Rhodes University, South Africa*	**Electrospinning of charged induced fiber scaffolds** Sara Metwally and Urszula Stachewicz *AGH University of Science and Technology, Poland*

3:20 PM – 3:50 PM BREAK		
	Room 1: Energy, Catalysis, Electronics and Sensors	**Room 2: Medical Applications, Biotechnology and Tissue Engineering**
3:50 PM	**Merging light emission and piezoelectric properties in electrospun polymer nanofibers** (Invited) Luana Persano,[1] Andrea Camposeo[1] and Dario Pisignano[1,2] *[1] NEST, Istituto Nanoscienze-CNR, Italy* *[2] Università del Salento, Italy*	**Biodegradable electrospun vascular grafts and their transformation in situ into neo-arteries** (Invited) Yadong Wang *Pittsburg University, USA*
4:10 PM	**Metal and semiconductor nanoparticles and their polymer fibres** (Invited) Makwena Moloto *Vaal University of Technology, South Africa*	**Electrospun nanofibers for advanced wound care** (Invited) Haydn Kriel, Megan Coates and Eugene Smit *The Stellenbosch Nanofiber Company, South Africa*
4:30 PM	**Electrospun polymer fibers for organic field effect transistors: from unipolar to ambipolar devices** Chiara Bertarelli, R. Castagna, B. Saglio, G. Mondini and M. Baroncini *Politecnico di Milano, Italy*	**Structure dependent cell activity on PCL/Gelatin and PCL/Collagen nanofibers electrospun from various solvents** Paweł Sajkiewicz, Judyta Dulnik, Dorota Kołbuk-Konieczny and Piotr Denis *Polish Academy of Sciences, Poland*
4:45 PM	**Morphological advances of thiophene and carbazole derivatives for superhydrophobic and opto-electric application** Khadija Kanwal Khanum and Praveen C. Ramamurthy *Indian Institute of Science, India*	**Characterization and evaluation of TPU-Hyaluronic acid membranes for tissue engineering applications** Magnus Kruse, Manuela Garay, Thomas Gries and Stefan Jockenhoevel *RWTH Aachen University, Germany*
5:00 PM	**Reinforcement of electrospun fibers with 2D MXene fillers** Patrik Sobolčiak,[1] Aisha Tanvir,[1] Anton Popelka,[1] Mohammad K. Hassan,[1] Khaled A. Mahmoud[2,3] and Igor Krupa[1] *[1] Qatar University, Qatar* *[2] Hamad Bin Khalifa University, Qatar* *[3] Port Said University, Egypt*	**Fabrication and characterization of electrospun alginate nanofibers impregnated with silver nanoparticles** Teboho Clement Mokhena[1,2] and A.S. Luyt[3] *[1] CSIR Materials Science and Manufacturing, South Africa* *[2] University of the Free State, South Africa* *[3] Qatar University, Qatar*
5:15 PM		**Electrospun PEO/ZNO nanofibers: characterization and UV-VIS drug delivery studies** Omolola E. Fayemi and Vuyisani M. Rabela *North-West University, South Africa*

WEDNESDAY, 17 JANUARY 2018

PLENARY SESSION 2

9:10 AM **Recent advances in tailored nanofibers for selective sensing and energy storage devices (Plenary)**
Il-Doo Kim
Korea Advanced Institute of Science and Technology (KAIST), Republic of Korea

10:00 AM - 10:30 AM BREAK

	Room 1: Energy, Catalysis, Electronics and Sensors	Room 2: Smart Materials and Novel Properties
10:30 AM	**Light diffusion and amplification in complex networks of electrospun nanofibers** (Invited) Dario Pisignano *University of Pisa, Italy*	**Smart multicomponent fibers** (Invited) Seema Agarwal, Li Liu and Martin Pretscher *Universität Bayreuth, Germany*
10:50 AM	**Constructing soft and solid-state lithium batteries with electrospinning techniques** (Invited) Jianhua Yan, Jianyong Yu, and Bin Ding *Donghua University, China*	**Synthesis of functional oxide nanocomposites via electrospinning** (Invited) Jennifer Andrew *University of Florida, USA*
11:10 AM	**Stretchable organic nanowire transistors** Yeongjun Lee,[1,2] Jin Young Oh,[2] Zhenan Bao[2] and Tae-Woo Lee[3] *[1] POSTECH, Republic of Korea* *[2] Stanford University, USA* *[3] Seoul National University, Republic of Korea*	**Electrospun copolyamide mats reinforced by cellulose nanocrystals** Igor Krupa, Patrik Sobolčiak, Aisha Tanvir and Anton Popelka *Qatar University, Qatar*
11:25 AM	**Influence of ionic liquid on the electrospun mat morphology** Illia Krasnou, Ljudmila Solovjova and Andres Krumme *Tallinn University of Technology, Estonia*	**Mechanical response of randomly oriented nanofibrous membranes: experimental characterization and constitutive modeling** Dannee Wong,[1] Andri Andriyana,[1] Bee Chin Ang[1] and Erwan Verron[2] *[1] University of Malaya, Malaysia* *[2] GeM UMR CNRS 6183, France*
11:40 AM	**All transparent-stretchable electrochromic-supercapacitor wearable patch device** Tae Gwang Yun, Dong-Ha Kim, Jin Gook Bae and Il-Doo Kim *KAIST, Republic of Korea*	**Eco-friendly aqueous electrospinning of polypropylene** Anne Hébraud, Chengzhang Xu and Guy Schlatter *ICPEES, UMR 7515 CNRS-University of Strasbourg, France*
11:55 AM	**Nanostructured carbon fibers as electrode materials for supercapacitors** Bonisiwe Seshabela, Bulelwa Ntsendwana, Sabelo D. Mhlanga and Edward N. Nxumalo *University of South Africa, South Africa*	**Application of melt differential centrifugal spun polypropylene micro-nanofibers as oil sorbent materials** Mahmoud Bubakir[1,2] and Haoyi Li[2] *[1] Aljabal-Algarbi University, Libya* *[2] Beijing University of Chemical Technology, China*

12:10 PM – 1:40 PM LUNCH		
	Room 1: Separation, Filtration and Additive Manufacturing	**Room 2: Smart Materials and Novel Properties**
1:40 PM	**Bio-waste-derived nanofibers formed by solution blowing and electrospinning and their applications as biomedical materials and adsorbents for heavy metals removal from polluted water** (Invited) Alexander Yarin *University of Illinois at Chicago, USA*	**Cellulose nanofibers and aerogels with tunable amphiphilicity and chemical functionalities** (Invited) You-Lo Hsieh *University of California, USA*
2:00 PM	**Polymer nanofibers: design, function and application** (Invited) Zenixole Tshentu *Nelson Mandela University, South Africa*	**Antimicrobial nanofibers – strong and lethal** (Invited) Bert Klumperman *Stellenbosch University, South Africa*
2:20 PM	**Current status in composite laminates enhanced by electrospun nanofibres** Karen De Clerck and Lode Daelemans *Ghent University, Belgium*	**Electrospun polyester mesofibers: a new tool in dispenser technology for broadcasting semiochemicals in plant protection against arthropod pests. The example of cosmopolitan *Lobesia botrana* (*Lep. Tortricidae*) in viticulture** Hans E Hummel[1,2] *[1] Justus-Liebig-University Giessen, Germany* *[2] University of Illinois Urbana-Champaign, USA*
2:35 PM	**Ecofriendly nanofiber material and its mask against PM 2.5 based on electrospinning and special structure design** Ashraful Islam and Yanbo Liu *Wuhan Textile University, China*	**Electrospun fibers in 3D – FIB-SEM tomography** Urszula Stachewicz *AGH University of Science and Technology, Poland*
2:50 PM	**Optimization of rheological solution properties for the development of wet direct-writing electrospinning for tissue engineering purpose** Laura Bourdon, Laura Courty, René Fulchiron, Arnaud Brioude and Vincent Salles *Claude Bernard University Lyon, France*	**The development and optimization of aspalathin-enriched green rooibos loaded polymer nanoparticles by electrospraying** Chantelle Human,[1] Dalene de Beer[1,2] and Elizabeth Joubert[1,2] *[1] Stellenbosch University, South Africa* *[2] Agricultural Research Council, South Africa*
3:05 PM	**Removal of rare earth metal ions by functionalised electrospun polystyrene nanofibers from aqueous solution** Omoniyi Pereao,[1] Chris Bode-Aluko,[1] Katri Laatikainen[2] and Leslie F. Petrik[1] *[1] University of the Western Cape, South Africa* *[2] Lappeenranta University of Technology, Finland*	**Fabrication of polymeric composites nanofiber material using electrospinning technique** Dikeledi More,[1,2] Makwena Moloto[1] and Nosipho Moloto[2] *[1] Vaal University of Technology, South Africa* *[2] Wits University, South Africa*

3:20 PM – 3:50 PM Break		
3:50 PM - 5:30 PM	Poster Session	
5:30 PM – 11:00 PM	Gala Dinner	

THURSDAY, 18 JANUARY 2018

PLENARY SESSION 3

9:10 AM **Stimuli-responsive polymer fibers (Plenary)**
Eyal Zussman
Israel Institute of Technology-Technion, Israel

10:00 AM - 10:30AM BREAK		
	Room 1: Separation, Filtration and Additive Manufacturing	**Room 2: Smart Materials and Novel Properties**
10:30 AM	**Electrospinning as part of additive manufacturing** (Invited) Geoffrey Mitchell *Polytechnic Institute Leiria, Portugal*	**Electrospinning of Nanofibers using Modified Slot Spinnerets** (Invited) Tong Lin, Guilong Yan, Haitao Niu *Institute of Frontier Materials, Deakin University, Australia*
10:50 AM	**Electrospinning activities at the DST/Mintek Nanotechnology Innovation Centre** (Invited) Phillemon Matabola *DST/Mintek NIC, South Africa*	**Has electrospinning come of age? Challenges and opportunities in biomaterials** (Invited) Brendan Robb *Electrospinning Company, UK*
11:10 AM	**New combination of technology: conductive electrospun nanofibers and 3D printed packaging material for freeform flexible Li-Air batteries** Ji-Won Jung, Ki Ro Yoon, Tae Gwang Yun, Chanhoon Kim, Su-Ho Cho, Jun-Young Cheong, Seok Won Songa and Il-Doo Kim *KAIST, Republic of Korea*	**Tannic acid nanofibers from polymer-free solutions** Domitille Mailley,[1] M. Allais,[2,3] P. Hébraud,4 V. Ball,[2,3] F. Meyer,[2,3] A. Hébraud[1] and G. Schlatter[1] *[1] ICPEES-UMR7515, CNRS, University of Strasbourg, France* *[2] INSERM, UMR 1121, France* *[3] Université de Strasbourg, France* *[4] IPCMS, UMR 7504, France*

11:25 AM	**Removal of nickel(II) by 2-(2'-pyridyl) imidazole functionalized polyacrylonitrile nanofiber** Katri Laatikainen,[1] Guillaume Ndayambajeb,[2] Markku Laatikainen,[1] Edith Beukes,[2] Olanrewaju Fatoba,[2] Nico van der Walt,[3] Leslie Petrik[2] and Tuomo Sainio[1] *[1] Lappeenranta University of Technology, Finland* *[2] University of the Western Cape, South Africa* *[3] Cape Peninsula University of Technology, South Africa*	**Real-time random lasing detection during structural transformation in electrospun fibrous structure** SungYeun Yang, Soocheol Kim, Chulmin Joo and WonHyoung Ryu *Yonsei University, Republic of Korea*
11:40 AM	**Electrospun nanofibrous mats modified with cyclodextrin for water treatment** Mandla Brian Chabalala,[1] Stijn WH Van Hulleb,[2] Bheki B Mambaa[1] and Edward N Nxumalo[1] *[1] University of South Africa, South Africa* *[2] Ghent University, Belgium*	
11:55 PM	**Chitosan and chitin based-nanofiber biosorbents for efficient removal of zinc from wastewater** Alicia Botes,[1,2] Albert Johannes Van Reenen,[1] Marietjie Lutz[1] and Sinha Ray Suprakas[2] *[1] Stellenbosch University, South Africa* *[2] CSIR, South Africa*	
12:15 PM	**END OF CONFERENCE**	

ORAL ABSTRACTS IN PROGRAMME ORDER

PLENARY

ULTRALIGHT POLYMER SPONGES FROM SHORT ELECTROSPUN FIBERS

Andreas Greiner

Macromolecular Chemistry, Bavarian Polymer Institute, University of Bayreuth, Universitätsstraße 30, 95440 Bayreuth, Germany

Sponges are open-cellular macroporous materials. They have received considerable interest in materials science for various applications [1]. Ultralight sponges (density < 10mg/cm^3) offer unique advantages such as low weight and large pore-volume. We found that dispersed short electrospun fibers could self-assemble to ultralight polymer sponges which show decent compressibility and potential for application in tissue engineering [2]. The mechanical properties of the sponges were improved considerably by chemical vapor deposition of poly(p-xylylene) (PPX) without significant increase in density [3]. These sponges showed very good heat insulation and also superhydrophobic properties which makes them of particular interest for textile application and oil/water separation. The concept of sponge property enhancement by post-processing coating was extended to liquid coating which was shown recently for polyimide sponges. The sponges showed very good compressibility, very high thermal stability even on air, very low volume shrinkage, and very good heat insulation [4]. The sponge showed also exceptional performance as carrier for nanoparticle catalysts [5]. These spongy catalysts were reusable many times and showed the highest reaction rates as comparted to other heterogeneous systems. The polymer sponges could take up a lot of guest material due to their large pore volume (up to 300 mL/g). Consequently, the ultralight sponges could take liquids up to 700 times of their own weight. In this state sponges behave rheologically like a gel and in fact show the characteristics of an organogel [6]. Since organogels are prepared by different route we have defined the gels made by filling of the pores of the sponges as spongy gels. The sponges could also take up a large amount of drug and display retarded drug release as shown recently for the anti-Malaria drug artemisone [7].

References

[1] S. Jiang, S. Agarwal, A. Greiner, Low-density open cellular sponges as functional materials (Review), Angew. Chem. Int. Ed. 2017, DOI 10.1002/anie.201700684.

[2] G. Duan, S. Jiang, V. Jerome, J. H. Wendorff, A. Fathi, J. Uhm, V. Altstaedt, M. Herling, J. Breu, R. Freitag, S. Agarwal, A. Greiner, Ultralight, soft polymer sponges by self-assembly of short electrospun fibers in colloidal dispersions, Adv. Funct. Mater. 2015, 25, 2850-2856.

[3] G. Duan, S. Jiang, T. Moss, S. Agarwal, A. Greiner, Ultralight open cell polymer sponges with advanced properties by PPX CVD coating, Polym. Chem. 2016, 7, 2759–2764.

[4] S. Jiang, B. Uch, S. Agarwal, A. Greiner, Ultralight, thermally insulating, compressible polyimide fiber assembled sponges, Appl. Mater. Interf. 2017, DOI: 10.1021/acsami.7b11045.

[5] G. Duan, M. Koehn-Serrano, A. Greiner, Highly Efficient Reusable Sponge-Type Catalyst Carriers Based on Short Electrospun Fibers, Macromol. Rapid Commun. 2016, DOI: 10.1002/marc.201600511.

[6] S. Jiang, G. Duan, U. Kuhn, M. Mörl, V. Altstädt, A. L. Yarin, A. Greiner, Spongy Gels by a Top-Down Approach from Polymer Fibrous Sponges, Angew. Chem., Int. Ed. 2017, DOI: 10.1002/anie.201611787.

[7] G. Duan, A. R. Bagheri, S. Jiang, J. Golenser, S. Agarwal, A. Greiner, Exploration of macroporous polymeric sponges as drug carriers, Biomacromolecules 2017 DOI: 10.1021/acs.biomac.7b00852.

RECENT ADVANCES IN TAILORED NANOFIBERS FOR SELECTIVE SENSING AND ENERGY STORAGE DEVICES

Il-Doo Kim*

Department of Materials Science and Engineering, Korea Advanced Institute of Science and Technology, 291 Daehak-ro, Yuseong-gu, Daejeon 305-701, Republic of Korea

**Email: idkim@kaist.ac.kr*

Electrospinning has been recognized as one of the most efficient techniques for producing non-woven fiber webs on the order of several hundreds of nanometers by electrically charging a suspended droplet of polymer solution with/without inorganic precursors or melt. Various types of materials with a high degree of porosity, a large surface area, superior mechanical properties and modified surface functionalities, can be electrospun into nanofiber structures. These materials include polymeric nanofibers as well as metallic and metal-oxide nanofibers which are prepared by a subsequent heat treatment in a reducing or oxidizing atmosphere of metal salt precursor/polymer composite fibers. In particular, the simplicity of the process combined with the possibility of large-scale production through the use of multiple-nozzles (> 10,000 pieces) makes this process very attractive and therefore opens up new commercial markets for diverse applications. In this presentation, I summarize recent progress and a collection of advances, particularly focused on the synthesis, characterization, and utilization of electrospun metal oxide nanofibers. I will end my presentation by suggesting possible future research direction and potential suitability of 3D nanofibers for applications in colorimetric sensors, exhaled breath gas analyzing sensors for early stage disease diagnosis, and nanocatalysts for next generation energy storage devices.

STIMULI-RESPONSIVE POLYMER FIBERS

Eyal Zussman

NanoEngineering Group, Department of Mechanical Engineering, Technion – Israel Institute of technology, Haifa 32000, Israel

Responsive polymer materials can regulate transport of ions and molecules, change geometry and mechanical and optical properties, as a result of external stimuli. These materials are playing an increasingly important part in a diverse range of applications, such as, tissue engineering, drug delivery, solar and optical systems. This talk focuses on stimuli-responsive macromolecular nanostructures that are capable of conformational and chemical changes on receiving an external signal such as a change in temperature or pH, traction forces, exposure to ionizing radiation, or to an electrical and magnetic fields. The talk will cover the formation of stimuli-responsive electrospun nanofibers. It will be demonstrated how to modulate their response by tuning the fiber microstructure as a function of the strength of the applied electrostatic field during electrospinning, the polymer solution rheology and the evaporation rate. Examples will include the development of drug release methods that deliver a drug in temporal- and dosage-controlled fashions. Implementation of such methods requires the use of materials that are susceptible to a specific physical stimulation or that, in response to a specific stimulus, undergo conformational change, protonation, or hydrolytic cleavage.

ORAL ABSTRACTS IN PROGRAMME ORDER

ROOM 1

ELECTROSPUN NANOFIBERS OF ORGANIC SEMICONDUCTORS AND HYBRID MATERIALS: NOVEL FLEXIBLE LIGHT SOURCES WITH ENHANCED PHOTON EMISSION (Invited)

Andrea Camposeo,[1] Luana Persano,[1] Maria Moffa,[1] Vito Fasano,[2] Dario Pisignano[2]

[1] NEST, Istituto Nanoscienze-CNR, Piazza S. Silvestro 12, I-56127 Pisa, Italy

[2] Dipartimento di Matematica e Fisica "Ennio De Giorgi", Universita del Salento, via Arnesano, 73100, Lecce, Italy

E-mail: andrea.camposeo@nano.cnr.it

Organic semiconductors have revolutionized the field of optoelectronics, enabling the fabrication of flexible light-emitting and light-harvesting devices, such as organic light-emitting diodes, organic solar cells, field effect transistors and lasers. The optoelectronic properties of such materials, and of the devices based on them, can be enhanced by a smart management of the processing methods, and, more specifically, by controlling the nanoscale arrangement of the polymer macromolecules. In this respect, electrospinning has been demonstrated to be very effective in enhancing the optical and electronic properties of nanofibers composed by organic semiconductors and nanocomposite materials opening interesting perspectives for their application in photovoltaics and optical sensing [1-3]. Here, we will present our recent results on the electronic energy migration properties of electrospun nanofibers made by conjugated polymers. Morphological analysis by X-ray scattering, and polarized and time-resolved spectroscopies evidence a directed energy migration towards extended conformational sub-units, emitting light with enhanced efficiency [4]. We will also show how emission can be locally enhanced in hybrid electrospun nanofibers by exploiting light confinement properties of either polymer nanofiber or of the embedded particles.

Acknowledgment. The research leading to these results has received funding from the European Research Council under the European Union's 7th Framework Programme (FP/2007-2013), the ERC Starting Grant "NANO-JETS" (grant agreement n. 306357).

References

[1] L. Persano, A. Camposeo, D. Pisignano, Prog. Polym. Sci. 43, 48 (2015).

[2] S.-J. Choi, L. Persano, A. Camposeo, et al., Macromol. Mater. Eng. 302, 1600569 (2017).

[3] M. Gaio, M. Moffa, M. Castro-Lopez, D. Pisignano, A. Camposeo, R. Sapienza, ACS Nano 10, 6125-6130 (2016).

[4] A. Camposeo, R. Pensack, M. Moffa, V. Fasano, D. Altamura, C. Giannini, D. Pisignano, G. D. Scholes, J. Am. Chem. Soc. 138, 15497 (2016).

ELECTROSPUN NANOFIBER MEMBRANES FOR ENERGY, ENVIRONMENTAL AND BIOMATERIAL APPLICATIONS (Invited)

Ilias Louis Kyratzis and Yen Bach Truong

CSIRO Manufacturing, Private Bag 10, Clayton South, Victoria, 3168 Australia

Abstract

Popular areas of materials research centre on in energy, environment and biomaterials. New materials for energy are required which are light weight and capable storing higher energy densities to power the multitude of devices we use in the modern world. In the environment space new materials and methods of assembly are required that are able to filter fluid media with reduced pressure drops and remove "pollutants" with high efficiency and selectivity. On the other hand new biomaterials are required to keep people healthy for longer at reduced costs. Electrospinning can play a very useful role in the fabrication of useful devices and components for both of these fast growing areas. This paper presents some of the work undertaken by CSIRO in the energy and biomaterials domain.

AIR PURIFICATION BY NANOSTRUCTURED ELECTROSPUN MEMBRANES: DIFFERENT STRATEGIES FOR ENHANCING THE PERFORMANCE OF NANOCOMPOSITE PHOTOCATALYSTS.

Roso Martina[1], Boaretti Carlo[1], Lorenzetti Alessandra[1] and Modesti Michele[1]

[1]University of Padova, Department of Industrial Engineering, Via Marzolo 9, 35131 Padova, Italy
Email: martina.roso@unipd.it

Volatile Organic Compounds (VOCs) represent relevant pollutants both in indoor and outdoor environment. Aromatics, alcohol, ketons and esters can be cited as typical VOCs emitted from a wide range of anthropogenic activities, especially those related to the use of solvents, such as, printing, spray painting, coil coating, wood treatment etc. Among the methods available for air purification, photocatalytic oxidation processes are the most feasible ones.

The present work is meant to show several strategies that can be used for enhancing the performance of TiO_2 based nanostructured electrospun membranes.

In particular, the use of an additional semiconductor (Ag_2CO_3) as well as the coupling of graphene based co-catalysts (Graphene and Graphene Oxide) during sol-gel production of TiO_2, have been found to be promising for this purpose. Other parameters have been investigated, such as the production strategy, which could involve a single electrospinning step, or a double step (electrospinning and electrospraying), and the interaction of the catalytic system with the polymer matrix (Polyacrylonitrile or polyvinylidene fluoride).

The nanostructured membranes have been tested with respect the abatement of methanol and acetaldehyde and the best obtained results showed a complete degradation of 600 ppm of methanol and 1300 ppm of acetaldehyde in less than 40 and 15 minutes, respectively.

The morphology of the nanostructured membrane and the chemical affinity of the catalytic system with the polymeric matrix, have been found to affect the performance of the active filter media; all these data are used for moving towards the design and production of new advanced solutions both for indoor and outdoor pollution.

A further implementation of this research show the real application of such filter media within a confined space, such as a refrigerator, and its ability to remove several odor simulants.

CONJUGATES OF PLATINUM NANOPARTICLES WITH GALLIUM TETRA – (4-CARBOXYPHENYL) PORPHYRIN AND THEIR USE IN PHOTODYNAMIC ANTIMICROBIAL CHEMOTHERAPY WHEN IN SOLUTION OR EMBEDDED IN ELECTROSPUN FIBER

Muthumuni Managa and Tebello Nyokong

Department of Chemistry, Rhodes University, Grahamstown 6140, South Africa (t.nyokong@ru.ac.za)

The field of antimicrobial chemotherapy has been regarded as one of the constant challenge due to the rapid evolutionary changes of pathogens. But this method has been found to be important due to drug resistance pathogens. Like photodynamic therapy (PDT), photodynamic antimicrobial chemotherapy (PACT) utilizes a photosensitizers and visible violet light in order to give phototoxic response, normally via oxidative damage [1]. The potential of PACT to promote microbial eradication is being progressively more accepted. [1].

Porphyrins are the first generation of photosensitizers and have been used in PACT as they have high binding affinity for cellular components and membranes [2]. The conjugation of porphyrin, Fig. 1 (A), and platinum nanoparticles will enhance phototoxic cell damage as platinum nanoparticles have antimicrobial and antifungal properties [3], further enhancement of phototoxic cell damage will be achieved by imbedding these conjugates onto fiber, Fig.1 (B).

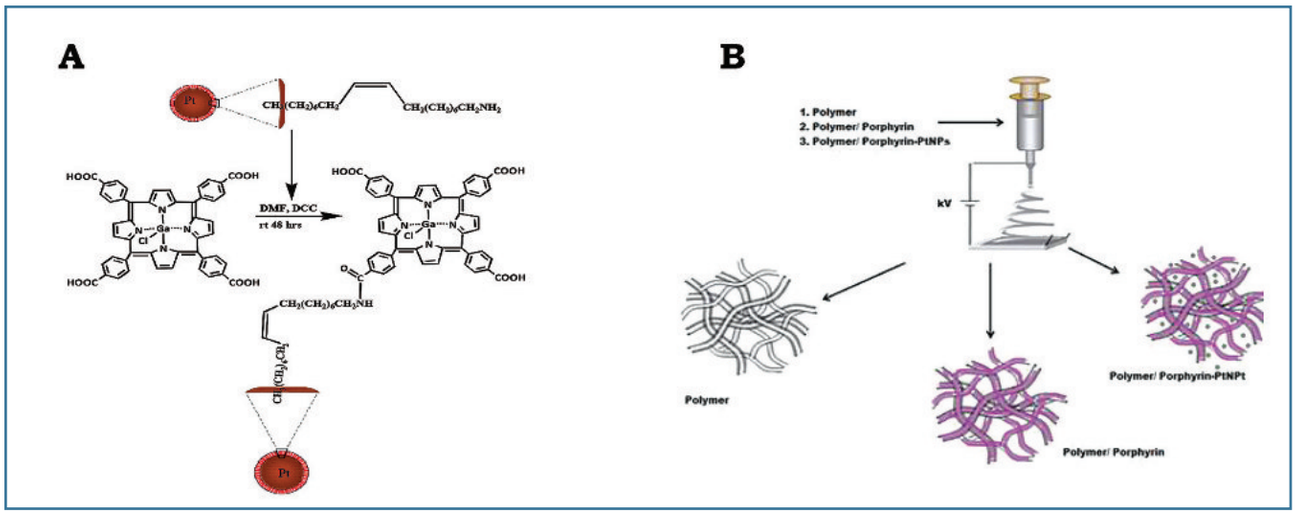


Figure 1: Covalent attachment of PtNPs (A) and diagrammatic representation of the electrospinning of non-functionalized and functionalized polymers (B).

References

[1]. Lipinski CA, Lombardo F, Dominy BW, Feeney PJ (2001) Experimental and computational approaches to estimate solubility and permeability in drug discovery and development settings. Adv Drug Deliv Rev. 46:3-26.

[2]. Alakhov V, Klinski E, Li S, Pietrzynski G, Venne A, Batrakova EV, Bronitch T, Kabanov AV (1999) Block copolymer-based formulation of doxorubicin. From cell screen to clinical trials, Colloids Surf. B: Biointerfaces 16:113–134.

MOF-TEMPLATED SYNTHESIS OF CO_3O_4 ON SNO_2 NANOFIBERS AS SUPERIOR ANODES FOR LITHIUM-ION BATTERIES

Jun Young Cheong, Won Tae Koo, Chanhoon Kim, Ji Won Jung, Su-Ho Cho, Il -Doo Kim*

Department of Materials Science and Engineering, Korea Advanced Institute of Science Technology (KAIST), Republic of Korea

Since their first commercialization in the 1990s, lithium rechargeable batteries have been utilized in various applications, ranging from electric vehicle (EV) to smartphones [1]. Nevertheless, their limited energy density has hampered their use for large-scale applications, such as large scale electric grid and public transportations. To solve these limitations, it is important to develop an alternative kind of anode materials with higher theoretical capacity compared with graphite [2]. Recently, various metal oxides have been researched as potential anode materials for metal-based batteries as they exhibit higher theoretical capacity (usually above 600 mAh g^{-1}), abundance, low cost, and environmental friendliness. Especially, tin (IV) oxide has been sought as one of the most feasible metal electrode materials for battery application due to its additional advantage in the stability with electrolytes [3]. Nevertheless, large volume changes, formation of unstable solid electrolyte interphase (SEI), along with low initial coulombic efficiency (I.C.E.) have hampered its use as more feasible electrodes for next generation rechargeable batteries.

In this study, we have employed a novel material synthetic processing step to fabricate highly porous, metal oxide composite nanofibrous structures by simple electrospinning step and subsequent calcination. Using ZIF-67 (co-based zeolitic imidazole frameworks) as the metal organic framework templates, the Co_3O_4 nanocubes were fabricated on various spots of SnO_2 nanofibers, when both ZIF-67 and Sn precursors were electrospun together and calcined afterwards. Such unique structure resulted in the highly facile Li and electron transport, alleviation of volume expansion through presence of many pores, and enhanced electrochemical properties arising from the synergistic effects of SnO_2 and Co_3O_4. As a result, the Co_3O_4/SnO_2 nanofibers exhibited stable cycling performance for 300 cycles at a current density of 0.5 A g^{-1}, with enhanced I.C.E. of over 70% compared pristine SnO_2 that shows I.C.E of ~60%.

[1] M. Bereibar, I. Gandiaga, Villareal, N. Omar, J. V. Mierlo, P. d. Bossche, Critical review of state health estimation methods of Li-ion batteries for reai applications, Renewable and Sustainable Energy Reviews, 56 (2016) 572 -587.

[2] L. Ji, Z. Lin, M. Alcoutlabi, X. Zhang, Recent developments in nanostructured anode materials for rechargeable lithium-ion batteries, Energy Environ. Sci., 4 (2011) 2682-2699.

[3] J.-H. Jeun, K. -Y. Park, D. -H. Kim, W. -S. Kim, H. -C. Kim, B.-S. Lee, H. Kim, W.-R. Yu, K. Kang, S.-H. Hong, SnO2@TiO2 double -shell nanotubes for lithium ion battery anode with excellent high rate cyclability, Nanscale 5 (2013) 8480-8483.

LASER INDUCED PHOTOCATALYTIC DEGRADATION OF ORANGE G USING HALOGENATED BODIPY DYES EMBEDED IN POLYSTYRENE NANOFIBERS

Augustus Kelechi Lebechi, Tebello Nyokong and John Mack

Center for Nanotechnology Innovation

Department of Chemistry Rhodes University Grahamstown 6140, South Africa J.Mack@ru.ac.za

Freshwater contamination by azo dyes predominantly from textile industry effluents remains a major contributing factor to the scarcity of freshwater, hence the need for remediation of the contaminated wastewater [1]. Functionalised electrospun polystyrene nanofibers incorporating halogenated boron dipyrromethene (BODIPY) dyes, as the sensitizer were prepared for the photocatalytic degradation of Orange G. Unfunctionalised electrospun polystyrene fiber mats were also generated. Within the fiber mats, the singlet oxygen generating proficiency of the sensitizer was found to be maintained. Using laser as the photoexcitation source, the photocatalytic efficiency of the polystyrene embedded sensitizer was determined. Reusability studies were also undertaken; the results showed that the rate of photodegradation increases with concentration and followed pseudo-first order kinetics.

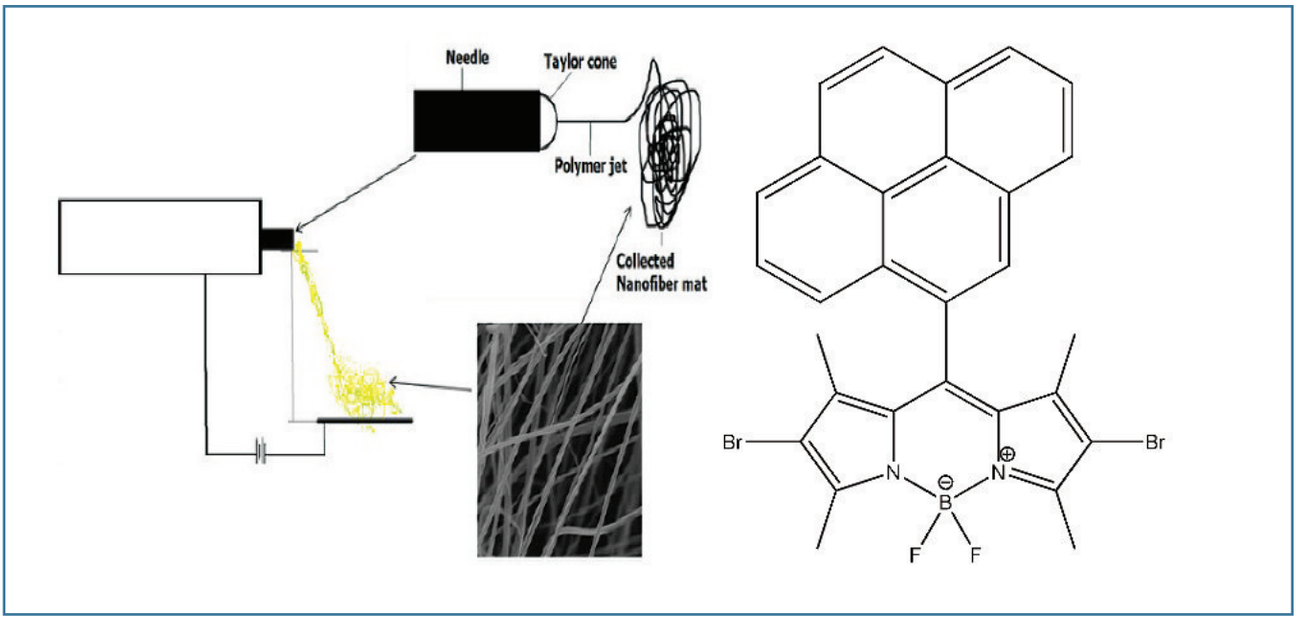


Fig.1. Electrospinning set-up

Fig.2. BODIPY dye

References

1. Domınguez, C.; Garcıa, J.; Pedraz, M.; Torres, A.; Galan, M. Photocatalytic oxidation of organic pollutants in water. Catalysis today 1998, 40, 85-101.

HIGHLY-ALIGNED NANOFIBER PRINTING FOR STRETCHABLE ELECTRONICS AND NEUROMOPHIC SYNAPSES (Invited)

Tae-Woo Lee

Dept. of Materials Science and Engineering, Seoul National University, Seoul, Rep. of Korea

Email: twlees@snu.ac.kr

We report our recent progress in printed organic nanofiber-based neuromorphic and stretchable electronics. Precisely controlled organic nanofibers are promising elements for upcoming innovative electronics such as brain-inspired computation and memory, light-weight wearable electronics and biomedical electronics based on their advantages of low-cost solution printing process, high speed and large scale fabrication, high-resolution (< 1μm) patterning, and so on. We reported organic nanofiber-based neuromorphic synapses which emulated important working principles of a biological synapse, e.g., excitatory post-synaptic current (EPSC), inhibitory post-synaptic current (IPSC), paired-pulse facilitation (PPF), short-term plasticity (STP), long-term plasticity (LTP) and spike-timing dependent plasticity (STDP). Electrochemical synaptic transistor arrays with nano-feature size were produced based on aligned organic semiconducting nanofibers and ion-gel dielectric which mimic fiber-like morphology of neurons and biological synaptic cleft. These properties are promising for neuromorphic computation and memory, and the devices would serve as building blocks of future neuromorphic systems. We also recently developed aligned organic semiconducting nanofiber-based stretchable electronics which are impervious to mechanical influence when mounted on the surface of dynamically-changing soft matter. Our stretchable field-effect transistors can be easily stretched by applied strains (both 100% tensile and compressive strains). The mechanical durability of nanofiber can be further significantly increased by simply re-engineering the geometric structure of the nanofiber. The stretchable transistors withstood 100% uniaxial stretching with minimal change of electrical properties, even after a 3D volume change (> 1700% and back to original state) of a rubber balloon. The stretchable transistors robustly operated on a mechanically-dynamic soft matter surface e.g. a pulsating balloon that mimics a beating animal heart, which demonstrates potential of the stretchable transistor for future biomedical applications.

DESIGN OF ECO-FRIENDLY AND SUSTAINABLE NANOFIBROUS SENSORS FOR DETECTING ENVIRONMENTAL POLLUTANTS (Invited)

A. Macagnano,[1] F. De Cesare,[1,2] E. Zampetti,[1] A. Bearzotti,[1] G. Scarascia-Mugnozza,[2] N. Pirrone[1]

[1] Institute of Atmospheric Pollution Research-National Research Council (IIA-CNR), Monterotondo (RM), Italy

[2] Department of Innovation in Biological Systems, Food and Forestry (DIBAF) -University of Tuscia, Viterbo, Italy

Environmental monitoring of chemical and biological contaminants is an ever-growing need of both industrialized and underdeveloped countries, because of the strong impact of several anthropogenic activities on environmental and human health. A close relationship between climate change and pollution has also been proven that further enforces the risks associated to the presence of pollutants in terrestrial, water and atmospheric ecosystems for humans and other organisms. To achieve this aim with cost effective strategies, novel sensors for environmental monitoring have been designed and developed to obtain reliable values comparable to those provided by standard methods and technologies. Engineered and functionalized nanofibers (NFs) have been investigated and used to date as smart materials for a large number of advanced environmental applications. Electrospinning technology has also been employed to create high performance sensors to detect gases and volatile organic compounds (VOCs) in the air. Sensors based on polymeric fibers look extremely attractive for the low cost and great versatility of the raw materials that can: i) be easily tunable, according to the transducer used and the application of interest; ii) take part to the resulting sensing features (selectivity and sensitivity). Based on these features, some promising electrospun nanofibrous and environmentally friendly materials designed for the detection of atmospheric pollutants will be here described. The attention will be mostly focused on the challenging goal of obtaining opto/conductive sensors for the monitoring of air pollutants employing suitable scaffolds of eco-friendly (PHB, PCL, etc.) and sustainable (recycled) nanomaterials. Biodegradability is a noteworthy feature to obtain sensing tools environmentally friendly and safe for health. However, sensors for gas monitoring (especially outdoor) must also be able to both persist intact for a reasonable shelf life and to preserve their sensing features over time, depending on the specific application and the working period. There are operative conditions where biodegradable polymers cannot be reasonably used. In these cases, some recycled plastics (as PET and PS) can be used to develop more durable sensing materials suitable and selective for optically/electrically active molecules/particles, according to a sustainable approach. In this case, these plastics can contribute to save energy and other major resources (e.g. food, soil, water) in strategic sectors (i.e. smart packaging).

CATALYST COMPRISING DUAL BIO-TEMPLATES ASSISTED WO_3 NANOTUBE TOWARD EXCEPTIONALLY SELECTIVE AND SENSITIVE H_2S SENSORS

Dong-Ha Kim,† Ji-Soo Jang,† Won-Tae Koo,† Seon-Jin Choi,¶ Hee-Jin Cho,† Min-Hyeok Kim,† Sang-Joon Kim† and Il-Doo Kim†

†Department of Materials Science and Engineering, Korea Advanced Institute of Science and Technology (KAIST), 291 Daehak-ro, Yuseong-gu, Daejeon, 34141, Republic of Korea

¶ Biomaterials Innovation Research Center, Division of Engineering in Medicine, Department of Medicine, Brigham and Women's Hospital, Harvard Medical School, Boston, MA 02139, USA.

Semiconducting metal oxides (SMOs) based gas sensor possesses inherent limitations associated with low sensitivity, selectivity, and slow response/recovery speed, particularly at high humidity levels, thus further advancement of this field toward commercialization, especially for exhaled breath sensor platforms, has been greatly hindered. To address these issues, simple and robust SMOs nanofabrication techniques to achieve breakthrough in terms of gas sensing performance are imperative to explore. By constructing hollow SMOs nanostructures, gas accessibility and surface area can be markedly increased inducing active interaction of air adsorbates with gas analytes. On the basis of the structural effect, fabrication of heterogeneous SMOs nanostructures functionalized with noble metal catalyst would be an excellent strategy to dramatically enhance the overall gas sensing characteristics.

In this work, we utilized dual sacrificial bio-templates, i.e., cellulose nanocrystal (CNC) and apoferritin, during electrospinning process to achieve three distinctive benefits, i.e., (i) facile synthesis of tubular WO_3 scaffold by utilizing self-agglomerating nature of CNC at the core of as-spun nanofibers, (ii) partial modification of crystal structures from monoclinic WO_3 to triclinic $Na_2W_4O_{13}$ induced by interaction between core-riched sodium doped CNC and shell-riched WO_3 during calcination, and (iii) uniform functionalization of apoferritin derived highly dispersive Pt catalytic nanoparticles (2.22 ± 0.42 nm). As a result, unprecedented tailored design of two combinations unparalled hydrogen sulfide (H_2S) selectivity was realized via chemical reaction among Na-H_2S and Pt-H_2S in ideal gas sensing structures. Not only highly selective H_2S sensing characteristics against 7 other interfering molecules, i.e., CH_3COCH_3 C_7H_8, HCHO, C_2H_5OH, CO, NH_3, and CH_4 were obtained. But also, synergistic effects stemmed from bio-inspired Pt catalyst, inducing exceptional high H_2S response (Rair/Rgas=203.52), remarkable selectivity (Rair/Rgas < 2.10 for 7 interfering molecules) and rapid response (< 10 s)/recovery (<30 s) time, particularly at 1 ppm H_2S level under highly humid ambient (95% RH). This work paves a new class of way to overcome critical shortcomings of SMOs based chemical sensors, thus providing potential exhaled breath sensing platforms with high sensing performance.

ELECTROSPINNING OF POLYTHIOPHENE WITH PENDANT FULLERENE NANOFIBERS FOR SINGLE-MATERIAL ORGANIC SOLAR CELLS

F. Pierini[1], M. Lanzi[2], P. Nakielski[1], S. Pawlowska[1], O. Urbanek[1] and T.A. Kowalewski[1]

[1] Institute of Fundamental Technological Research, Polish Academy of Sciences, Warsaw, Poland

[2] Department of Industrial Chemistry "Toso Montanari", University of Bologna, Bologna, Italy

Organic photovoltaics have been attracting great attention due to their remarkable properties of low cost, flexibility and lightweight. Bulk heterojunction (BHJ) devices are the most investigated organic solar cells (OSCs). BHJ cell applicability is severely affected by their active material intrinsic properties which are based on thermodynamically unstable blends. OSCs based on single-component active materials have been developed to avoid the challenging optimization of BHJ cells. Single-material organic solar cells (SMOCs) are based on polymers in which the covalent linking of electron accepting moieties to a hole-transporting conjugated polymer allows intramolecular electron transfer from donors to acceptors. SMOC efficiency is affected by the charge recombination and randomly-directed transport in their structures composed by randomly oriented polymer chains. Electrospinning is the most efficient technique to elongate and align polymer chains to form nanofibers [1], therefore we studied the effect of the electrospun fibers inclusion on the active material structure and cell performance. Here we describe the development of an electrospun nanofiber-based single-material organic solar cell (Figure 1) with high power conversion efficiency (PCE= 5.58%).

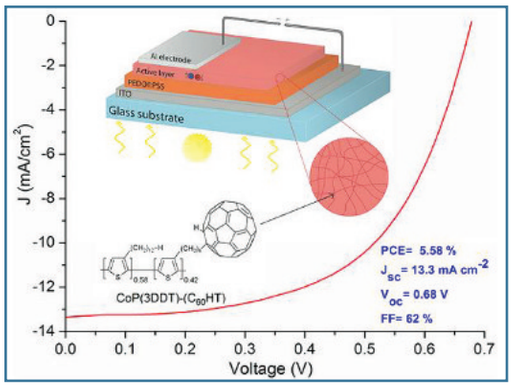


Figure 1: structure and photovoltaic properties of an electrospun nanofiber-based SMOC [2].

We report on the synthesis of a new donor-acceptor double-cable conjugated copolymer, the fabrication of electrospun CoP(3DDT)-(C_{60}HT) nanofibers and their integration into SMOCs. The inclusion of electrospun nanofibers led to a great improvement of the photovoltaic cell performance (+33.2% and +57.2% in terms of efficiency if compared with the best reported SMOC and a conventional bulk heterojunction device, respectively). Finally, detailed polymer, nanofibers and device hierarchical structure characterizations as well as an exhaustive discussion of the mechanism driving the improvement in single-material organic solar cell development by the presence of electrospun nanofibers will be shown. Our results suggest that the active material structure optimization obtained by the application of electrospun nanofibers plays a pivotal role in the development of efficient SMOCs and open and alternative and compelling way to increase organic solar cell performance and applicability [2].

Project supported by the National Science Centre (NCN) grant no. 2015/19/D/ST8/03196.

References

[1] F.Pierini et al., Polym. Adv. Technol. 2016, 27, 1465-1475.

[2] F.Pierini et al. Macromolecules 2017, 50, 4972-4981.

ELECTROSPUN PMMA POLYMER BLEND NANOFIBROUS MEMBRANE: ELECTROSPINABILITY, SURFACE MORPHOLOGY AND MECHANICAL RESPONSE

Jacky Jia Li Lee[1], Bee Chin Ang[2],*, Andri Andriyana1, Md Islam Shariful[1], M. A. Amalina[1]

[1]Center of Advanced Materials, Department of Mechanical Engineering, University of Malaya, Lembah Pantai, Kuala Lumpur 50603, Malaysia

[2]Center of Advanced Materials, Department of Chemical Engineering, University of Malaya, Lembah Pantai, Kuala Lumpur 50603, Malaysia

Abstract

The present work focuses on the electrospinning ability, the evaluation of resulting surface morphology and mechanical response of PMMA polymer blend nanofibrous membranes. For this purpose, electrospinning ability of PMMA polymer blend is firstly investigated by exploring various set of electrospinning parameters. From the evaluation of surface morphology of the resulting electrospun membranes, the optimum parameters are identified. Using these optimum parameters, tensile specimens are subsequently produced. Three deformation modes are considered: monotonic tensile test, cyclic test with increasing maximum strain and cyclic-relaxation test. Morphological analysis shows that the optimized tensile specimens are initially isotropic on the plane. The mechanical test results highlight the strong inelastic responses of the materials, which include inelastic strain and time-dependent behavior characterized by stress relaxation. Finally, in-situ tensile test outcomes suggest that strain-induced fiber re-orientation took place from human breath with smartphone camera. We expect that facile optical-type sensing methods will be of practical importance for general-purpose gas detector (for healthcare, drugs for example).

LASER INDUCED PHOTODEGRADATION OF ORANGE G USING PHTHALOCYANINE – COBALT FERRITE MAGNETIC NANOPARTICLE CONJUGATES ELECTROSPUN IN POLYSTYRENE NANOFIBERS.

Sivuyisiwe Mapukata and Tebello Nyokong*

Centre for Nanotechnology Innovation, Department of Chemistry, Rhodes University, Grahamstown, South Africa. Email: t.nyokong@ru.ac.za

Abstract

The photocatalytic oxidation of pollutants through advanced oxidation process (AOP) using a photosensitiser, molecular oxygen and light is important for pollution control. The AOP method is based on the use of reactive oxygen species (ROS) in oxidizing water pollutants and doesn't liberate additional pollutants. In this work, phthalocyanines (Pcs) with varying functionalities are conjugated to complementary cobalt ferrite magnetic nanoparticles ($CoFe_2O_4$ MNPs) via amide bond formation resulting in Pc-MNP conjugates (Fig. 1). Upon conjugation, the synergistic effect between the Pcs and MNPs causes increased production of ROS [1]. The conjugates are then electrospun with polystyrene yielding nanofibers promoting reuasability of the photocatalysts. The functionalised fibers are then employed for the oxidative degradation of Orange G; a toxic water pollutant. Using laser as the photoexcitation source, real life applications for water purification can be devised from electrospun fibers when functionalised with photosensitisers.

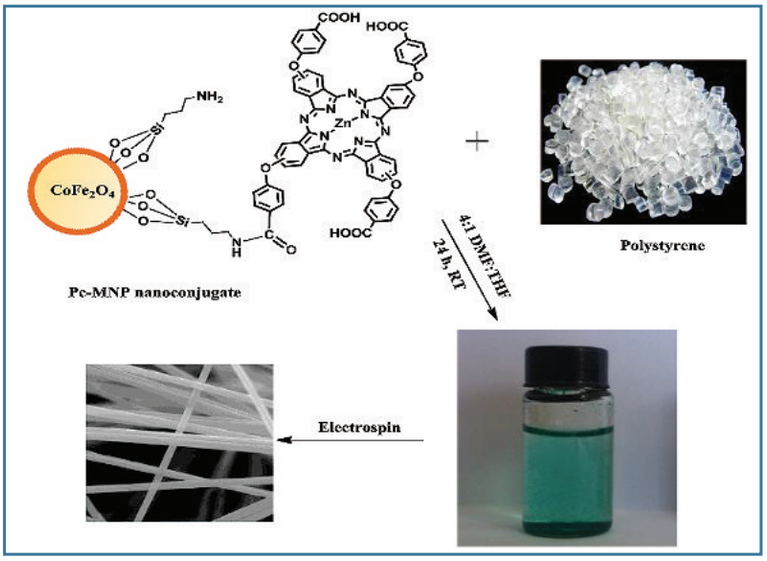


Fig. 1: Preparation of electrospun fibers for water purification

Reference

1. S. Mapukata, F. Chindeka, K. E. Sekhosana, T. Nyokong, J. Mol. Cat. A: Chem, 439 (2017) 211-223.

MERGING LIGHT EMISSION AND PIEZOELECTRIC PROPERTIES IN ELECTROSPUN POLYMER NANOFIBERS (Invited)

Luana Persano,[1] Andrea Camposeo[1] and Dario Pisignano[1,2]

[1] NEST, Istituto Nanoscienze-CNR, Piazza S. Silvestro 12, I-56127 Pisa, Italy

[2] Dipartimento di Matematica e Fisica "Ennio De Giorgi", Università del Salento, via Arnesano, 73100, Lecce, Italy

E-mail: luana.persano@nano.cnr.it

Polymer nanofibers made by electrospinning are one-dimensional nanostructures exhibiting smart physicochemical properties which enable their use in different fields such as photonics, biotechnology, optoelectronics and energy harvesting. Among the fabrication and synthetic methods so far available for the production of 1D polymeric nanostructures at laboratory and pre-industrial scale, electrospinning is indeed a unique technology due to its operational simplicity, as well as for the large variety of materials and solvents that can be combined in order to tailor specific properties and functionalities. These aspects can lead to fibers with unconventional properties, in which different functions are coupled to realize a new generation of active nano-components. Here we report on electrospun fibers merging photonic function and energy harvesting capability. Material optimization aspects, processing parameters, and tunability of the emitted light as well as inherent piezoelectric behavior are studied and optimized in view of realizing multi-functional nanofiber materials and devices which include mechano- and position sensors. The research leading to these results has received funding from the European Research Council under the European Union's 7th Framework Programme (FP/2007-2013), the ERC Starting Grant ''NANO-JETS'' (grant agreement n. 306357).

METAL AND SEMICONDUCTOR NANOPARTICLES AND THEIR POLYMER FIBRES (Invited)

Makwena J. Moloto

Department of Chemistry, Vaal University of Technology, P/Bag X021, Vanderbijlpark,1900, South Africa.

Tel: +27(0)16 9506689 | Email: makwenam@vut.ac.za

Quantum dots (QDs) are semiconductor nano-particles, which have many unique properties and show interesting phenomena, such as size dependent emission wavelength, narrow emission peak and broad excitation range[1,2]. QDs have been studied for almost three decades and are nano-crystals in which excitons are confined in all three spatial dimensions. The confinement can be realized by fabricating the semiconductor in very small size, typically several hundred to thousands of atoms per particle[1,2]. Due to quantum confinement effects, QDs act like artificial atoms, showing controllable discrete energy levels. QDs were first fabricated in the 80's by Louis E. Brus[3] and the unique properties of these special nano-structures attracted interest from many fields. CdSe is a binary semiconducting material of cadmium and selenium. CdSe is being developed in research for use in opto-electronic devices, nanosensing, and biomedical imaging.1 This presentation will be focused on CdSe and other metal based chalcogenides such as AgSe, CuSe, TiO_2 and Ag. Various methods have been explored in making metal chalcogenide nanoparticles and for example, CdSe nanoparticles are prepared using a solution of cadmium and selenide under controlled conditions. The incorporation of nanoparticles prepared into the polymer PMMA using electrospinning technique in order to make polymer fiber. Variation of percentages of CdSe nanoparticles into the polymer cause coiling of fibers and decreased luminescence intensity. CdSe nanoparticles were also used as core in the synthesis of CdSe/ZnO and CdSe/PbS nanomaterials using thioglycerol, hexadecylamine and trioctylphosphine oxide. The semiconducting, metal nanoparticles and polymer fibers will be discussed for their synthesis and characterization; their properties will be explored from their synthetic conditions. Some have shown very strong antibacterial activity against selected bacteria.

References

[1] Ma, C; Ding, Y; Moore, D; Wang, X; Wang, Zl (2004). Journal of the American Chemical Society 126 (3): 708.

[2] Califano, Marco (2004). Applied Physics Letters 84: 2409.

[3] Brus L. E.(1984), J. Chem. Phys. 80, 4403

ELECTROSPUN POLYMER FIBERS FOR ORGANIC FIELD EFFECT TRANSISTORS: FROM UNIPOLAR TO AMBIPOLAR DEVICES

C. Bertarelli*#, R. Castagna*, B. Saglio*#, G. Mondini*, M. Baroncini*

**Politecnico di Milano, Dipartimento di Chimica, Materiali e Ingegneria Chimica, piazza Leonardo da Vinci 32, 20133, Milan, Italy*

#Center for Nano Science and Technology @Polimi, Istituto Italiano di Tecnologia, via G. Pascoli 70/3, 20133 Milan, Italy

Fibers of both p-type [1] and n-type [2] semiconducting polymers are produced with a two-fold aim: first, they allow for an efficient miniaturization of organic field effect transistors (OFETs)[3]. Moreover, the anisotropy of the fibrous structure combined with confinement at the small scale influences the charge transport resulting in strong variation of the charge mobility. In the case of electrospun fibers of the n-type poly-[N,N'-bis(2-octyldodecyl)-1,4,5,8-naphtalenedicarboximide-2,6-diyl]-alt-5,5'-(2,2'-bithiophene) (P(NDI2OD-T2) we demonstrate an interesting relationship between the processing parameters, the molecular structure and the resulting electron mobility. To understand the origin of these large variations in charge transport features, chain orientation and crystal structure have been investigated by FTIR with polarized light and GIWAXS, respectively. The results clearly support a lamellar conformation modelling, indicating that hopping rather than the intramolecular charge transport occurs in P(NDI2OD-T2).

Worth noting, ambipolar fibers made by (P(NDI2OD-T2) and poly(3-hexylthiophene-2,5-diyl) (P3HT) are also shown for the first time. Their electrical characteristics turn out to depend on the electrospinning parameters and a balanced ambipolarity, with high values of both hole and electron mobility, has been finally obtained.[4] An in-deep characterization of the balanced ambipolar fibers reveals the presence of semicrystalline nanofibers of the two materials, namely 1D nanostructures with a critical dimension in the order of the ten of nanometres. These ambipolar fibers open to the development of logic circuits in miniaturized flexible electronics.

[1] A. Bianco, C. Bertarelli, S. Frisk, J.F. Rabolt, M.C. Gallazzi, G. Zerbi, Synth. Metals, 2007, 157, 276-281

[2] E.V. Canesi, A. Luzio, B. Saglio, A. Bianco, M. Caironi, C. Bertarelli, ACS Macro Lett., 2012, 1, 366-369

[3] A. Luzio, E.V. Canesi, C. Bertarelli, M. Caironi, Materials, 2014, 7, 906-947.

[4] B. Saglio, M. Baroncini, A. Luzio, M. Caironi, R. Castagna, C. Bertarelli, "Ambipolar semiconducting polymer fibers", manuscript in preparation.

MORPHOLOGICAL ADVANCES OF THIOPHENE AND CARBAZOLE DERIVATIVES FOR SUPERHYDROPHOBIC AND OPTO-ELECTRIC APPLICATION

Khadija Kanwal Khanum and Praveen C. Ramamurthy*

*Department of Materials Engineering, IISc, Bangalore, India *onegroupb203@gmail.com*

Abstract

In the field of organic electronics, increasing the conductivity of conjugated materials is of prime importance for its application in transistors, photodiodes, photovoltaics and sensors[1]. Conductivity of a given molecule is structure related property, as increase in crystallinity aids in improving the conductivity. Especially in the case of nanofibers improving the fiber orientation enhances the crystallinity. Fiber orientation either could be post fabrication process such as annealing or stretching to realign the polymer chain or it could be in-situ process where the fibers are drawn using very high potential force to draw the nanofibers as carried out in melt spinning, wet spinning force spinning or electrospinning/electrospraying[2].

The well known conjugated small molecules are thiophene, carbazole, fluorene and pyrrole derivatives, these are photoactive materials with varied levels of optical absorption and electrical conductivity. Morphological architecturing enables the enhancement of optical absorption and surface area in these materials. In this study, morphological engineering of conjugated small molecules is carried out using electrospraying. Electrospraying process parameters such as high voltage, tip to collector distance, solvent and substrates are varied in order to

control the morphologies[3]. Further the degree of effect of individual parameters on the hierarchical structures is studied especially for (i) solvent vapor pressure[4] (ii) addition of moiety to the molecular structure and (iii) addition of optical enhancers. This study is initially carried using thiophene derivative, and subsequently mapped to carbazole derivatives. Morphological characterization revealed the spike, spheres, sphere-spike, hollow spheres, 2D and 3D pyramid structures[5]. These hierarchical structures are further studies for structural, superhydrophobic, optical and opto-electrical properties. The understanding of underlying mechanism in realization of such geometrical structures assists in better engineering the photovoltaic devices.

References

1. Helgesen M, Søndergaard R, Krebs FC (2009) Advanced materials and processes for polymer solar cell devices. J Mater Chem 20:36–60 . doi: 10.1039/B913168J

2. Deitzel JM, Kleinmeyer J, Harris D, Beck Tan NC (2001) The effect of processing variables on the morphology of electrospun nanofibers and textiles. Polymer 42:261–272 . doi: 10.1016/S0032-3861(00)00250-0

3. Bhardwaj N, Kundu SC (2010) Electrospinning: A fascinating fiber fabrication technique. Biotechnol Adv 28:325–347 . doi: 10.1016/j.biotechadv.2010.01.004

4. Khanum KK, S SB, Ramamurthy PC (2015) Design and morphology control of a thiophene derivative through electrospraying using various solvents. RSC Adv 5:60419–60425 . doi: 10.1039/C5RA06468F

5. Khanum KK, Ramamurthy PC (2018) Effect of molecular architecture on morphology in the nanostructures and its applications in superhydrophobicity and organic photovoltaics. J Mater Sci 53:1264–1278 . doi: 10.1007/s10853-017-1578-4

REINFORCEMENT OF ELECTROSPUN FIBERS WITH 2D MXENE FILLERS

Patrik Sobolčiak[1], Aisha Tanvir[1], Anton Popelka[1], Mohammad K. Hassan[1], Khaled A. Mahmoud[2,3], Igor Krupa[4]

[1] Center for Advanced Materials, Qatar University, P. O. BOX 2713, Doha, Qatar.

[2] Qatar Environment and Energy Research Institute (QEERI), Hamad Bin Khalifa University (HBKU), P. O. Box 5825, Doha, Qatar.

[3] Department of Physics & Mathematical Engineering, Faculty of Engineering, Port Said University, 42523 Port Said, Egypt

[4]QAPCO Polymer Chair, Center for Advanced Materials, Qatar University, P.O. Box 2713 Doha, Qatar.

Abstract

The high demand for conductive, lightweight and flexible materials for various applications has sparked interest in developing new methods to fabricate freestanding and flexible films, containing minimum inactive ingredients. Nanofibers prepared by electrospinning (ES) are of considerable interest for various applications due to their unique nanofibrous structure, large surface area and high porosity [1].

Very recently, a new class of 2D metal carbides and carbonitrides called MXenes, which are both conductive as well as hydrophilic have been discovered [2]. MXenes have general formula $M_{n+1}X_n$, which is derived from MAX phases, where M is an early transition metal, A is an A-group element, mostly IIIA and IVA, or groups 13 and 14, and X is either carbon and/or nitrogen, by chemical etching in HF or NH_4HF_2 solutions, where n = 1, 2 or 3. The unique structure of MXenes offers combination of excellent mechanical properties, hydrophilic surface, transparency and metallic conductivity. Herein, we report the fabrication of electrospun fibers based on 2D MXene fillers and different hydrophilic polymers.

The results show that even at very low loading of MXene, nanofibers exhibited good mechanical strength and high electrical conductivity compare to their casted analogues. The electrospun nanofibers were analysed using scanning electron microscopy (SEM), atomic force microscopy (AFM), dynamic mechanical analysis (DMA), tensile measurement, thermogravimetric measurement (TGA), broadband dielectric spectrometry (BDS) and showed potential application for water treatment and electrical applications.

Acknowledgements

This work was made possible by NPRP grant No.: 7-1724-3–438 from the Qatar National Research Fund (A Member of Qatar Foundation). The statements made herein are solely the responsibility of the authors.

References

1. ZM. Huang, YZ. Zhang, M. Kotaki, S. Ramakrishna, Composites Science and Technology. 2003, 63(15), 2223.

2. M. Naguib, M. Kurtoglu, V. Presser, J. Lu, J. Niu, M. Heon, L. Hultman, Y. Gogotsi, MW. Barsoum, Advanced Materials 2011, 23, 4248.

LIGHT DIFFUSION AND AMPLIFICATION IN COMPLEX NETWORKS OF ELECTROSPUN NANOFIBERS (Invited)

Dario Pisignano

University of Pisa, Italy

CONSTRUCTING SOFT AND SOLID-STATE LITHIUM BATTERIES WITH ELECTROSPINNING TECHNIQUES (Invited)

Jianhua Yan[1, 2], Jianyong Yu[2], Bin Ding[1, 2]

[1] Key Laboratory of Textile Science & Technology, College of Textile, Donghua University, Shanghai 201620, China

[2] Innovation Center for Textile Science and Technology, Donghua University, Shanghai 200051, China

Abstract

The evolution of portable electronics strongly requires soft lithium (Li) batteries, which help products to be light weight, safe, and flexible. Soft Li-batteries can also be stacked one over the other to increase its voltage and power supply, also making them capable of providing enough energy required for heavy devices such as electrical cars. The demand for flexible batteries is expected to increase and grow fast in the future 20 years because of their advantages over liquid type Li-batteries. Fabrication of flexible nanofibrous electrodes and solid-state electrolytes with improved mechanical properties and electrical conductivities is therefore becoming an attractive research work for soft Li-batteries. However, getting flexible electrodes and electrolytes have been proven extremely challenging. More importantly, how to improve the interfacial resistance between solid-state electrolyte and electrodes is still an open problem. Herein, we report our designs of soft and all solid-state Li-batteries with very low interfacial resistances, and a systematically investigations on fabricating flexible hierarchical CNF based electrodes and pure $LiLaTiO_3$ (LLTO) ceramic electrolytes with enhanced mechanical elasticity and durability by using electrospinning techniques. In our work, flexible LLTO, CNFs/Si, CNF/SiO_2, CNF/VN/S and CNF/S with various structures were synthesized by electrospinning techniques. The mechanisms of softness of each different membrane and the electrochemical performance of such soft electrodes and electrolytes are also discussed. The improved elasticity and robust durability of conductive nanofibrous electrodes and electrolytes promise for their wide applications in soft and solid-state Li-batteries.

STRETCHABLE ORGANIC NANOWIRE TRANSISTORS

Yeongjun Lee,[1,2] Jin Young Oh,[2] Zhenan Bao,[2*] and Tae-Woo Lee[3*]

[1] Dept. of Materials Science and Engineering, POSTECH, Pohang, Rep. of Korea

[2] Dept. of Chemical Engineering, Stanford University, Stanford, USA

[3] Dept. of Materials Science and Engineering, Seoul National University, Seoul, Rep. of Korea

Email: twlees@snu.ac.kr

Stretchable electronic devices impervious to mechanical influence when mounted on the surface of dynamically-changing soft matter have great potential for next-generation implantable bioelectronic devices. Here, we present a stretchable organic semiconducting (OSC) nanowire (NW), composed of diketopyrrolopyrrole (DPP)-based polymer semiconductor and high-molecular-weight polyethylene oxide (PEO) as a molecular binder for electrospinning. We achieved a stretchable OSC NW field-effect transistor (FET) and synaptic transistor (ST). Our obtained electrospun OSC NW showed high field-effect mobility > 8 $cm^2V^{-1}s^{-1}$ in a conventional FET geometry with high-κ polymer dielectric, and can also be easily stretched by applied strains (both 100% tensile and compressive strains). Furthermore, the mechanical durability of NW can also be significantly increased by simply re-engineering the geometric structure of the stretchable OSC NW. Our fully-stretchable OSC NW FET withstood 100% uniaxial stretching with minimal change of electrical properties, even after a 3D volume change (> 1700% and back to original state) of a rubber balloon. The stretchable transistor robustly operated on a mechanically-dynamic soft matter surface e.g. a pulsating balloon that mimics a beating animal heart, which demonstrates potential of the stretchable transistor for future biomedical applications. In addition, stretchable OSC NW ST also showed stable I-V characteristics after both 100% strain and repeated stretching cycles in both channel length and width directions, as well as typical postsynaptic behaviors such as excitatory postsynaptic current, neural facilitation and so on.

INFLUENCE OF IONIC LIQUID ON THE ELECTROSPUN MAT MORPHOLOGY

Illia Krasnou, Ljudmila Solovjova, Andres Krumme

Department of Materials and Environmental Technology, Tallinn University of Technology, Tallinn, Estonia

In electrospinning applications one of the most used ways to increase the conductivity of solutions is to add salts. Addition of room temperature ionic liquids (RTILs) also could be used for this reason, but they could interact with polymer molecules and have significant influence on the spun fibers morphology and properties. One of the high interests to RTILs is to use them as electrolytes and as part of composite polymeric materials with electrical conductivity.

In our work we study the influence of different imidazolium based ionic liquids as co-solvent for electrospinning of polyethylene oxide (PEO) and styrene acrylonitrile (SAN). We produced electrospun electrically conductive fibrous mats with diameters of few hundreds of nanometers. We have not found dependence of fibers properties on anion nature of added IL. But in contrast the presence of RTILs in solution affects the fiber properties if consider polymers soluble and not soluble in RTILs.

ALL TRANSPARENT-STRETCHABLE ELECTROCHROMIC-SUPERCAPACITOR WEARABLE PATCH DEVICE

Tae Gwang Yun, Dong-ha Kim, Jin Gook Bae, Il-Doo Kim

Department of Material Science and Engineering, Korea Advanced Institute of Science and Technology, Daejeon, 305-701, Republic of Korea

Electrochromic devices that control transmittance of ultraviolet and visible light by electrochromism due to charge transfer have been applied to low emission mirrors and energy saving functions by suppressing the internal temperature rise of the smart buliding system. Furthermore, electrochromic device can be used as a werable healthcare device that detect harmful substances in human body as electric signals. For example, wearable electrochromic-chemical sensor technology have been developed by integrated a chemical sensor that detects resistance change by a target chemical component and an electrochromic device that generates a color change by electron movement. Wearable electrochromic devices have attractive functions and development possibilities that can be applied in everyday life, however, the limitations of conventional electrochromic devices based on

ITO-glass, which is brittle and required external electrical input did not overcome.[1-5]

All transparent-stretchable electrochromic-supercapacitor wearable patch devices with high electrochemical and electrochromic performance was fabricated to overcome the limitations of conventional electrochromic devices. All transparent-stretchable wearable patch device was consisted of transparent-stretchable low density silver nanowire embedded PDMS substrate, electrospunned WO_3 nanotube-PEDOT:PSS thin layer composite and transparent-stretchable Li ion-poly acryamide based hydrogel electrolyte. Especially, the WO_3 nanotube can be increased contact efficiency with low density silver nanowire current collector. In addition, PEDOT:PSS thin layer can be prevented to delaminate WO_3 nanotube and enhanced coloration efficiency by dual electrochromic coloration. As a result, electrochemical energy capacity, electrochemical cycle reliability and electrochromic coloration efficiency was enhanced 20.6%, 7.0%, 12.0% by WO_3 nanotube-PEDOT:PSS active materials. The electrochromic-supercapacitor wearable patch device capable of stretching-bending deformation and simultaneously electrochromic coloration-electrochemical energy storage with enhanced electrochemical-electrochromic properties was operated by integrated hydrogel electrolyte with high ionic conductivity, transparency and more than 80% elongation. Therefore, the fabricated all transparent-stretchable electrochromic-supercapacitor wearable patch device was demonstrated to suitable for wearable electronic applications.

Reference

[1] S. Lin, X. Bai, H. Wang, H. Wang, J. Song, K. Huang, C. Wang, N. Wang, B. Li, M. Lei, H. Wu, Adv. Mater, 2017, 1703238

[2] A. Llordés, Y. Wang, A. Fernandez-Martinez, P. Xiao, T. Lee, A. Poulain, O. Zandi, C. A. S. Cabezas, G. Henkelman, D. J. Milliron, Nat. Mater, 2016, 15, 1267

[3] M. Sassi, M. Salamone, R. Ruffo, G. E. Patriarca, C. M. Mari, G. A. Pagani, U. Posset, L. Beverina, Adv. Funct. Mater, 2016, 26, 5240

[4] L. Zhu, W. L. Ong, X. Lu, K. Zeng, H. J. Fan, G. W. Ho, Small, 2017, 13, 1700084

[5] G. Cai, P. Darmawan, M. Cui, J. Wang, J. Chen, S. Magdassi, P. S. Lee, Adv. Energy Mater, 2016, 6, 1501882

NANOSTRUCTURED CARBON FIBERS AS ELECTRODE MATERIALS FOR SUPERCAPACITORS

Bonisiwe C. Seshabela, Bulelwa Ntsendwana, Sabelo D. Mhlanga, Edward N. Nxumalo*

Nanotechnology and Water Sustainability Research Unit, College of Science, Engineering and Technology, University of South Africa, Florida, 1709, Johannesburg, South Africa

**email: nxumaen@unisa.ac.za, Tel: +27 11 670 9498*

Abstract

Renewable energy has attracted considerable attention as an alternative to fossil fuels and nuclear energy. Our planet naturally replenishes energy from renewable resources such as sunlight, rain, wind, tides, geothermal heat and waves. The use of renewable energy can therefore be considered sustainable and safe as it produces little or no waste products; thus, it has a low environmental footprint. However, renewable energy is intermittent and therefore there is a growing need for enhanced energy storage devices such as supercapacitors that will allow this energy to be stored efficiently for use at a time when it is not available. Carbon-based materials are increasingly becoming popular as electrode materials for supercapacitors. These include among others polymeric and activated carbons to more exotic “nanoshaped” carbons such as nanohorns, nanofoams and nanofibers. In this work, we explore the use of heterostructured carbons referred to as N-doped electrospun carbon nanofibers (N-CNFs) as electrode materials for hybrid supercapacitors. These doped nanostructured carbons impart high specific surface area and porosity and excellent electrical conductivity and also allow for efficient surface modification. Nitrogen functionalization and/or substitutional doping of CNFs transforms the electron acceptor/donor properties of CNFs, inducing surface polarity which improves the surface wettability of the material within the electrolyte solution. In addition, the incorporation of nanostructured MnO_2 into doped and porous CNFs will help produce high surface area, large pore volume and long fiber lengths which allow for easy access to electrolyte ions decreasing the diffusion pathways and increasing electron transport in the process. The study will also investigate the electrochemical performance of the electrospun carbon/metal oxide nanohybrids including energy and power density and specific capacitance over a number of cycles.

Key words: Carbon nanofibers, nitrogen doping, metal oxide nanoparticles, hybrid capacitor, renewable energy.

BIO-WASTE-DERIVED NANOFIBERS FORMED BY SOLUTION BLOWING AND ELECTROSPINNING AND THEIR APPLICATIONS AS BIOMEDICAL MATERIALS AND ADSORBENTS FOR HEAVY METALS REMOVAL FROM POLLUTED WATER (Invited)

A.L. Yarin

[1] *Department of Industrial and Mechanical Engineering, University of Illinois at Chicago, 842 W. Taylor St., Chicago IL 60607-7022, USA*

Solution blowing of such plant-derived biomaterials as soy protein, zein, lignin, oats, sodium alginate and cellulose acetate, and such animal-derived biomaterials as silk protein (sericin), chitosan and bovine serum albumin, was demonstrated as a versatile, robust and industrially scalable approach to form monolithic and core-shell nanofibers from bio-waste. Mechanical properties of such nanofiber mats were investigated. The collected nanofiber mats were also bonded both chemically (using aldehydes and ionic cross-linkers) and physically (by means of wet and thermal treatment) to increase the tensile strength to widen the range of applications of such green nonwovens. Fluorescent dye Rhodamine B was used as a model hydrophilic drug in controlled release experiments after it had been encapsulated in solution-blown soy protein-containing hydrophilic nanofibers and the release kinetics associated with dye desorption was studied in detail. Electrospinning of bio-polymers was used to form membranes for protection of pruned vines from Esca fungi. Also, the antibacterial activity of solution-blown soy protein nanofiber mats decorated with silver nanoparticles was studied. Nanofiber membranes containing such biopolymers as lignin, oats, soy protein, sodium alginate and chitosan were used for heavy metals adsorption from aqueous solutions in equilibrium in the batch experiments, as well as under the throughflow conditions. The results revealed attractive capabilities of these inexpensive nano-textured biopolymer adsorbents formed from waste materials using the process scalable to the industrial level. The results also elucidated the physico-chemical mechanisms of heavy metal adsorption on biopolymers.

POLYMER NANOFIBERS: DESIGN, FUNCTION AND APPLICATION (Invited)

Z.R. Tshentu

Chemistry Department, Nelson Mandela University, PO Box 77000, Port Elizabeth 6031.

e-mail: zenixole.tshentu@mandela.ac.za

The work focuses on the design of selective reagents and catalysts towards metal ions and organic compounds, respectively, in the quest for developing reagents for recovery of precious metals and for developing strategies for removal of contaminants in fuel. These regents and catalysts are hosted on solid supports to create functional materials including nanofibers. The functional chemistries are developed using computer modelling as well as experimental approaches before it is hosted on materials for a specific function. This presentation will illustrate some fundamental chemistry of design of such reagents and catalysts as well as demonstrate the application of the functional materials. Several applications will be presented such as metal ions separation, conversion of fuel components using catalytic fibers as well as removal of fuel contaminants using molecularly imprinted polymer nanofibers. The approaches for the assembly of recognition sites on polymers include covalent, semi-covalent and non-covalent interactions (Figure 1). Additional applications such as development of colorimetric probes hosted on nanofibers, for metals and biomarkers, will be discussed albeit briefly.

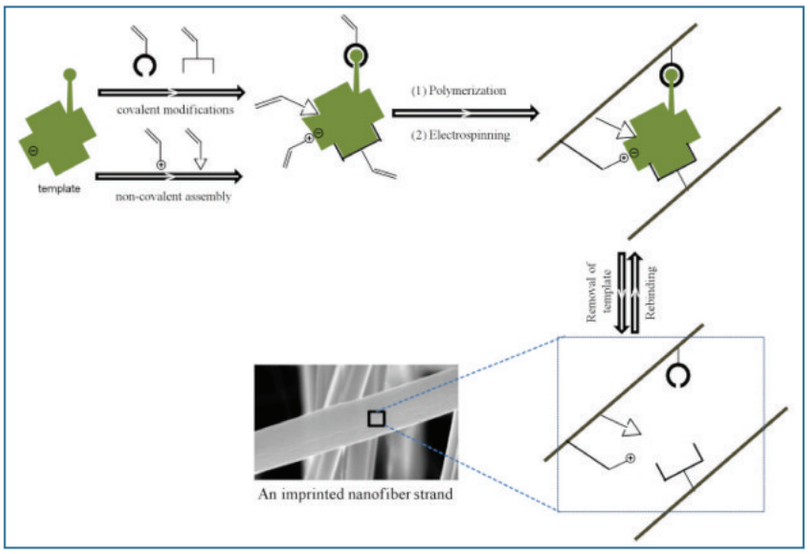


Figure 1. A schematic representation of the molecular imprinting process through the formation of reversible interactions between the template and polymerizable functionalities.

CURRENT STATUS IN COMPOSITE LAMINATES ENHANCED BY ELECTROSPUN NANOFIBRES

Karen De Clerck[1], Lode Daelemans[1]

[1] Department of Materials, Textiles and Chemical Engineering (MATCH), Ghent University, BELGIUM

Abstract

Fibre reinforced polymer composites are the material of choice for designing applications which require a high strength and stiffness at minimal weight such as aerospace structures, wind turbines or ultralight vehicles. However, delamination between the reinforcing plies remains a major problem as it limits further breakthrough of these materials. Recently, interleaving electrospun nanofibres between the reinforcing plies has proven to be a viable interlaminar toughening method which can significantly limit the occurrence of delamination failure in composite materials [1,2]. The interleaved composites can be thought to have three different levels at which the nanofibres affect the properties (Fig 1.). These levels coincide with the hierarchical nature of the laminate itself: (i) the nanotoughened epoxy resin, (ii) the nanotoughened interlayer and (iii) the nanotoughened laminate. The effect of the nanofibres was analysed on each level separately. This multilevel analysis led to a significant advancement of the understanding of these materials in a more structured and general sense, a step that is crucial to be able to design better damage resistant composite structures. Nanofibre interleaved composites with excellent delamination resistance were designed, while obtaining a lot more fundamental knowledge about the prerequisites for effective nanofibre toughening. The improvements were in-line with and often even better than those obtained with traditional toughening methods.

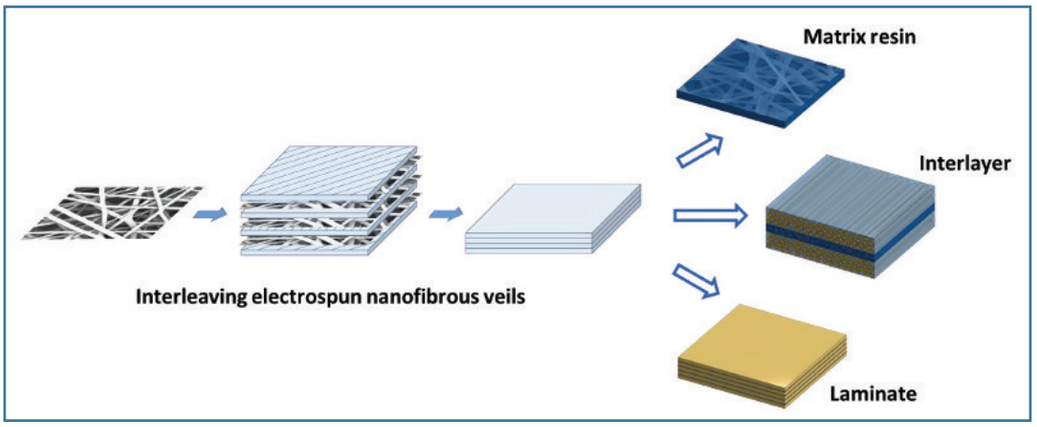


Fig 1. Illustration of the interleaving technique and the multilevel nature of nanofibre interleaved composite laminates.

[1] L. Daelemans, K. De Clerck et al., ACS Appl. Mater. Interfaces 8 (18), 11806-11818 (2016).

[2] L. Daelemans, K. De Clerck et al., Compos. Sci. Technol. 117, 244-256 (2015)

ECOFRIENDLY NANOFIBER MATERIAL AND ITS MASK AGAINST PM 2.5 BASED ON ELECTROSPINNING AND SPECIAL STRUCTURE DESIGN

ASHRAFUL ISLAM[1]*, YANBO LIU[2]

[1] School of Chemistry and Chemical Engineering, Wuhan Textile University, Wuhan, China

[2] School of Textile Science and Engineering, Wuhan Textile University, Wuhan, 430200, China

**Corresponding author: ashrafulislam73@mails.ucas.ac.cn*

Abstract

This aim of this work was to fabricate an efficient nanofiber based face mask in an ecofriendly way, which able to function well against particulate matter (PM) 2.5. Poly Vinyl Alcohol (PVA-DH: 98% ~ 99%) used as the prime polymer for electrospun nanofiber mat preparation. PAA (MW= 50000) added along with PVA (PVA: PAA, 60:40) to improve the physicochemical property by inducing crosslinkages among the polymer chains of nanofiber mat. Orthogonal experiment design was performed to get the optimal condition for electrospinning. Nanofibers

prepared in optimal condition were treated at different temperature to increasing the crystallinity of PVA and to impart thermal crosslinking. Samples were examined and evaluated for their surface morphology, fiber diameter, fiber structure, water insolubility through SEM, FTIR, contact angle and water insolubility tests. We have found 100% water insolubility with the contact angle of θ = 90.07° (which implies very less hydrophilic property). The average fiber diameter we found is 476nm. Prepared nanofiber mat is still somehow water absorbent, but it is not water soluble. So, it is very much possible to use as PM 2.5 protective mask, even at highly humid weather/ environment. The best filtration efficiency and pressure drop was found 48 Pa by single layer structure. Variations in fiber diameters in the same nanofiber mat creates well spacing at the point of interlacement or connecting point. That's why it succeed to achieve a very high filtration efficiency against PM 2.5 with relatively low pressure drop. The existence of thermal crosslinkages has been observed through FTIR analysis and it has been found that -OH group of PVA and -COOH group of PAA linked with thermal crosslinking by ester (-C=O-O-R) formation at elevated temperatures. Water was the only solvent used to prepare the polymer solution of PVA and PAA and there is no use of other chemicals in the electrospinning technique. All of these things made this work totally ecofriendly to nature and for the potential application as face mask/respirator by human beings. Nonwoven fabrics have been used for strengthen the nanofiber mat structure as base materials as well as make it more efficient against PM2.5 with low pressure drop.

OPTIMIZATION OF RHEOLOGICAL SOLUTION PROPERTIES FOR THE DEVELOPMENT OF WET DIRECT-WRITING ELECTROSPINNING FOR TISSUE ENGINEERING PURPOSE

Laura Bourdon, Laura Courty, René Fulchiron, Arnaud Brioude, Vincent Salles

Nowadays a great attention is payed to regenerative medicine and tissue engineering. This discipline is based on the use of a bioactive 3D biomaterial for helping cells to grow and organize themselves in space like it is the case in organs [1]. A logical trend is to develop porous biodegradable materials with a high surface reactivity with the biological environment. Shaping of the materials by electrospinning (ES) allows fabricating non-woven filament structures which interact well with the biological environment but the no-control of pore size renders difficult the optimization of cell invasion through the material [2]. Since a decade ago, printing technologies based on an ES process have attracted significant interest for tissue engineering applications due to their micro- or nano-scale resolution. The team of Paul Dalton has recently highlighted the possibility to produce very fine and resolute structure from direct-writing ES of melted poly(ε-caprolactone) [3].

In this study, we used a wet direct-writing technique with which it is possible to produce structures from a polymer solution containing bioactive molecules. In order to improve the precision of this solvent-based technology and take advantage of its benefits, we investigated the electrospun jet stability according to different parameters. Rheological properties of polymer solution turn out to have a strong effect on jet stability. In the present work, the jet stability of different solutions of Polyethylene oxide (PEO) in water was tested in conventional electrospinning with fixed conditions. The rheological properties of solutions differed either by the PEO concentration or by the molar mass of the PEO (from $2x10^5$ to $5x10^6$ $g.mol^{-1}$). They were classified according to their spinnability and the length of the rectilinear trajectory of the jet before it starts to bend. Concurrently, the rheological behaviors of the solutions were characterized in steady mode or, when possible, in dynamic mode. The results were first analyzed in terms of specific viscosity η_{sp} versus the product of concentration and intrinsic viscosity $c[\eta]$. The transition between semi-dilute particle solution and semi-dilute network solution is clearly obtained and can be correlated with the change in jet behavior from spray to filament. Furthermore, for a given product $c[\eta]$, the polymer of highest molar mass leads to a better stability of the filament. This could be linked to the mean relaxation time of the solution.

[1] K. C. Rustad et al., "Strategies for organ level tissue engineering," Organogenesis, vol. 6, no. 3, pp. 151–157, 2010.

[2] S. Agarwal, J. H. Wendorff, and A. Greiner, "Use of electrospinning technique for biomedical applications," Polymer, vol. 49, no. 26, pp. 5603–5621, 2008.

[3] G. Hochleitner et al., "Additive manufacturing of scaffolds with sub-micron filaments via melt electrospinning writing.," Biofabrication, vol. 7, no. 3, p. 35002, 2015.

REMOVAL OF RARE EARTH METAL IONS BY FUNCTIONALISED ELECTROSPUN POLYSTYRENE NANOFIBERS FROM AQUEOUS SOLUTION

Omoniyi K., Pereao[1]*, Chris, Bode-Aluko[1], Katri, Laatikainen[2] and Leslie F., Petrik[1]

[1] Environmental and Nanoscience Research Group, University of the Western Cape, P.M.B. X17, Bellville 7535, South Africa.

[2] Lappeenranta University of Technology, Laboratory of Separation Technology, P.O. Box 20, 53851 Lappeenranta, Finland.

Rare earth elements (REEs) are important in the transition to a green, low-carbon economy. Increased environmental exposure and water pollution from numerous REEs commercial products and rare earth metal mines has led to harmful effects upon humans [1]. Electrospinning has gained much consideration due to its versatility in spinning a wide variety of polymeric fibres [2]. Electrospun polystyrene (PS) was modified with diglycolic anhydride (DGA) and its application for the adsorption of Ce^{3+} and Nd^{3+} from aqueous solution in a batch mode was studied under optimum adsorption conditions; Ce^{3+} and Nd^{3+} concentration- 100 mg/l, pH-3.5, adsorbent dosage-75 mg/10 mL at room temperature. The kinetic data were analysed by pseudo-first-order and pseudo-second-order kinetic models. The Freundlich and Langmuir isotherm models were used to describe the equilibrium data.

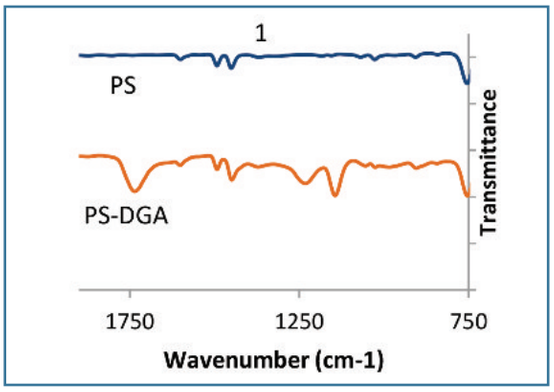


Figure 1: FTIR spectra of PS and modified PS-DGA nanofibre adsorbent

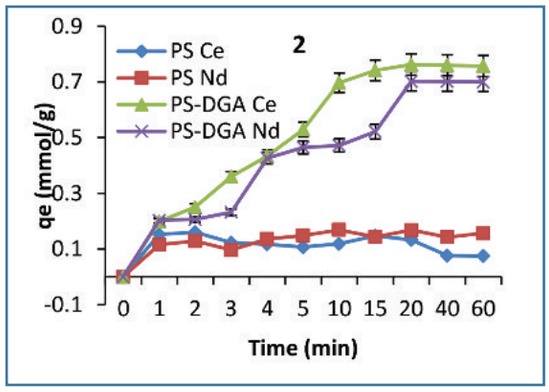


Figure 2: Effect of contact time on the removal efficiency of Ce^{3+} and Nd^{3+} using Pristine PS and PS-DGA-3-3 nanofibre

FTIR spectra (Figure 1) of the PS nanofiber and modified nanofibre adsorbent (PS-DGAA) revealed that the PS-DGA presented peaks for C=O ($_{\nu}$C=O , 1732,), peaks of (--C=O of-- COOH), at 1223 and 1140 cm^{-1} which were assigned to carboxylate groups from functional groups expected from DGA. More than 90% of the total concentration of Ce^{3+} and Nd^{3+} metal ions were removed within 20 mins (Figure 2). The amount adsorbed reached 0.762 mmol/g Ce^{3+} (which was 90.5 %) and 0.702 mmol/g Nd^{3+} (which was about 91.4 %) of the available metal ion concentration present in the solution. The results showed that the PS-DGA nanofibre adsorbent possessed extra high extraction capability within a relatively short time for the removal of rare earth metal ions. The adsorption equilibrium data for the metal solutions fitted the Langmuir model well.

References

1. Guo, Y.; Zhang, S.; Lai, L.; Wang, G. Journal of Food Composition and Analysis 2015, 44, 122.

2. Reneker, D. H.; Yarin, A. L.; Fong, H.; Koombhongse, S. J. Appl. Phys. 2000, 87, 4531.

ELECTROSPINNING AS PART OF ADDITIVE MANUFACTURING (Invited)

Geoffrey Mitchell

Polytechnic Institute Leiria, Portugal

ELECTROSPINNING ACTIVITIES AT THE DST/MINTEK NANOTECHNOLOGY INNOVATION CENTRE (Invited)

Phillemon Matabola

Email: PhilemonM@mintek.co.za

The Water Nanotechnology Unit (WNU) at the DST/Mintek/Nanotechnology Innovation Centre has been involved with research and development (R & D) of the nano-based materials for water and wastewater treatment for the past six years. Electrospun nanofibers are one such nanomaterials currently being explored in the group. This is as a result of their higher porosities and interconnected pore structure that offer higher permeability to water filtration over conventional materials being used. The latter materials are fabricated by a simple, rapid, and inexpensive method technique called electrospinning.

This talk will cover recent work activities in the group on the development of polymer nanofibers, polymer blends and the composite nanofibrous membranes' fabrication and characterization. Moreover, information on the fundamental understanding of the influence of the electrospinning parameters, additives and properties of the nanostructured fibrous materials is also provided in this presentation.

NEW COMBINATION OF TECHNOLOGY: CONDUCTIVE ELECTROSPUN NANOFIBERS AND 3D PRINTED PACKAGING MATERIAL FOR FREEFORM FLEXIBLE LI-AIR BATTERIES

Ji-Won Jung,[a] Ki Ro Yoon,[a] Tae Gwang Yun,[a] Chanhoon Kim,[a] Su-Ho Cho,[a] Jun-Young Cheong,[a] Seok Won Song[a] and Il-Doo Kim*[a]

[a] *Department of Materials Science and Engineering, Korea Advanced Institute of Science and Technology, 291 Daehak-ro, Yuseong-gu, Daejeon, 34141, Republic of Korea*

There have been urgent needs for flexible power sources for diversely shaped-flexible devices. Lithium (Li)-air battery, which has higher energy density compared to state-of-the-art Li-ion battery, can be one of promising energy storage system with flexible electrode and packaging materials. However, two key issues limit practical implementation of flexible Li-air batteries for customizing next-generation electronic devices; (i) short-cycle life of the battery with low round-trip efficiency: this is mainly attributed to carbon-based cathode part in the battery cell (e.g., formation of Li_2CO_3 stemming from interface between discharge product (Li_2O_2) and carbon). (ii) flexible packaging materials made in a tailorable manner: to adjust the packaging material to match size and shape of flexible devices, "freeform fabrication system" is needed.

Herein, we fabricated free-standing Al-coated polyimide nanofiber membrane (PI@Al NF) as carbon-free air cathode and flexible polyurethane film using electrospinning technique and 3D printing technology, respectively, for freeform flexible Li-O_2 batteries. Firstly, self-standing PI NF was synthesized via electrospinning of PAA solution (pyromellitic dianhydride (PMDA) and 4,4'-oxydianiline (ODA) in N,N-dimethylformaide (DMF)) followed by heat treatment. Then, through our unique chemical solution-based Al coating technique, Al overlayers were conformally coated on entire surfaces of the PI NFs; thickness of Al coating layer was precisely optimized in terms of electronic conductivity, flexibility and pore blockage in controllable manner. Besides preparation of conductive electrode, flexible packaging material was also fabricated via 3D printer ("Prusa i3"). We used 3D modeling software to enable production of complex and functional shapes using flexible polyurethane. When a file is uploaded in the 3D printer, the object we want to make is ready to be 3D printed layer by layer. The freeform flexible Li-air batteries created by new combination of electrospinning and 3D printing technology were tested and investigated through electrochemical evaluation and ex-situ SEM, XRD, TEM and XPS analyses. Flexible circle, triangular and star-shaped Li-O_2 battery cells with the PI@Al NFs was successfully fabricated and applied as prototypes for flexible electronics. It is demonstrated that this strategy of integrated technology ("electrospinning-3D printing") for creating conductive nanopaper and packaging material will give an applicable solution for advanced Li-O_2 batteries.

REMOVAL OF NICKEL(II) BY 2-(2'-PYRIDYL)IMIDAZOLE FUNCTIONALIZED POLYACRYLONITRILE NANOFIBER

Katri Laatikainen[a]*, Guillaume Ndayambaje[b], Markku Laatikainen[c], Edith Beukes[b], Olanrewaju Fatoba[b], Nico van der Walt[d], Leslie Petrik[b], Tuomo Sainio[c]

[a] *Lappeenranta University of Technology, Laboratory of Chemical Metrology, P.O. Box 20, FI-53851 Lappeenranta, Finland*

[b] *University of the Western Cape, Department of Chemistry, Private Bag. X17, 7535 Bellville, South Africa*

[c] *Lappeenranta University of Technology, Laboratory of Separation Technology, P.O. Box 20, FI-53851 Lappeenranta, Finland*

[d] *Cape Peninsula University of Technology, Department of Chemistry, P.O. Box 1906. Bellville, South Africa*

During the last decades, there has been increasing interest in fibrous functionalized nanomaterials for the removal of heavy metals from aqueous industrial streams [1-2]. Poly(acrylonitrile) (PAN) is one of the most widely used raw materials for functionalized nanofibers because of its low price and good chemical, thermal and mechanical stability. In applications where selective uptake of a given metal is required, the selectivity of functionalized nanofibers can be enhanced by modification of the surface of the fibers with special chelating ligands. The open structure and very thin functionalized nanofiber fabrics should also attain very fast overall metal binding kinetics. Surprisingly, in some cases the binding kinetics of nanofibers have been found to be similar but mostly higher for granular ion exchange resins and adsorbents.

In this study, the surface of polyacrylonitrile nanofibers (PAN) was chemically modified with 2-(2'-pyridyl) imidazole ligand (pim) to generate PAN-pim nanofibers. Nickel was chosen because it is a carcinogenic but also economically valuable metal which can be recycled from mine water before its disposal. The pim chelating ligand was anchored on the PAN by a nucleophilic reaction of the 2-(2'-pyridyl)imidazolate anion with the nitrile groups. A 36 % conversion of the acrylonitrile repeating units to AN-pim groups was obtained after 60 min at 70°C using 1.0 mol/L pim ligand. The product was characterized by Fourier Transform Infrared (FTIR), Nuclear magnetic Resonance (NMR) and morphological analyses. The adsorption equilibrium and rate of nickel were studied in batch experiments and the data were correlated using the Non-ideal Competitive Adsorption (NICA) isotherm and a pseudo-homogeneous kinetic model. Equilibrium uptake of nickel at pH 3 and pH 5 was 0.3 and 0.7 mol/kg respectively, at a nickel concentration of 0.0025 mol/L. Nickel was shown to be bound predominantly as a 1:1 complex on PAN-pim. The adsorption rate was very high and equilibrium was attained in 1 minute. The uptake rate was only slightly lower than the nickel-pim complex formation rate measured in aqueous solution. 0.1 M EDTA solution was shown to be suitable for desorption of nickel from the loaded PAN-pim even after three adsorption/desorption cycles. Nickel was successfully separated from cobalt using gradient elution with EDTA in a column system.

References

1. R. Zhao, X. Li, B. Sun, M. Shen, X. Tan, Y. Ding, Z. Jiang, C. Wang, Chem. Eng. J. 268 (2015) 290–299.

2. J. Wang, L. Xu, C. Cheng, Y. Meng, A. Li, Chem. Eng. J. 193–194 (2012) 31–38.

ELECTROSPUN NANOFIBROUS MATS MODIFIED WITH CYCLODEXTRIN FOR WATER TREATMENT

Mandla B Chabalala[a], Stijn WH Van Hulle[b], Bheki B Mamba[a], Edward N Nxumalo[a]*

[a] Nanotechnology and Water Sustainability Research Unit, College of Science, Engineering and Technology, University of South Africa, Johannesburg, Florida, 1709

[b] Laboratory of Industrial Water and Ecotechnology, Department of Industrial Biological Sciences, Faculty of Bioscience Engineering, Ghent University, Ghent, Belgium

**Corresponding author: nxumaen@unisa.ac.za, Tel.: +27 11 670 9498*

Abstract

One of the greatest concerns today is the presence of emerging micro-pollutants (EMPs) in both waste and treated water. EMPs include hormones, phenols, detergents, pharmaceuticals, illicit drugs, personal care products and endocrine disruptors. EMPs are present in small amounts, biologically active, persistent and thermally and chemically stable. Nanomaterials such as nanofibers have properties such as high porosity, diameter of nanometre to few micrometres and high surface area per unit volume. Other advantages include easy handling, good reusability and recyclability. Electrospun nanofibrous mats also form good support material for nanoparticles such as photocatalytic nanomaterials like ZnO nanoparticles. Cyclodextrins (CDs) form good inclusion complexes with a wide range of EMPs. Electrospinning is a versatile, flexible and facile method for the production of uniform nanofibers. This work discusses the synthesis of a multi-functional system for wastewater treatment based on the combination of the properties of PES/CD nanofibrous mats and ZnO nanomaterials. The multi-functional system is then used for the adsorption, photodegradation and inclusion complexation of EMPs such as propranolol, pentachlorophenol, alachlor, humic acid and bisphenol-A. Nanofibrous mats were prepared by electrospinning while the photocatalyst was prepared using modified sol-gel methods. ZnO nanoparticles were then loaded onto the PES/CD nanofibrous mats in situ and ex situ. The performance of these materials was tested in the presence and the absence of light. Recovery, recyclability, reusability and leaching studies that were conducted over a number of cycles will also be discussed.

Key words: Cyclodextrin, Electrospun-nanofibers, EMPs, Photocatalysis, Polyether sulfone.

CHITOSAN AND CHITIN BASED-NANOFIBER BIOSORBENTS FOR EFFICIENT REMOVAL OF ZINC FROM WASTEWATER

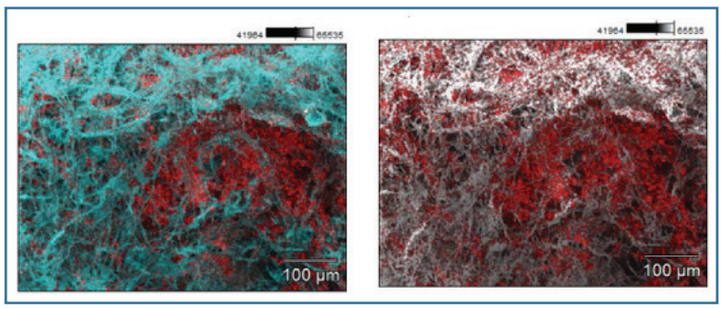
Alicia Botes [a,b], Albert Johannes Van Reenen[a], Marietjie Lutz[a], Sinha Ray Suprakas[b]

[a] *Department of Polymer Science, Stellenbosch University, Stellenbosch, 7599,Cape Town, South Africa*

[b] *National Centre for Nano-structured Materials, Council for Scientific and Industrial Research, Meiring Naude Road, Pretoria, 0001, Gauteng, South Africa*

Abstract

Heavy metal contamination causes damage to the environment and poses health risks to humans. The aim of this project is to investigate the adsorption capacity of chitin derivatives such as chitosan and chitin nanowhiskers (chnw), with biodegradable characteristics. The investigation focuses using biopolymers created in our lab and comparing it to existing biosorbents such as pristine chitosan and also testing the behavior of these biopolymers under varying conditions. Electrospinning was used to synthesize chnw/EVOH and CTS nanofibers. The adsorption capacity for these biosorbents were then tested for Zinc metal cations adsorption using isotherm models from inductively couple plasma (ICP) analysis and EDX-SEM. The preparation and synthesis of the nanofibers and the nanowhiskers were characterized using transmission (TEM), scanning (SEM) and confocal microscopies as well as X-ray diffraction (XRD). The CTS nanofibers synthesized in our lab showed an improved morphology and more uniform surface area compared to the pristine CTS. The pH influenced the adsorption capacity significantly for the biosorbents. There were important physiochemical differences between CTS nanofibers and chnw/EVOH nanofibers that affected the behaviour of these biosorbents at higher and lower pH. The general trend showed that qe increased for higher heavy metal ion concentration. Chitosan nanofibers showed good adsorption at pH 5 and chnw/EVOH nanofibers showed good stability in all the conditions even though the adsorption capacity did not match the other biosorbents. CTS powder shows poor retention after 30 min and CTS nanofiber had an adsorption capacity of 4.45 mg/g for Zn after 60 min at pH 5.



Zn metal ion (red) adsorbed to chitin nanowhisker/polyethylene vinyl alcohol nanofibers (cyan or white)

References:

1. Hegazi, H. A. Removal of heavy metals from wastewater using agricultural and industrial wastes as adsorbents. HBRC J. 9, 276–282 (2013).

2. Mincea, M., Negrulescu, A. & Ostafe, V. Preparation , Modification , and Applications of Chitin Nanowhiskers : a Review. 30, 225–242 (2012).

3. Marianti, A., Anatiasara, D. & Ashar, F. F. Chitosan as Chelating and Protective Agents from Lead Intoxication in Rat. Biosaintifika J. Biol. Biol. Educ. 9, 126 (2017).

4. Fan, L., Luo, C., Lv, Z., Lu, F. & Qiu, H. Preparation of magnetic modified chitosan and adsorption of Zn2+ from aqueous solutions. Colloids Surfaces B Biointerfaces 88, 574–581 (2011).

ELECTROSPUN CARDIOVASCULAR DEVICES: SCAFFOLDS FOR BLOOD VESSEL AND HEART VALVE PROSTHESES (Invited)

Deon Bezuidenhout

Strait Access Technologies, South Africa

ELECTROSPUN 3D POROUS NANOFIBER SCAFFOLDS FOR TISSUE ENGINEERING (Invited)

Xiumei Mo

*College of Chemistry, Chemical Engineering and Biotechnology, Donghua University, Shanghai, 201620, People's Republic of China. *Corresponding E-mail address: xmm@dhu.edu.cn*

Electrospinning fabrication technique most commonly produces relatively 2D mats and the construction 3D structure nanofibers with higher porosity is still a major challenge. In this study, two methods were used to fabricate the 3D nanofiber scaffolds.

A dynamic electrospinning method were developed to fabricate the nanoyarn scaffold, by this way electrospun poly(L-lactide-co-ε-caprolactone)/collagen (P(LLA-CL)/Col) nanofibers were deposited and twisted into yarns in a water vortex before collecting on a rotating mandrel to form a nanoyarn scaffold. The nanoyarn scaffold contained 3D aligned microstructures with larger interconnected pores and higher porosity comparing with nanofiber scaffold. The biomimetic nanoyarn has a positive influence on cell proliferation and morphology. Cells cultured on the nanoyarn scaffolds showed significantly higher proliferation rates than that on traditional electrospun nanofiber scaffolds. After implanting the nanoyarn scaffold seeded with tendon derived stem cells into the nude mice, the fluorescence imaging indicated that the tendon derived stem cells had long-term survival, and the macroscopic evaluation, histology and immunohistochemistry examinations showed high-quality neo-tendon formation under mechanical stimulation in vivo.

Gelatin/PLA nanofiberous scaffold was fabricated by using combined electrospinning and freeze-drying. Gelatin/PLA nanofibers membranes were prepared by electrospinning; secondly, nanofibers membranes were cut into small pieces and were dispersed in tert-butanol by homogenizer; thirdly, the dispersions were frozen and freeze dried. Finally the scaffold was crosslinked by heating at 190^{O}C or grafting HA on the nanofibers surface of scaffold by EDC/NHS. Thus obtained 3D nanofiber scaffold could promote cells growth and proliferation. In order to evaluate the repair capacity of 3D scaffold in vivo, an articular cartilage defect was created on rabbits and scaffolds were implanted into the defect. The in vivo study indicated that the cartilage repair capacity of scaffold without HA was limited, but scaffold modified with HA could enhance the repair of cartilage.

Keywords: Tissue regeneration; Electrospinning; Nanofiber sponges; Nanoyarn

References

[1]. Chen WM, et al, ACS Applied Materials &Interfaces, 2016, 8, 24415-24425.

[2]. Wu JL, et al, Journal of Biomedical Nanotechnology, 2014, 10(4), 603-614

NOVEL POLY(ε-CAPROLACTONE)/GELATIN WOUND DRESSINGS PREPARED BY EMULSION ELECTROSPINNING WITH CONTROLLED RELEASE CAPACITY OF KETOPROFEN ANTI-INFLAMMATORY DRUG

A.O. Basar[1], S. Torres-Giner[2], S. Castro[3], Turkoglu Sasmazel[1] and J.M. Lagaron[2]

[1] Atilim University, Incek, Golbasi, Ankara, Turkey

[2] Novel Materials and Nanotechnology Group, CSIC, Paterna (Valencia), Spain

[3] FluidnatekTM Applications Department, Bioinicia S.L., Paterna (Valencia), Spain

e-mail: lagaron@iata.csic.es

Abstract

In the present work, a single and double phase Ketoprofen-loaded mats of ultrathin fibers were developed by electrospinning and their physical properties and drug release capacity were analyzed. The single phase

material was prepared by solution electrospinning of poly(-caprolactone) (PCL) with Ketoprofen at a weight ratio of 5wt%. This Ketoprofen-containing PCL solution was also used as the oil phase in an emulsion with gelatin. The resultant stable oil-in-water (O/W) emulsion of PCL-in-gelatin, also containing Ketoprofen at 5 wt%, was electrospun to produce the double phase mat. Cross-linking was performed by means of glutaraldehyde vapor to prevent dissolution of the hydrophilic gelatin phase. The performed characterization indicated that Ketoprofen was successfully embedded in both electrospun mats, i.e. PCL and PCL/gelatin, and both mats showed high hydrophobicity. *In vitro* release studies interestingly revealed that, in comparison to the single phase PCL electrospun mat, the double phase PCL/gelatin mat significantly hindered Ketoprofen burst release and exhibited a sustained release capacity of the drug for up to 4 days. In addition, the electrospun Ketoprofen-loaded mats showed enhanced attachment and proliferation of L929 mouse fibroblast cells, presenting the double phase mat the highest cell growth yield due to its improved porosity. The here-developed electrospun materials clearly show a great deal of potential as novel wound dressings with an outstanding controlled capacity to release drugs.

References

Basar et al., Materials Science and Engineering: C, 2017

https://doi.org/10.1016/j.msec.2017.08.025

BEAD-ON-STRING ELECTROSPUN NANOCOMPOSITE FIBROUS SYSTEM FOR TISSUE ENGINEERING

Chiara Rinoldi[1], Ewa Kijeńska[1], Adrian Chlanda[1], Emilia Choinska[1], Wojciech Swieszkowski[1]

[1] Warsaw University of Technology, Faculty of Material Science and Engineering. Warsaw 02-507, Poland

Abstract

Tissue Engineering holds great potential in the production of functional substitutes to restore, maintain or improve the functionality in defective or lost tissues. Up to date, a great variety of techniques and approaches for fabrication of scaffolds have been developed and evaluated, allowing researchers to tailor precisely the morphological, chemical and mechanical features of the final constructs. In this frame, electrospinning of biocompatible and biodegradable polymers is considered the first-choice method to produce homogeneous nanofibrous structures, which might reproduce the nano-sized organization of native extracellular matrix. Moreover, due to their large specific surface area and high porosity, electrospun scaffolds can provide a suitable micro-environment for cells attachment, proliferation, migration and differentiation, promoting an efficient tissue regeneration [1]. Lately, composite materials obtained by incorporating nanoparticles within electrospun fibers have been explored in order to enhance the properties and the functionalities of the pristine polymeric constructs [2]. The presented study is focused on the design and fabrication of biocompatible electrospun nano-composite fibrous scaffolds for tissue regeneration. The main aim was to accomplish a specific topography on the scaffolds which allows the maximum exposure of the ceramic particles to better profit their beneficial characteristics. To achieve this goal, silica nanoparticles having considerable bigger dimension than fiber diameters were selected and embedded into the nanofibers to create a bead-on-string like system. The nanostructures morphology was investigated by SEM imaging, the physico-chemical characterization was carried out by contact angle measurements, TGA and ATR-FTIR analysis, and the mechanical properties were evaluated by mechanical tensile test.

Dispersion of relatively big silica particles was proven to enhance the hydrophilicity, degradability and biocompatibility of the polymeric constructs. *In vitro* studies using L929 fibroblasts demonstrated that the presence of 20 wt% of silica nanoparticles in polycaprolactone-based scaffolds enhanced cell attachment, proliferation and spreading.

The results reveal that the electrospun nano-composite beaded fibrous system might represent an interesting alternative for tissue engineering applications.

Acknowledgment

The study was funded by the National Centre for Research and Development in the frame of START project (STRATEGMED1/233224/10/NCBR/2014).

[1] N. Bhardwaj, S.C. Kundu, Electrospinning: A fascinating fiber fabrication technique, Biotechnol. Adv. 28 (2010) 325–347. doi:10.1016/j.biotechadv.2010.01.004.

[2] Y. Wang, Q. Zhao, N. Han, L. Bai, J. Li, J. Liu, E. Che, L. Hu, Q. Zhang, T. Jiang, S. Wang, Mesoporous silica nanoparticles in drug delivery and biomedical applications, Nanomedicine Nanotechnology, Biol. Med. 11 (2015) 313–327. doi:10.1016/j.nano.2014.09.014.

IMPROVED HEALING OF ELECTROSPUN TISSUE ENGINEERING SCAFFOLDS BY INCREASED POROSITY AND DRUG DELIVERY

Wian van den Bergh[a,b], Anel Oosthuysen[a], Thomas Franz[b], Peter Zilla[a], Deon Bezuidenhout[a]

[a] *Cardiovascular Research Unit, Chris Barnard Division of Cardiothoracic Surgery, University of Cape Town, South Africa*

[b] *Division of Biomedical Engineering, Human Biology, University of Cape Town, South Africa*

The desired healing response to electrospun scaffolds in tissue engineering is often limited by poor ingrowth due to insufficient porosity, thrombogenicity, lack of vascularisation and/or excessive inflammation [1]. This study aimed at increasing structural porosity and incorporating/delivering anti-thrombotic/angiogenic (heparin) and anti-inflammatory (dexamethasone) agents.

Porosity enhancement techniques were explored using two different approaches i) electrospinning polyurethane (PU) with concomitant electrospraying of soluble microparticles, which were subsequently removed to increase scaffold interconnectivity and ii) electrospinning polyesterurethane (PEU) at low collecting temperatures. Dexamethasone was incorporated by simple admixture, however, heparin required chemical modification to achieve solution solubility [2]. Release rates were determined *in vitro*, followed by thrombogenicity (thromboelastography) and cytotoxicity (cell viability) assessments of modified/unmodified heparin prior to incorporation and after elution. Finally, in vivo responses were evaluated in a subcutaneous model (24 rats) for up to 12 weeks.

Porosity was enhanced ($P<0.001$) for both PU (79 to 90%) and PEU (50 to 83%) scaffolds. Incorporated drugs showed a burst release (dexamethasone 36%, heparin 47%, 7days) followed by a sustained delivery (78%, 48%, 90days). Heparin, post modification, retained its anti-thrombotic properties and showed no difference in cytotoxicity ($P>0.1$). At 12weeks of implantation, high porosity PU scaffolds allowed for full tissue ingrowth (>98%) while conventional scaffolds were limited (<42%). The localised delivery of heparin resulted in additional blood vessel formation ($P<0.01$), while dexamethasone did not significantly suppress scaffold inflammation ($P>0.3$).

High porosity scaffolds produced by combined electrospinning/spraying have the potential to enhance healing. Dexamethasone or heparin can be incorporated and eluted from degradable electrospun scaffolds. Moreover, localised delivery of heparin improves implant vascularisation. This study may contribute towards tissue engineered vascular graft development where anti-thrombogenicity and increased vascularisation are desired.

Acknowledgement:

Helen Ilsley for histological preparations and our sponsors: National Research Foundation (NRF), Medical Research Council (MRC IUCHRU) of South Africa and Ab Medica (Italy).

References:

[1] Voorneveld J, Oosthuysen A, Franz T, Zilla P, Bezuidenhout D (2016) Dual electrospinning with sacrificial fibers for engineered porosity and enhancement of tissue ingrowth. J Biomed Mater Res Part B Appl Biomater:1–14.

[2] Kwon IK, Matsuda T (2005) Co-electrospun nanofiber fabrics of poly(L-lactide-co-epsilon-caprolactone) with type I collagen or heparin. Biomacromolecules 6(4):2096–105.

ELECTROSPUN POLYACRYLAMIDE HYDROGEL NANOFIBERS: FROM NANOCARRIERS TO STIMULI RESPONSIVE NANOMATERIALS

S. Pawlowska, P. Nakielski and F. Pierini

Institute of Fundamental Technological Research, Polish Academy of Sciences, Warsaw, Poland.

Tissue engineering and drug delivery strategies have great potential for medical treatments of several diseases and injuries. Their applicability is limited by the lack of implanted materials adaptability to the specific biological tissue requirements over time. Smart hydrogels appear to be promising materials for the development of a new generation of biomaterials [1]. The present study is based on the idea that smart electrospun polymer hydrogel materials based on polyacrylamide and liquid crystals allow tuning of the material rigidity and drug delivery properties as required. The material changes could be triggered by external stimuli which interact with the incorporated stimuli responsive molecules inducing localized stresses inside the polymer networks. The required hosting materials can be developed using coaxial electrospinning and an appropriate post-electrospinning treatment [2]. Herein, we describe a novel method based on electrospinning for obtaining soft hydrogel nanofibers able to accommodate liquid crystals and release dedicated molecules. Two different types of hydrogels with several polymer/cross-linker ratios were produced and deeply studied. Nanofibers chemical, morphological (Figure 1), structural and mechanical properties as well as their ability to carry and release drugs were characterized.

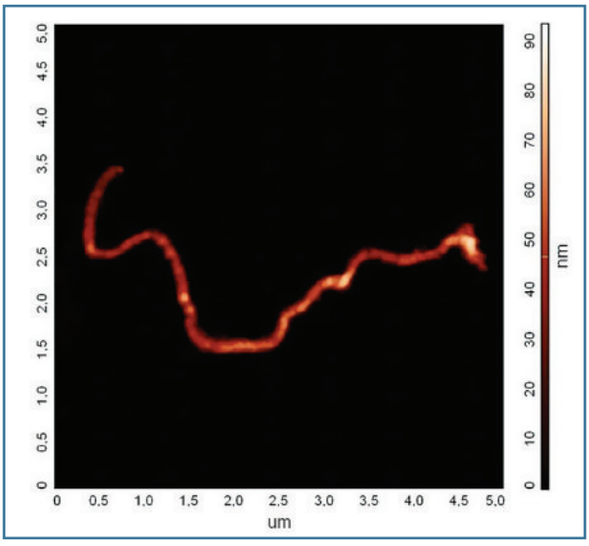


Figure 1: AFM topography of a single electrospun hydrogel nanofilament [2].

Moreover, based on the fact that the developed elongated, soft and flexible nanomaterials can easily travel in crowed environments of body fluids and biological tissues, particular attention was paid to the study of their dynamics and rheology in flow. Nanofilaments were placed in a microchannel and their motion was then analysed studying bending dynamic and migration under the influence of a pulsatile laminar flow, which is designed to simulate body fluid flow. The results highlight the key role of morphology and stiffness on mobility of nanofilaments and their applicability as drug nanocarriers and stimuli-responsive materials.

Project supported by the National Science Centre (NCN) grant no. 2015/19/D/ST8/03196.

References

[1] U. Freudenberg et al., Advanced Materials, 2016, 28, 8816.

[2] P. Nakielski, S. Pawlowska, F. Pierini et al. PLoS One, 2015, 10, 0129816-0129832.

TAILORING ELECTROSPINNING TECHNIQUES FOR REGENERATIVE MEDICINE (Invited)

Marc Simonet

IME Technologies, Netherlands

In the regenerative medicine field, electrospinning has gained widespread interest to produce extracellular matrix (ECM) mimicking scaffolds for tissue engineering. This technique often was and still is the preferred choice due to its capability to produce 3 dimensional fibrous ECM lookalike scaffolds with similar nano- to micrometer length scales using an extensive range of natural and synthetic polymers. The process is highly versatile and tunable, allowing to tailor scaffold properties to fit many demands and various applications. This versatility has led to more than 10 000 scientific publication and nearly 2000 patents on electrospinnning for biomedical engineering, but only handful biomedical products. Controlling all the parameters, which create the base of this method's versatility, has proven to be a challenge holding back the development of medical electrospun products. We will show that thanks to a better understanding and tighter control on process parameters, namely to tackle challenges such as a general lack of reproducibility and a limited heterogeneous cell ingrowth, the number of electrospun products is expected to growth and electrospinning can fulfill its great potential also for the regenerative medicine market.

ADVANCED NANOSTRUCTURED FABRICS FOR LOW BURDEN PROTECTION (Invited)

Yen Bach Truong[1, 6]*, Jacinta Poole[1, 6], Ilias Louis Kyratzis[1, 6], Josh Ince[1, 6], Jurg Schutz[1, 6], Lucy Cotter[1, 6], Yvonne Douglas[1, 6], Shadi Houshyar[2, 6], David Nielsen[3, 6], Liberty Wagner[4, 6], Gareth Beckermann[5, 6] and Deepak Ganga[6]

[1] CSIRO-Manufacturing, Clayton, Victoria, 3168, Australia

[2] School of Fashion & Textiles, RMIT University, Brunswick, Victoria, 3056, Australia

[3] Defence Science and Technology Group, - 506 Lorimer St, Fishermans Bend, Victoria, 3207, Australia

[4] Bruck Textiles Pty Ltd, 1E Marine Parade, Abbotsford, Victoria, 3067 Australia

[5] Revolution Fibres, 9A Corban Ave, Henderson, Auckland 0612, New Zealand

[6] DMTC Ltd, Level 2, 24 Wakefield St. Hawthorn, Victoria 3122, Australia

**Corresponding author's email address: Yen.Truong@csiro.au*

Abstract

The focus of the Advance Nanostructured Fabrics for Low Burden Personal Protection project is the development of a composite fabric for use in a low burden Chemical, Biological and Radiological (CBR) suit which exceeds the protective capability of the current systems. The adsorbent-nanofibre composite technology can be incorporated into a broad range of existing outer face fabrics. The adsorbent-nanofibre composite layer(s) will not interfere with the existing fabric coatings and surface treatments (e.g dyes) while providing protection against gases, vapours and particulate aerosols.

Several scientific development stages must be achieved for the success of the project, including

(i) The development of novel adsorbent-nanofibre membrane materials

(ii) Investigation and selection of a robust path for integrating the adsorbent-nanofibre membrane and

(iii) Testing of novel adsorbent-nanofibre membrane materials and integrated composite fabrics to meet set target performances.

Results and findings from these scientific development stages of the project will be presented.

NANOFIBROUS SCAFFOLDS LOADED WITH NEUROTHROPIN FOR PERIPHERAL NERVE TISSUE ENGINEERING

Ewa Kijeńska,* Wojciech Swieszkowski*

**Materials Design Devision, Faculty of Materials Science and Engineering, Warsaw University of Technology, Poland*

Accidents, injuries caused by sharp objects or versatile surgical interventions often cause hardly curable defects in peripheral nerves, which may lead to their death or loss of their function. Current gold standard of treatment, which is autografting do not guarantee full recovery of the damaged region or return of full functionality of the nerves connection. In presented study scaffolds composed of P(LLA-CL), collagen I and collagen III with different (random and aligned) fiber orientations have been fabricated by electrospinning. Chemical, physical and mechanical properties of the constructs, along with the influence of their composition on the morphology, proliferation and differentiation of C17.2 nerve stem like cells were studied. The connotation of fiber topography towards the differentiation of the cells was also investigated. The results of *in vitro* cell proliferation, cell-scaffold interaction and neurofilament protein expression studies demonstrated that the aligned P(LLACL)/colII/col III nanofibrous scaffolds mimic more closely the extracellular matrix of peripheral nerves and have great potential as a tissue engineering construct for accelerated regeneration of the nerves [1]. Thus in further studies three types scaffolds based on P(LLA-CL), coll I and coll III with aligned orientation of the fibers were fabricated. Evaluation of two concepts of bio-active agents delivering nanofibrous scaffolds has been applied: (i) scaffolds with patterned oriented surface and (ii) scaffolds with ordered surface coupled with bio-active agent (BSA) and growth factor (NGF). P(LLA-CL)/coll I/coll III scaffolds were fabricated by electrospinning, while the P(LLA-CL)/coll I/coll III-NGF/BSA scaffolds were prepared by either electrospinning of the blend of P(LLA-CL) with collagens and NGF/BSA or by encapsulation of NGF/BSA in the core of the fibers via co-axial electrospinning. The chemical, physical and mechanical properties of the scaffolds were further evaluated in this study. At the same time the influence of the NGF and BSA incorporation method on the release profile and NGF dependent PC12 nerve stem like cells response were investigated. It was found that encapsulation of the growth factor within the core of core-shell nanofibers enables its control and stable release. This result in PC 12 behavior – interaction with material, cells were found to differentiate better, expressing bi- and tri-polar elongations retaining their typical phenotype on core-shell P(LLA-CL)/col I/col III-NGF/BSA comparing to other scaffolds. Presented studies indicate that P(LLA-CL)/col I/col III-NGF/BSA scaffolds with aligned orientation of the fibers are promising material and can be applied as substrates for peripheral nerve regeneration.

References

[1]. E. Kijeńska et al. J Biomed Mater Res B Appl Biomater, 100B/4 (2012), 1093-1102.

Acknowledgements:

This work was financed by National Science Center on the basis of a decision number2013/11/B/ST8/03401.

ELECTROSPUN ANTIMICROBIAL WOUND DRESSINGS AS DRUG DELIVERY SYSTEMS- DESIGN AND DEVELOPMENT

L. Preem,[1] G.-M. Lanno,[2] M. Putriņš,[2] T. Tenson[2] and K. Kogermann[1]

[1] *Institute of Pharmacy, University of Tartu, Estonia*

[2] *Institute of Technology, University of Tartu, Estonia*

BACKGROUND: Chronic wound infections are responsible for considerable morbidity and increased healthcare costs. Recently, it has been recognized that biofilm formation is one of the main problems associated with chronic wounds and persistent infections causing delayed healing. The current therapies to treat the bacterial infection in the wound do not have the required efficacy in the presence of wound exudate or biofilm. Therefore, there is a need to find better treatment options for infected wounds. We have started to develop antimicrobial-loaded electrospun fibrous dressings for the local wound care.

AIMS: To design and develop antibacterial drug-loaded electrospun fibrous mats as novel drug delivery systems (DDSs) for the prevention and local treatment of wound infections. Our aim was to understand the effect of differently designed drug-loaded electrospun mats on the drug release and consequently on the antimicrobial and antibiofilm efficacy.

METHODS: Electrospinning (ES) was performed using an ESR200RD robotized ES system. Biodegradable polycaprolactone (PCL) was used as a polymer for fiber formation. Model antimicrobial drug chloramphenicol (CAM, Sigma) was incorporated directly into the fibers by blending and/or into mesoporous silica nanoparticles (MSNs) and then into ES fibers. Different ES set-ups, processing and environmental conditions, solvents and PCL concentrations were tested in order to find the most suitable methods and materials for preparation. ES fiber mats morphology, relevant physicochemical properties (e.g. crystallinity) and thermal behavior was investigated using SEM, fluorescent microscopy, FT-IR, XRD, and DSC. Drug release was studied using modified dissolution testing. Safety of the ES mats was studied in *in vitro* cytotoxicity assay using primary human dermal fibroblasts.

RESULTS: The selection of appropriate polymer concentration as well as solvents was crucial for successful ES and obtaining stable DDSs. Porous microfibers were obtained with PCL and different binary solvent systems. Largest fiber diameters were obtained with tetrahydrofuran:DMSO system (2.0 ± 3.0 μm), chloroform (CF):DMSO and acetone:dichlorometane systems provided similar diameters (average 1.3 ± 0.5 μm). Whilst the ES of CF:methanol (3:1) PCL solution resulted in nanofibers (average 0.5 ± 0.3 μm). Higher polymer concentration resulted in higher viscosity and generally increased the diameter of the prepared fibers. Humidity was the main parameter affecting the pore formation and increasing the humidity enhanced the creation of pores. Incorporation of CAM changed the ES process as well as pore formation, but no significant changes were detected in fiber diameter. CAM was in an amorphous state within the fibers hence their physical stability needs to be investigated further. The presence and distribution of MSNs within the electrospun PCL fibers was nicely seen by microscopy. Dual drug release behavior was obtained with both CAM-loaded fiber mats and CAM-loaded MSNs incorporated into fibers mats. CAM incorporation into the MSN allowed prolonging the drug release from MSNs as well as electrospun fiber mat. All mats were biocompatible and the antimicrobial and antibiofilm efficacy of the fiber mats will be investigated further using previously developed disc diffusion and biofilm assays and relevant pathogenic bacterial strains (e.g. *S. aureus* DSM 2569, *S. epidermidis* DSM 28319, *E. coli* CFT073)(1).

CONCLUSION: CAM-loaded electrospun biocompatible nano- and microfibrous mats with suitable antibacterial properties and different drug release profiles were developed. CAM-loaded MSNs were successfully incorporated into fibers using monoaxial ES. Prolonged drug release was obtained using CAM-loaded fiber mats having also the desired burst release relevant for antibacteria efficacy.

Acknowledgements

Estonian Research Council project PUT1088, Dr D. Sen Karaman and Prof J. Rösenholm (Åbo Akademi University) are acknowledged for the MSNs preparation and analysis. Prof K. Kingo is thanked for providing human dermal fibroblasts. Prof K. Kirsimäe, J. Aruväli (Department of Geology, University of Tartu) and K. Semjonov (Institute of Pharmacy) are thanked for the XRD and SEM measurements.

Literature

(1) Preem, L.; Mahmoudzadeh, M.; Putrinš, M.; Meos, A.; Laidmäe, I.; Romann, T.; Aruväli, J.; Härmas, R.; Koivuniemi, A.; Bunker, A.; Tenson, T.; Kogermann, K. Interactions between chloramphenicol, carrier polymers and bacteria – implications for designing electrospun drug delivery systems countering wound infection. Mol. Pharmaceutics 2017, in press. DOI: 10.1021/acs.molpharmaceut.7b00524

ELECTROSPINNING OF COLLAGEN WITH NANOCAPSULES OF PLGA FOR DELIVERY OF PACLITAXEL IN DRUG-ELUTING STENTS

Liliana Maria Agudelo[1, 2], Jesus Antonio Carlos Cornelio[2], Luis Fernando Rodriguez[1,2], Isabel Cristina Ortiz[1], Lina Marcela Hoyos[1, 2], Gabriel Jaime Colmenares[1, 2].

[1] Grupo de Biología de Sistemas, Escuela de Ciencias de la Salud, Universidad Pontificia Bolivariana, Circular 1° #70-01, Medellín, Antioquia, Colombia

[2] Grupo de investigación Nanomat, Nanomat S.A.S, Carrera 71 A circular 5-71, Medellín, Antioquia, Colombia

Corresponding author: gabriel.colmenares@upb.edu.co

Key words: Electrospinning, drug delivery, drug-eluting stents, bioabsorbible, polymers, nanocapsules.

Drug-eluting stents can facilitate a drug's release directly to the specific site, but the main difficulty with drug-eluting stents is that the initial burst of drug release can extremely affect the pharmacological action and this is the biggest drawback that worries physicians and researchers in this field [1], [2]. Therefore, the drug release rate has become an important standard in evaluating Drug-eluting stents [2]. The factors affecting the drug release rate include the drug, drug carrier, coating methods, drug storage, direction of elution, coating thickness, pore size in the coating, and release conditions like pH, temperature, release medium and hemodynamics after the stent implantation. This work develops a new delivery system trying to understand better, the factors that influences the drug release. This system use nanofiber produced by electrospinning technic and bioabsorbable polymeric nanocapsules produced by the nanoprecipitation processes in a recirculated system develop in the research group.

We select the electrospinning processes because is perhaps the most promising of all nanotechnologies, in terms of versatility and cost to produce nanofibers, with large surface area, porosity, orientation and dimensions, in a controlled manner with excellent mechanical and easy functionalization properties for multiple applications [3]–[7]. For this work, we used an electrospinning equipment built at the university, in which you can control the process parameters such as voltage, deposition rate, collector distance, speed and direction of rotation of the collector, to control the morphology and diameter of the nanofibers. The final electrospinning condition to obtain nanofiber of collagen (Sigma-Aldrich) with 99 ± 26 nm was 18 V, collector distance of 14cm, flow rate of 0.1mL/h and polymer concentration was 25% W/V in acetic acid and distilled water 1:1.

On the other hand, we encapsulated Paclitaxel in bioabsorbible polymeric nanocapsules of PLGA (Resomer 752 H, Evonik) produced in a recirculated system design in the university. The conditions used to encapsulate the paclitaxel was 4mg/mL of polymer concertation, 20% of drug respect to dry polymer, 162 mL/min of flow rate in the recirculating system, 0.25% of Pluronic F127 (Sigma-Aldrich) as surfactant in the aqueous phase and 2:1 ratio between aqueous phase and organic phase. The nanocapsules were lyophilized and added to the collagen solution for electrospinning of the samples. The nanostructured delivery system and his individual components was characterized using TEM, SEM, AFM, contact angle and DLS for the nanocapsules. The released of paclitaxel was measurement using the HPLC method.

References

[1] W. Hohenforst-Schmidt, P. Zarogoulidis, G. Pitsiou, B. Linsmeier, D. Tsavlis, I. Kioumis, E. Papadaki, L. Freitag, T. Tsiouda, J. F. Turner, R. Browning, M. Simoff, N. Sachpekidis, K. Tsakiridis, B. Zaric, L. Yarmus, S. Baka, G. Stratakos, and H. Rittger, "Drug eluting stents for malignant airway obstruction: A critical review of the literature," J. Cancer, vol. 7, no. 4, pp. 377–390, 2016.

[2] T. Hu, J. Yang, K. Cui, Q. Rao, T. Yin, L. Tan, Y. Zhang, Z. Li, and G. Wang, “Controlled Slow-Release Drug-Eluting Stents for the Prevention of Coronary Restenosis: Recent Progress and Future Prospects,” ACS Appl. Mater. Interfaces, vol. 7, no. 22, pp. 11695–11712, 2015.

[3] R. Sridhar, J. R. Venugopal, S. Sundarrajan, R. Ravichandran, B. Ramalingam, and S. Ramakrishna, “Electrospun nanofibers for pharmaceutical and medical applications,” J. Drug Deliv. Sci. Technol., vol. 21, no. 6, pp. 451–468, 2011.

[4] X. Hu, S. Liu, G. Zhou, Y. Huang, Z. Xie, and X. Jing, “Electrospinning of polymeric nano fi bers for drug delivery applications,” J. Control. Release, vol. 185, pp. 12–21, 2014.

[5] J. Zeng, L. Yang, Q. Liang, X. Zhang, H. Guan, X. Xu, X. Chen, and X. Jing, “Influence of the drug compatibility with polymer solution on the release kinetics of electrospun fiber formulation,” J. Control. Release, vol. 105, no. 1–2, pp. 43–51, 2005.

[6] Z. Ershuai, Z. Chuanshun, Y. Jun, S. Hong, Z. Xiaomin, L. Suhua, W. Yonglan, S. Lu, and Y. Fanglian, “Electrospun PDLLA / PLGA composite membranes for potential application in guided tissue regeneration,” Mater. Sci. Eng. C, vol. 58, pp. 278–285, 2016.

[7] U. Paaver, J. Heinämäki, I. Laidmäe, A. Lust, J. Kozlova, E. Sillaste, K. Kirsimäe, P. Veski, and K. Kogermann, “Electrospun nanofibers as a potential controlled-release solid dispersion system for poorly water-soluble drugs,” Int. J. Pharm., vol. 479, no. 1, pp. 252–260, 2015.

ELECTROSPINNING OF CHARGED INDUCED FIBER SCAFFOLDS

Sara Metwally and Urszula Stachewicz*

International Centre of Electron Microscopy for Materials Science

Faculty of Metal Engineering and Industrial Computer Science

AGH University of Science and Technology, Kraków, Poland

**ustachew@agh.edu.pl*

Surface electric potential significantly influences cell behavior such as adhesion, growth and proliferation. Generally, positively charged surfaces increases cell proliferation, as their membrane is negatively charged [1]. Surface charge of fiber scaffolds can be tuned by applying positive or negative voltage polarity during electrospinning. It has been shown that alternating voltage polarity allows controlling molecular orientation of functional groups within polymers chains [2]. Our studies present the possibility of tailoring not only functional groups of fibers but surface charges as well. Thus, we are able to create charged induced fiber scaffolds for tissue engineering applications.

The surface charge on electrospun samples is examined using scanning Kelvin probe microscopy (SKPM), measured simultaneously with surface topography using the standard atomic force microscopy (AFM) tapping mode and a surface chemistry is analyzed with X-ray photoelectron spectroscopy (XPS). The *in vitro* studies using osteoblast-like cells are performed on the charge induced fibrous scaffold. Cell proliferation is verified with scanning electron microscope (SEM) and fluorescence microscopy. Additionally, the 3D structure of scaffolds and cells integration with fibers is investigated with 3D tomography based on SEM with focused ion beam (FIB-SEM). The results are showing possibility of enhancing cell integration with polymer scaffolds just by controlling voltage polarity during electrospinning of fibers.

References

1. D.A. Haydon Biochim. Biophys. Acta 50, 450-457 (1961).

2. U. Stachewicz, C.A. Stone, C.R. Wilis, A.H. Barber J. Mater. Chem. 22, 22935–22941 (2012).

Acknowledgments

The study was conducted within the funding from SONATA 8 project granted by National Science Centre in Poland, No 2014/15/D/ST5/02598

BIODEGRADABLE ELECTROSPUN VASCULAR GRAFTS AND THEIR TRANSFORMATION IN SITU INTO NEO-ARTERIES (Invited)

Yadong Wang

Pittsburg University, USA

ELECTROSPUN NANOFIBERS FOR ADVANCED WOUND CARE (Invited)

Haydn Kriel*, Megan Coates and Eugene Smit

Stellenbosch Nanofiber Company (Pty) Ltd, 7 Marconi Road, Montague Gardens, Cape Town, South Africa, 7441

**Corresponding contributor. E-mail: haydn@sncfibers.com*

The global market for advanced wound care is estimated to grow from US$ 10bn in 2017 to more than US$ 13bn by 2022. This rapid growth is driven by factors such as the global increase in the incidence of surgical wounds and various ulcer types (diabetic foot ulcers, pressure ulcers, and venous leg ulcers), the aging population, rising R&D activities in this field, and increasing awareness of the improvements in therapeutic outcomes and quality of life offered to patients by advanced wound care therapies.

While the technical and commercial barriers to entry in the market of advanced wound care are high, electrospun fibers present a new category of materials that offer value addition that can be leveraged with existing products and can also be used to create new-to-the-world products. This potential has not fully been realized and there is huge capacity for electrospun fiber-based materials to be applied in developing dressings and devices aimed at controlling infection, managing wound moisture, and reducing scarring.

This talk describes electrospun fiber developments and applications in advanced wound care and looks at commercialization aspects of electrospun fiber products. Some of the aspects covered will include:

- Smart formulations and architectures that directly address the indication at the biointerface;
- The use of a suitable high-throughput electrospinning platform technology;
- The necessity for a good understanding of the regulatory path, economic and reimbursement factors; and
- Clear understanding of the user needs from the design phase.

All of these factors will affect the likelihood of successful transition of novel electrospun fiber based wound care product concepts from the lab to commercial production.

STRUCTURE DEPENDENT CELL ACTIVITY ON PCL/GELATIN AND PCL/COLLAGEN NANOFIBERS ELECTROSPUN FROM VARIOUS SOLVENTS

Paweł Sajkiewicz*, Judyta Dulnik, Dorota Kołbuk-Konieczny, Piotr Denis

Laboratory of Polymers and Biomaterials, Institute of Fundamental Technological Research, Polish Academy of Sciences, Pawińskiego 5B, 02-106 Warszawa, Poland

** Corresponding author's e-mail address: psajk@ippt.pan.pl*

Bicomponent nanofibers consisting of polycaprolactone (PCL) and one of the biopolymers, gelatin or collagen, were formed by electrospinning using two types of solvents - hexafluoroisopropanol (HFIP) and the acetic acid (AA) and formic acid (FA) mixture. The electrospinning was optimized previously [1], providing similar morphology for both types of solvents. Cellular *in vitro* tests were performed using L929 mouse fibroblast cells and human primary fibroblasts. MTT cytotoxicity tests performed on extracts, revealed no cytotoxicity irrespective of the solvent used. The results of investigations of cellular activity in direct contact using various methods - SEM, fluorescent dying of nuclei and cytoskeleton, DNA proliferation test, and MTT, indicate that the biopolymer addition increases cell adhesion and spreading on the surface of nonwovens. Slightly higher cell

activity observed for nanofibers containing collagen compared to those with gelatin can be explained by non-complete denaturation of the collagen native structure as observed by FTIR. The most important result is that the cellular activity on nanofibers electrospun from HFIP is higher than for nanofibers electrospun from AA/FA. We see two reasons of this observation. The first one is related to different molecular conformation of biopolymers in both type of solvents, as deduced from our viscosity measurements. In the case of strong solvent like HFIP, the molecular conformation is more expanded compared to compact conformation caused by prevailing polymer-polymer internal interactions in weak solvent (AA/FA). The conformation of polypeptide molecules seems be crucial for accessibility of RGD sequence, with easier access for integrin receptors in the case of more extended conformation in HFIP. The second reason can be attributed to slower leaching of biopolymer from nanofibers electrospun from HFIP compared to the case of using AA/FA, as observed from analysis of biodegradation in PBS solution at 37°C. The origin of differences in the kinetics of biopolymer leaching during biodegradation is related to the structure of solution and hence final nanofibers. In the case of strong HFIP solvent, there is molecular dispersion of polymers, while segregation of components was observed for nanofibers electrospun from weak AA/FA solvent, leading to easier biopolymer leaching.

Acknowledgements

This work was funded by the Polish National Science Center (NCN) under the Grant No.: 2013/09/B/ST8/03463.

References

[1] P. Denis, J. Dulnik, P. Sajkiewicz, Int. J. Polym. Mater. 64, 354-364 (2015).

CHARACTERIZATION AND EVALUATION OF TPU-HYALURONIC ACID MEMBRANES FOR TISSUE ENGINEERING APPLICATIONS

Magnus Kruse[1]*, Manuela Garay[1], Thomas Gries[1] and Stefan Jockenhoevel[1]

[1] Dept. Biohybrid & Medical Textiles (BioTex), AME-Helmholtz Institute for Biomedical Engineering & ITA-Institut für Textiltechnik Aachen (ITA), RWTH Aachen University, Aachen, Germany

**Corresponding author's e-mail address: magnus.kruse@ita.rwth-aachen.de*

The objective of the presented study was the development of an electrospun membrane produced from hyaluronic acid (HA) and thermoplastic polyurethane (TPU). In the fabrication process of the two components TPU/HA-membrane TPU was electrospun from a chloroform/methanol solution while HA was electroblown from an aqueous solution. The resulting membranes feature a broad field of application in the tissue engineering area ranging from the design of artificial heart valve leaflets to skin regeneration.

Stable production parameters for the electrospinning of TPU and the electroblowing of HA were determined in the present study. The correlation between the process parameters and the fibre properties were statistically analysed for TPU. It was found that the fibre diameter increased with increasing polymer concentration and also with increasing relative humidity in the spinning chamber. In order to determine the process parameters for HA a solution parameter assessment was completed to evaluate the fabrication of hyaluronic acid nanoparticles with the electro-blowing technique. The resulting spinning parameters were set to 8 wt% TPU in chloroform/methanol, 1 wt% HA in water, -15 kV on the collector and 20 kV on the spinnerets.

Different test methods were used to characterize the membranes with regard to their usage as artificial scaffolds for different tissue engineering applications. Fourier transform infrared spectroscopy (FTIR) was used to confirm the existence of the two components in one membrane. Scanning electron microscopy (SEM) showed that HA was dispersed as nanospheres and small films inside the TPU fibre matrix. The diameter of the TPU-fibres was also determined from the SEM pictures (2.1 ± 0.2 μm). The mechanical properties were determined in uniaxial stress-strain tests, the measurements showed an ultimate tensile strength of 2.2 ± 0.4 MPa and a strain of 110.2 ± 25.9%. Contact angle measurements displayed an enhancement of the hydrophilicity. The contact angle decreased from 108° ± 0.8° for pure TPU-membranes to 83° ± 1° for TPU/HA-membranes. Also the enhancement of the biocompatibility was indicated in XTT-Assays. This study successfully demonstrated the reproducible production of TPU/HA membranes with tuneable microstructures.

FABRICATION AND CHARACTERIZATION OF ELECTROSPUN ALGINATE NANOFIBERS IMPREGNATED WITH SILVER NANOPARTICLES

T.C. Mokhena[1,2], **A.S. Luyt**[3]

[1] *CSIR Materials Science and Manufacturing, Polymers and Composites, Port Elizabeth, South Africa*

[2] *Department of Chemistry, University of the Free State (Qwaqwa Campus), Private Bag X13, Phuthaditjhaba, South Africa*

[3] *Center for Advanced Materials, Qatar University, PO Box 2713, Doha, Qatar*

Electrospinning has attracted a lot of attention during the past decades because of its capability to produce flexible nanofibrous membranes with micro- or nanoscale diameters for synthetic and natural polymers. A processor can control the processing variables, such as solution properties, setup properties and environmental conditions to produce a desired morphology of the ensuing nanofibers. One of the reliable methods to broaden the application of the electrospun nanofibers include the incorporation of various nanoparticles. In this study silver nanoparticles synthesized from a chitosan solution was coated onto alginate nanofibers to produce a good antibacterial polyelectrolyte complex (PEC) nanofibrous composite. AgNPs were synthesized using heat treatment with chitosan as a stabilizing and at the same time a reducing agent. The composites were characterized by scanning electron microscopy (SEM), Fourier transform infrared spectroscopy (FTIR) and X-ray diffraction (XRD). PEC demonstrated a good antibacterial efficiency and acceptable water vapour transmission rate (WVTR) for wound dressing.

ELECTROSPUN PEO/ZNO NANOFIBERS: CHARACTERIZATION AND UV-VIS DRUG DELIVERY STUDIES

Omolola E. Fayemi[1,2], **Vuyisani M. Rabela**[1,2],*

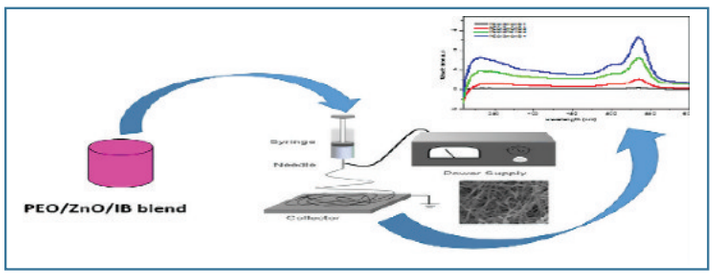
[1] *Department of Chemistry, School of Mathematics and Physical Sciences, Faculty of Agriculture, Science and Technology, North-West University (Mafikeng Campus), Private Bag X2046, Mmabatho 2735, SouthAfrica.*

[2] *Material Science Innovation and Modelling (MaSIM) Research Focus Area, Faculty of Agriculture, Science and Technology, North-West University (Mafikeng Campus), Private Bag X2046, Mmabatho 2735, SouthAfrica.*

**Corresponding author: 25704168@nwu.ac.za; Material Science Innovation and Modelling (MaSIM) Research Focus Area, Faculty of Agriculture, Science and Technology, North-West University (Mafikeng Campus), Private Bag X2046, Mmabatho 2735, South Africa; Tel: +27183892440*

Abstract

One of the prerequisite for therapeutic effect is the delivery of pharmaceutical agents to a target tissue or organ in an acceptable physiological manner [Rathinamoothy., 2012]. Therefore the purpose of this work was to fabricate nano-compositeof zinc oxide nanoparticle loaded on poly (ethylene) oxide as drug delivery system for Ibuprofen through the electrospinning technique. This was done in order to improve the therapeutic index of the Ibuprofen as shown in the scheme. The influence of different concentrations of ZnO nanoparticles on the prepared polymeric drug delivery system was tested. Successful synthesis of the zinc oxide and nanocomposites were confirmed by using spectroscopic techniques such as Ultraviolet-Visible (UV-Vis), Fourier transform – infrared (FT-IR), and the morphology of the electrospun nanofibers were characterized by using scanning electron microscope (SEM). The release of ibuprofen was followed by UV-vis spectroscopy in phosphate buffer pH 7.4 at 310K for 5 consecutive days. The results showed that Ibuprofen was released at a higher rate from the blend with higher zinc oxide nanoparticle (1.0% w/w) as compared to the other concentration studied. Therefore, from these results, polyethylene oxide loaded zinc oxide nanoparticles may be considered effective drug delivery system for Ibuprofen at the concentration of 1.0% w/w zinc oxide nanoparticles.



Reference

R. Rathinamoorthy. Nanometer for drug delivery system-principle and application. 2012, 47

SMART MULTICOMPONENT FIBERS (Invited)

Seema Agarwal*, Li Liu, Martin Pretscher

Department of Chemistry, University of Bayreuth, Universitätsstrasse 30, Bayreuth, Germany

agarwal@uni-bayreuth.de

Solution electrospinning is a well-established method to process homogeneous fibers from different polymers with a huge range of properties. Multicomponent fibers made using special nozzles and additives provide further new opportunities with special properties. Co-axial, triaxial and side-by-side spinning are some of the multi-nozzle options for getting special fiber structures. Right choice of polymers as two components can provide special mesostructures and a set of mechanical properties which are not possible using simple blend or otherwise. The talk will highlight some examples for the formation of multicomponent fibers and discuss the formation of special structures and properties. Special emphasis will be on smart bicomponent fibers with actuation capability, reversible change in fiber structure with external stimuli and water purification [5].

Acknowledgements

We would like to thank DFG (SFB 840 and GIP) for the financial support. L.L. thank CSC (China Scientific Council) for the fellowship for carrying out PhD in the group of Prof. S. Agarwal.

References

[1] L. Liu, A. Ghaemi, S. Gekle, S. Agarwal, Advanced Materials, 28, 9792-9796 (2016).

[2] L. Liu, S. Jiang, S. Agarwal, Advanced Functional Materials, 26,1021-1027 (2016).

[3] S. Jiang, A. Lerch, L. Ionov, S. Agarwal, Advanced Materials, 27, 4865-4870 (2015).

[4] L. Peng, S. Jiang, M. Seuß, A. Fery, G. Lang, T. Scheibel, S. Agarwal,

Macromol. Mater. Eng., 301, 48-55 (2016).

[5] L. Peng, J. Zhu, S. Agarwal, Macromol. Rapid Commun., DOI: 10.1002/marc.201700034 (2017).

SYNTHESIS OF FUNCTIONAL OXIDE NANOCOMPOSITES VIA ELECTROSPINNING (Invited)

Jennifer S. Andrew

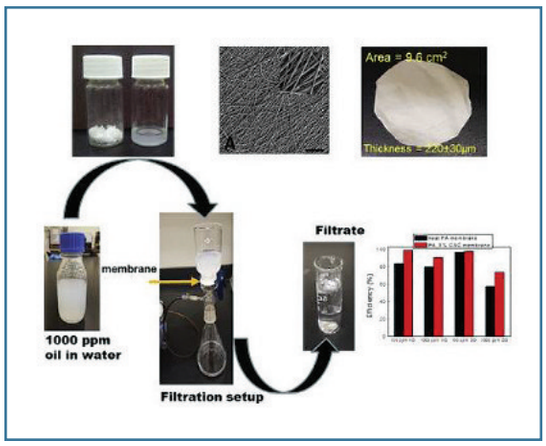
Nanostructured composite materials have the potential to overcome challenges in many areas of materials research, which cannot be addressed by more conventional singlephase materials. The unique properties of these composite materials often arise due to unique phenomena that occur at the interface between the phases being coupled. An additional control is the anisotropy of the individual phases and the resultant composite, which can be used to control the magnitude and direction of composite properties. For example, ferroelectric and ferromagnetic materials can be combined to form composites with enhanced multiferroic or exchange coupling properties. Here, I will present on these composite materials prepared using the electrospinning technique, generating materials with controllable anisotropy and resultant properties. Specifically, Janus type nanofibers, where two phases are coupled longitudinally, are used to create an anisotropic building block that allow access to both surface and bulk properties of each phase. This novel architecture is linked to an anisotropic interface between the coupled phases, and a model is developed relating fiber composition to interfacial area and resulting functional properties.

ELECTROSPUN COPOLYAMIDE MATS REINFORCED BY CELLULOSE NANOCRYSTALS

Igor Krupa[1], Patrik Sobolčiak[1], Aisha Tanvir[1], Anton Popelka[1]

[1] Center for Advanced Materials, Qatar University, P. O. BOX 2713, Doha, Qatar

In this paper we present the preparation and properties of unique material system manufactured by electrospinning of co-polyamide 6,10 from n-propanol solution [1]. A significant advantage of this system is that n-propanol can be considered as a safe, ecologically friendly organic solvent. As far as we know, no further polymer electrospun from n-propanol has been reported in literature. The co-polyamide mats were modified by cellulose nanocrystals prepared from date palm leaves to enhance their mechanical properties. Adding of 1wt.% of cellulose nanocrystals improved Young's modulus and the tensile strength of composites. Young's modulus increased in 224% and the tensile strength increased in 110% if filled with 1 wt.% of CNC. Electrospun coPA mats shown significantly higher hydrophobicity as spin coated foils. The contact angle of water measured at electrospun mats was 134° whereas contact angle measured at coPA foils was 84°. Electrospun mats also shown good ability to absorb oil impurities from water.



Literature

1. P. Sobolčiak, A. Tanvir, A. Popelka, J. Moffat, K. A. Mahmoud, I. Krupa, Materials and Design, 132, 314 (2017)

Acknowledgements

This work was made possible by NPRP grant No. : 7 - 1724 - 3 - 438 from the Qatar National Research Fund (A Member of The Qatar Foundation). The statements made herein are solely the responsibility of the authors.

MECHANICAL RESPONSE OF RANDOMLY ORIENTED NANOFIBROUS MEMBRANES: EXPERIMENTAL CHARACTERIZATION AND CONSTITUTIVE MODELING

Dannee Wong[1], Andri Andriyana[1],*, Bee Chin Ang[2], Erwan Verron[3]

[1] Centre of Advanced Materials, Department of Mechanical Engineering, Faculty of Engineering University of Malaya, 50603 Kuala Lumpur, Malaysia

[2] Centre of Advanced Materials, Department of Chemical Engineering, Faculty of Engineering University of Malaya, 50603 Kuala Lumpur, Malaysia

[3] Ecole Centrale de Nantes, Institut de Recherche en Génie Civil et Mécanique (GeM)

UMR CNRS 6183, BP 92101, 44321 Nantes, France

**Corresponding Author. E-mail: andri.andriyana@um.edu.my*

Abstract

Following the extensive potential applications of electrospun nanofibrous membranes, investigations have been mostly focused on the manipulation of chemical content and physical properties in order to produce materials with good functionalities for various purposes. While the mechanical charateristics play important role during material service, unfortunately less attention has been given to the understanding of the mechanical aspects of these materials. In fact, for design purpose, there is an urgent need to understand the mechanical responses of electrospun nanofibrous membranes subjected to complex loading conditions as well as to be able to model and capture these responses by means of efficient constitutive model. Furthermore, modeling could provide prediction of materials performance where different loading conditions could be simulated with ease and thereby reducing the high dependence on daunting and time consuming experiments.

The present work focuses on the experimental characterization and constitutive modeling of the mechanical responses of PVDF electrospun nanofibrous membrane. To this end, the membrane is subjected to a set of mechanical tests that include monotonic tensile test and cyclic loading test with increasing maximum strain. A continuum mechanical model is subsequently developed in order to capture the experimentally observed materials behavior. The main feature of this model is its simplicity that involves a reduced number of material parameters. Preliminary validation shows that the proposed model is capable to capture the fundamental mechanical response of materials under complex loading conditions including nonlinearity, hysteresis, inelastic deformation and deformation-induced fiber reorientation.

Keywords: Nanofiber, mechanical response, constitutive model, membrane, electrospinning.

ECO-FRIENDLY AQUEOUS ELECTROPINNING OF POLYPROPYLENE

Anne Hébraud*, Chengzhang Xu, and Guy Schlatter

ICPEES, UMR 7515 CNRS-University of Strasbourg, ECPM, 25 rue Becquerel, 67087 Strasbourg cedex 2, France

**Corresponding author: anne.hebraud@unistra.fr*

Electrospinning is a very versatile technique to produce nanofibers from polymer solutions or melt. It allows the production of fibers of an infinity of organic or inorganic materials, relevant for a wide variety of applications such as filtering, catalysis, sensors or biomedical applications. One of its drawbacks is the use of large amounts of solvents in order to obtain small fibers from polymers in the case these polymers are not soluble in water. A few of them can be electrospun from their melt but it leads to larger fibers of a few microns in diameter. Green electrospinning has been developed as a mean to produce nanofibers of polymers from water suspension, thus avoiding the use of toxic solvents [1].

We present here the production of polypropylene fibers from water suspensions. The addition of a template polymer, soluble in water and providing polymer chain entanglements is necessary to avoid breaking of the electrospun jet into droplets and to produce continuous fibers. We have studied and compared two different techniques: coaxial electrospinning, with the PP suspension in the core and the template polymer in the shell, and blend electrospinning, with the template polymer added directly to the PP suspension. The fibers were then cured at a temperature higher than the melting temperature of PP, and finally, the template polymer is washed away in water.

Both processes allow the production of mats of PP nanofibers with diameters of 300-400 nm, with Young modulus of 15 MPa. The hydrophilicity of the final mats, due to small amounts of template polymer remaining in the fibers, make them very interesting for filtration of aqueous liquids.

[1] Agarwal, S. & Greiner, A. On the way to clean and safe electrospinning-green electrospinning: emulsion and suspension electrospinning. Polymers for Advanced Technologies 22, 372–378 (2011).

APPLICATION OF MELT DIFFERENTIAL CENTRIFUGAL SPUN POLYPROPYLENE MICRO-NANOFIBERS AS OIL SORBENT MATERIALS

Mahmoud M Bubakir,[1, 2, 3]* Haoyi Li,[2, 3]

[1] Garian Engineering college, Aljabal-Algarbi University, Garian, Libya

[2] College of Mechanical and Electrical Engineering, Beijing University of Chemical Technology, Beijing 100029, China

[3] State Key Laboratory of Organic–Inorganic Composites, Beijing University of Chemical Technology, Beijing 100029, China

Abstract

Oil is one of the most important sources of energy in today industrial society, but the risk of oil pollution at sea has also increased with increasing demand for this source , which posed serious environmental concerns that made scientistes and decision makers at all levels call for urgent measures to clean up oil spill in effective and secure ways. Many approachs have been applied for the cleanup process, and the use of sorbents is one of

them. The aim of this paper is to study the effectiveness of using melt differential centrifugal spinning fabricated polypropylene (PP) micro-nanofibers as sorbents in oil clean-up and reterivel from spills . Two kinds of microfiber samples (air assisted and non air assisted) were prepared by the technique at rotating speed of 3000 r/min, and air flow of 5m/s for air assisted fabricated fibers. Characterization of the centrifugal spun fibers performed by scanning electron microscopy (SEM), X-ray diffraction (XRD), and contact angle analysis. Fibrous sorbents prepared hereafter were investigated for their efficiency in removing oil spills. The experimental results showed a variation in the sorption capacities of the two kinds of fibers to motor oil. The maximum oil-sorption capacity of the air assisted PP fibers was 63.2g/g , and for the non- air assisted fibers was 47.2 g/g, also fibers have a high selective affinity for motor oil in aqueous medium In addition, after six sorption/desorption cycles, our chosen fiber sample (air-assisted) proved to be reusable for four times, and more than 60 % of oil could be retrieved . It was concluded that melt differential centrifugal fibers performance as oil sorbent materials is a promising one, and could be improved by some additives enhancement .

Keywords: Oil spills, melt differential centrifugal spinning, micro-nanofibers, sorption capacity, applications.

CELLULOSE NANOFIBERS AND AEROGELS WITH TUANABLE AMPHIPHILICITY AND CHEMICAL FUNCTIONALITIES (Invited)

You-Lo Hsieh
University of California, Davis, USA
ylhsieh@ucdavis.edu

Abstract

Biopolymers are synthesized by living organisms in a variety of sophisticated structures that serve as excellent precursors as well as inspiration for advanced materials. One of the most significant challenges in engineering biopolymers into fibers is their non-thermoplastic nature and insolubility. Polysaccharides are difficult to dissolve whereas proteins tend not to disperse uniformly. Coupling materials chemistry approaches, biopolymer derivatives become easily soluble in a range of common organic solvents and to be miscible with other polymers and additives to be facilely electrospun. Dissolved cellulose and chitin derivatives have been robustly electrospun into nanofibrous, micro-porous and meso-porous fibers, shealth-core hybrid, hierarchical multi-scale structures[1-3]. Top-down and bottom-up approaches to generate ultra-fine cellulose fibers and 3D structures are also contrasted. Self-assembling of nanocelluloses has created new fibrous network[4], super-absorbent hydrogels[5] and amphiphilic aerogels.[6] These cellulose aerogels engineered by either electropsinning or self-assembling have shown to exhibit super-absorbency, wet-resiliency, dry strength and tunable amphiphilic-to-hydrophobic characteristics. While fibers and aerogels from these two approaches share some similar morphologies, their crystalline structures, thermal behavior and chemical functionalities are distinctively different, offering a wide range of characteristics as novel functional materials. Biological nanomaterial innovations will not only meet future demand in novel, better and sustainable materials but also help to minimize negative environmental impact from our food and energy supply chain.

Acknowledgments

Funding from USDA-NIFA, NSF, NIH, CAPES, California Rice Research Board, Chevron and AgTech Innovation Center is greatly appreciated, so are research contributions from P. Lu, J. Du, H. Liu, J. Xie, H. Chen, Y. Wang, L. Zhang F. Jiang, S. Hu, A.G.B. Pereira,

References

1. Liu, H. and Y.-L. Hsieh, J. Polymer Sci, Polymer Physics, 40(18):2119-2129 (2002).

2. Du, J. and Y.-L. Hsieh, Cellulose, 16(2): 247-260 (2009).

3. P. Lu, Y.-L. Hsieh, J. Membrane Science, 348 (1-2):21-27 (2010).

4. Jiang, F., S. Han, Y-L. Hsieh, RSC Advances, 3(30): 12366-12375 (2013).

5. Jiang, F., Y.-L. Hsieh, J. Materials Chemistry A, 2: 6337-6342 (2014).

6. Jiang, F., Y.-L. Hsieh, ACS Applied Materials & Interfaces, 9 (3), 2825–2834 (2017).

ANTIMICROBIAL NANOFIBERS – STRONG AND LETHAL (Invited)

Bert Klumperman

Stellenbosch University, South Africa

ELECTROSPUN POLYESTER MESOFIBERS: A NEW TOOL IN DISPENSER TECHNOLOGY FOR BROADCASTING SEMIOCHEMICALS IN PLANT PROTECTION AGAINST ARTHROPOD PESTS. THE EXAMPLE OF *LOBESIA BOTRANA* (LEP.: TORTRICIDAE)

Hans E. Hummel[1,2]

[1] *Chair in ORganic Farming, Justus-Liebig-University Giessen, Karl-Gloeckner-Str. 21 C, D-35394 Giessen, Germany; Hans.E.Hummel@agrar.uni-giessen.de*

[2] *University of Illinois Urbana-Champaign, Prairie Research Institute, 1816 S. Oak Street, Champaign, IL. 61820, USA*

Among half a dozen different dispenser systems for arthropod pheromones, electrospun organic polymer fibers are lately gaining attention as one of the most advanced and flexible, yet also environmentally compatible and completely biodegradable variants. The mesofibers have a number of virtues unmatched by competing technologies. Their price is very moderate and mainly dictated by the inherent cost of the nontoxic sex pheromone rather than by the cheap dispenser material. Ecoflex® is completely biodegradable and producible both sustainably and renewably, just as the lipid pheromones, which are accessible from nonpetroleum materials. Unlike ampoule and "spaghetti" type dispensers, mesofibers are suitable for non-manual, mechanized, even automated distribution and deployment. They meet the increasing need for agricultural cost reduction on various levels.

In our hands, mesofibers electrospun from Ecoflex® specifically can disrupt *Lobesia botrana* mating communication in vineyards of Southern Germany for a period of up to seven weeks, enough time to cover one of the 3-4 distinct flight periods of the European grapevine moth. An extension of the observed life time of our mesofibers to a period of up to three months seems to be feasible with some minor system adjustments. Thus, mesofiber technology can replace earlier used pastes, creams, inorganic dusts, impregnated cork material, cotton, hollow cellulose macrofibers, and plastic sheets with pheromone impregnation. Mesofibers can now claim their due place in IPM of fruit orchard pests. Applications include those of high priced produces like almonds, walnuts, pistachios, and peaches. The invention is comprehensively protected by eight patents from German, European and US patent authorities, all granted between 2011 and 2013.

BANSAL P, BUBEL K, AGARWAL S & GREINER A (2012) Water-Stable All-Biodegradable

Microparticles In Nanofibers By Electrospinning Of Aqueous Dispersions For Biotechnical Plant Protection. Biomacromolecules 13(2):439-444.

GREINER A & WENDORFF JH (2007) Electrospinning: A fascinating method for the preparation of ultrathin fibers. Angew. Chem. International Edition, 46:5670-5703.

HUMMEL H.E., LANGNER S.S. & BREUER M (2015) Electrospun mesofibers, a novel biodegradable pheromone dispenser technology, are combined with mechanical deployment for efficient IPM of Lobesia botrana in vineyards. Comm Agric. Appl. Biol. Sci. Ghent Univ. 80(3):331-341.

HUMMEL HE, LANGNER SS, BREUER M, HEIN DF, GREINER A & LEITHOLD G (2017) Dreams versus accomplished facts in pheromone technologies as exemplified in recent viticultural applications towards sustainable Lobesia management. IOBC/wprs Bulletin 128:52-65.

ELECTROSPUN FIBERS IN 3D – FIB-SEM TOMOGRAPHY

Urszula Stachewicz* International Centre of Electron Microscopy for Materials Science

Faculty of Metal Engineering and Industrial Computer Science

AGH University of Science and Technology, Kraków Poland

**ustachew@agh.edu.pl*

Nanoscale engineering opens enormous opportunity to explore 3D imaging at high spatial resolution for understanding the interaction between various materials, water, oil and cells. Via electrospinning we can create complex structures with nanofibers for example high porosity scaffolds, porous fibers, fibers with fillers or wrinkled fibers creating nano-roughness.

The complex 3D organization of nanofibers at different scale levels gives amazing opportunity of nanoscale investigation using 3D tomography, based on focus ion beam and scanning electron microscopy (FIB-SEM). This 'slice and view' technique uses SEM to image exposed surfaces following the FIB sectioning. Usually, the sequence of 2D SEM images is used to obtain 3D reconstructions.

In our research we use the 3D tomography for understanding the interaction between liquid droplets and nanofibers to exploit their wetting behavior [1] and new approach in high resolution visualization of cells growth on/in electrospun nanofibers, to design scaffolds for a range of biomedical applications [2, 3].

References:

[1] U. Stachewicz, R.J. Bailey, H. Zhang, C.A. Stone, C.R. Willis, A.H. Barber, Wetting hierarchy in oleophobic 3D electrospun nanofiber networks, ACS Appl. Mater. Interf. 4 (2015), 16645–16652.

[2] U. Stachewicz, T. Qiao, S.C.F. Rawlinson, F.V. Almeida, W.-Q Li, M. Cattell, A.H. Barber, 3D Imaging of Cell Interactions with Electrospun PLGA Nanofiber Membranes for Bone Regeneration, Acta Biomater, 27 (2015), 88-100.

[3] U. Stachewicz, P. Szewczyk, A. Kruk, A. H. Barber, A. Czyrska-Filemonowicz, "Pore shape and size dependence on cells growth into electrospun fiber scaffolds for tissue engineering: 2D and 3D analyses using SEM and FIB-SEM tomography", Materials Science and Engineering: C, in press, 2017

Acknowledgments

The study was conducted within the funding from SONATA BIS 5 project granted by National Science Centre in Poland, No 2015/18/E/ST5/00230

THE DEVELOPMENT AND OPTIMIZATION OF ASPALATHIN-ENRICHED GREEN ROOIBOS LOADED POLYMER NANOPARTICLES BY ELECTROSPRAYING

Chantelle Human[1]; Dalene de Beer[1,2]; Elizabeth Joubert[1,2]

[1] *Department of Food Science, Stellenbosch University, Cape Town, South Africa*

[2] *Plant Bioactives Group, Post-Harvest and Agro-Processing Technologies, Agricultural Research Council Infruitec-Nietvoorbij, Stellenbosch, South Africa*

Nanoencapsulation is an attractive option for the delivery of pharmaceuticals and nutraceuticals, as it can increase absorption of bioactive compounds in cellular structures due to particle shape, size, and surface properties [1-2]. Nanoencapsulation by electrospraying has been shown to be advantageous as it results in higher encapsulation efficiency, omits the use of extreme temperatures and vacuums and is a simple one step process [3]. Rooibos extract has potential as a condition-specific nutraceutical aimed at prevention of the metabolic syndrome due to a high level of the unique dihydrochalcone aspalathin [4]. Susceptibility of aspalathin to oxidation when in solution, leading to poor long-term storage stability and limited intestinal absorption, resulting in poor bioavailability, limit exploitation of its full potential [4].

Nanoencapsulation of an aspalathin-enriched green rooibos extract by electrospraying was investigated as a means to overcome these problems associated with aspalathin as a bioactive compound. Four polymers, i.e. lecithin, poly(lactide-co-glycolic acid) (PLGA), chitosan and methyl-methacrylate polymers (Eudragit (ES100)) were investigated to nanoencapsulate the rooibos extract. The yield, particle morphology (scanning electron microscopy), mean size (dynamic light scattering), zeta potential, encapsulation efficiency, loading capacity, and *in vitro* release of aspalathin were determined to evaluate the different nanoparticles. ES100 rooibos nanoparticles had the most favourable properties with smaller particles, higher zeta potential, higher encapsulation efficiency, higher loading capacity and slowest sustained release profile. Subsequent to this, a central composite design (CCD) was used for the optimisation of the electrospraying process for the encapsulation of the rooibos extract in the ES100 polymer. The most notable advantage of using a CCD is the small number of experiments required for optimisation [5]. The design input parameters included the voltage, solution concentration and ratio of polymer:tea whereas the tip-to-collector distance and flow rate were kept constant. The yield, encapsulation efficiency, loading capacity and particle size and distribution were used as the response factors. Pareto charts, response surface plots and desirability plots were used to identify the optimum electrospraying conditions for the nanoencapsulation of rooibos with ES100.

[1] Bilia, A. R.; Isacchi, B.; Righeschi, C.; Guccione, C.; Bergonzi, M. C. Flavonoids loaded in nanocarriers: an opportunity to increase oral bioavailability and bioefficacy. Food Nutr. Sci. 2014, 5, 1212-1327.

[2] Xiao, J.; Cao, Y.; Huang, Q. Edible nanoencapsulation vehicles for oral delivery of phytochemicals: A perspective paper. J. Agric. Food Chem. 2017. DOI:10.1021/acs.jafc.7b02128.

[3] Zamani, M.; Prabhakaran, M. P.; Ramakrishna, S. Advances in drug delivery via electrospun and electrosprayed nanomaterials. Int. J. Nanomed. 2013, 8, 2997-3017.

[4] Muller, C. J. F.; Malherbe, C. J.; Chellan, N.; Yagasaki, K.; Miura, Y.; Joubert, E. Potential of rooibos, its major C-glucosyl flavonoids and Z-2-(β-D-glucopyranoloxy)-3-phenylpropenoic acid in prevention of metabolic syndrome. Crit. Rev. Food Sci. Nutr. 2017, DOI:10.1080/10408398.2016.1157568.

[5] Bezerra, M. A.; Santelli, R. E.; Oliveira, E. P.; Villar, L. S.; Escaleira, L. A. Response surface methodology (RSM) as a tool for optimization in analytical chemistry. Talanta 2008, 76, 965-77.

FABRICATION OF POLYMERIC COMPOSITES NANOFIBER MATERIAL USING ELECTROSPINNING TECHNIQUE

Dikeledi More, Makwena Moloto[a] Nosipho Moloto[b]

[a] *Department of Chemistry, Faculty of Applied and Computer Sciences, Vaal University of Technology, Private Bag X021, Vanderbijlpark, 1900, South Africa*

[b] *2School of Chemistry, Faculty of Science, Wits University, Private Bag 3, Johannesburg, 2050, South Africa.*

Email: dikeledimore@webmail.co.za

Abstract:

Electrospinning is the unique technique used to produce fibers with diameters ranging from 10 micrometers to 10 nanometers. Nanofibers produced by electrospinning have high surface area to volume ratio and high porosity with small pore size [1, 2]. In this study, natural polymer chitosan (CS) and synthetic polymer poly vinyl alcohol (PVA) were used to prepare a blended nanofiber scaffolds using the electrospinning technique with a view to preparing a material for wound healing application. The CS/PVA blends were further incorporated with a mixture of silver (Ag) and copper (Cu) nanoparticles to produce (Ag/Cu/CS/PVA) composite nanofibers using electrospinning technique. The effects of the weight ratio, voltage and the concentration on the morphology and diameter of the fibers were investigated and characterized using the following techniques SEM, TEM, FTIR spectroscopy, X-ray diffraction, thermal gravimetric analysis and UV-Vis spectroscopy.

References:

[1]Shin, Y. M., Hohman, M. M., Brenner, M. P., & Rutledge, G. C. (2001). Polymer, (25), 9955–9967.

[2] Park, W. H., Jeong, L., Yoo, D. I., & Hudson, S. (2004). Polymer, (21), 7151–7157.

ELECTROSPINNING OF NANOFIBERS USING MODIFIED SLOT SPINNERETS (Invited)

Tong Lin, Guilong Yan, Haitao Niu

Institute for Frontier Materials, Deakin University, Victoria 3216, Australia

Slot electrospinning that uses narrow slot as a spinneret combines the advantages of both needle and needleless electrospinning with precisely controlled solution condition. Most of the existing slot electrospinning techniques, however, use a straight linear slot as spinneret. The effects of slot geometry and auxiliary fields on electrospinning process and fiber morphology have less been reported. In this study, we examine the effects of slot line shape and solution temperature on electrospinning process, fiber morphology and productivity. Aerodynamic fields are also introduced to improve fiber production.

HAS ELECTROSPINNING COME OF AGE? CHALLENGES AND OPPORTUNITIES IN BIOMATERIALS (Invited)

Brendan Robb

Electrospinning Company, UK

Restoring damaged tissue through regenerative medicine strategies has gained significant momentum over the last decade, with broad portfolios of biomaterials available to the end user. Equally, publications outlining the unique benefits of electrospinning to manufacture highly innovative medical devices have increased as well. However, the vast majority of commercially available regenerative medicine products are based on processed collagen, decellularized tissue (human and animal) and ceramic-associated processes with only a handful products utilising electrospinning. Most of these electrospun products have received CE/FDA approval only very recently, suggesting that electrospinning may finally be coming of age as a method for biomaterial production.

In this presentation, we share our experiences as a contract design and manufacturer for electrospun medical devices highlighting some of the challenges and opportunities in the future.

TANNIC ACID NANOFIBERS FROM POLYMER-FREE SOLUTIONS

D. Mailley[a], M. Allais[b,c], P. Hébraud[d], V. Ball[b,c], F. Meyer[b,c], A. Hébraud[a], G. Schlatter[a]*

[a] *ICPEES-UMR7515, CNRS, University of Strasbourg, 25 rue Becquerel, 67087 Strasbourg, France*

[b] *Institut National de la Santé et de la Recherche Médicale, Unité mixte de Recherche 1121, 11 rue Humann, 67085 Strasbourg Cedex, France*

[c] *Université de Strasbourg, Faculté de Chirurgie Dentaire, 8 rue Sainte Elisabeth, 67000 Strasbourg, France*

[d] *IPCMS, UMR 7504, 23 rue du Loess, 67034 Strasbourg Cedex 02, France*

**email: guy.schlatter@unistra.fr*

Abstract

Usually electrospinning solutions are composed of a polymer solubilized into a solvent. The electrospinning of fibers from polymer solutions is the result, for a sufficiently concentrated solution, of polymer chain entanglements. It has been shown that some non-polymeric molecules (cyclodextrins [1], diphenylalanine [2]) can also be electrospun into fibers thanks to intermolecular forces in the solution. We present here the case of the electrospinning of pure tannic acid (TA). Indeed, it was possible to electrospin this non-polymeric and highly hydrophilic molecule in water and in a mixture of water and ethanol.

The conditions required for the electrospinning of TA fibers were firslty evidenced. Experiments were performed in various proportions of water and ethanol. For each solvent, beads, bead-on-string fibers were obtained and finally for high enough concentrations in TA, fibers were obtained with average diameters ranging from 0.60 μm to 1.8 μm.

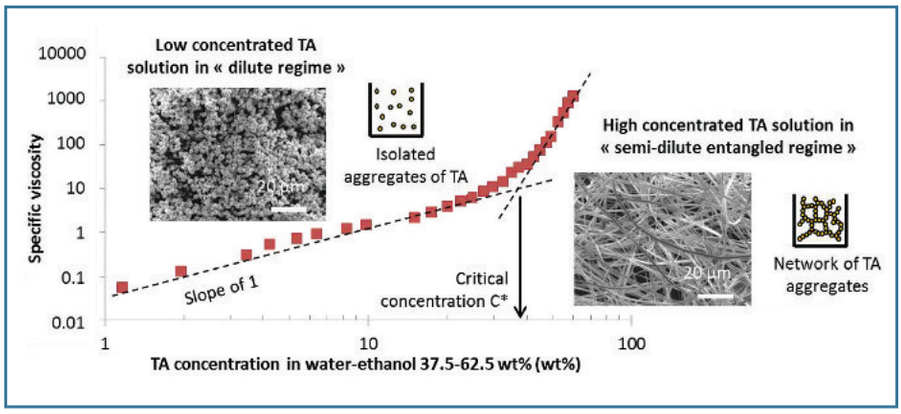


Figure 1: Specific viscosity of TA solutions in the water-ethanol solvent 37.5-62.5 wt% as a function of the TA concentration related to electrospinning experiments.

Dynamic light scattering and rheology experiments highlighted the formation of TA aggregates in the solutions (Fig. 1). Below a critical concentration C*, determined for each solvent, the number of independent TA aggregates increases with the concentration in TA. Above C*, TA aggregates form an interconnected network allowing the formation of fibers during electrospinning. Potential biomedical applications were then studied.

References

1. Celebioglu A, Uyar T. Electrospinning of nanofibers from non-polymeric systems: polymer-free nanofibers from cyclodextrin derivatives. Nanoscale. 2012 Jan 4;4(2):621–31.

2. Singh G, Bittner AM, Loscher S, Malinowski N, Kern K. Electrospinning of Diphenylalanine Nanotubes. Adv Mater. 2008 juin;20(12):2332–6.

REAL-TIME RANDOM LASING DETECTION DURING STRUCTURAL TRANSFORMATION IN ELECTROSPUN FIBROUS STRUCTURE.

SungYeun Yang[1], Soocheol Kim[1], Chulmin Joo[1] and WonHyoung Ryu[1]

[1] School of Mechanical Engineering, Yonsei University, Seoul, Republic of Korea

Abstract

Electrospinning has gathered great attention about fabricating nano-fibers with various materials(1). Currently, it is expanding the research fields by adjusting the various parameters to control the numerical values of nanofibers, deforming the fiber structure by changing the nozzle or collector, and fabricating a three-dimensional structure with near-field electrospinning. These electrospun fibrous structures are applied in various parts. Examples are nanofibers for various filter applications, composite-fiber-reinforced materials, biomedical applications(2) (tissue engineering), fibers loaded with catalysts, optical applications (waveguides)(3), or nanocables for microelectronics applications(4).

Random Lasing (RL) is a progressive form of lasers(5). As the material itself performs the role of the optical cavity, it provides simplification of the system, experimental application of various materials, convenience and, the possibility of RL sensor. It was reported that the RL responses such as the threshold, linewidth, output power, and the center of wavelength are closely related to the structure such as porosity, pore size, fiber diameter and density(6).

In this study, we have performed real-time RL during applying a tensile force to the electrospun silk fibroin (SF) fibers. Silk fibroin solution was prepared from *Bombyx mori* cocoon and electrospun to the drum collector. As the tensile force is applied to the nano-fibrous sample, the internal fibers are naturally aligned in the tensile direction. Random lasing response for structural deformation by tensile force was measured. For comparison, samples with different degrees of internal alignment of the fibers were also prepared by varying collecting drums rpm. As a result, when the internal structure was aligned due to the tensile force, the threshold was lower than when the

tensile force was not applied. This result is similar to the lasing threshold of aligned fibers being less than the lasing threshold of random fibers.

Through this experiment, we could confirm the possibility of a random lasing technique to predict the internal structure of a material and to find out its mechanical properties. SF nanofibers were doped with rhodamine B dye and Nd:YAG laser as a pumping laser source

Reference

1. Z.-M. Huang, Y.-Z. Zhang, M. Kotaki, S. Ramakrishna, A review on polymer nanofibers by electrospinning and their applications in nanocomposites. Composites science and technology 63, 2223-2253 (2003).

2. S. Y. Yang et al., Membrane-reinforced three-dimensional electrospun silk fibroin scaffolds for bone tissue engineering. Biomed Mater 10, 035011 (2015).

3. D. Di Camillo et al., Near-field electrospinning of light-emitting conjugated polymer nanofibers. Nanoscale 5, 11637-11642 (2013).

4. S. Y. Min et al., Large-scale organic nanowire lithography and electronics. Nat Commun 4, 1773 (2013).

5. D. S. Wiersma, A. Lagendijk, Light diffusion with gain and random lasers. Phys Rev E Stat Phys Plasmas Fluids Relat Interdiscip Topics 54, 4256-4265 (1996).

6. X. Liu et al., Random laser action from a natural flexible biomembrane-based device. Journal of Modern Optics 63, 1248-1253 (2016).

POSTER ABSTRACTS IN NUMBER ORDER

1. POLYMERIC THERMAL RESISTANT SPONGE FROM ELECTROSPUN POLY (BIS (BENZIMIDAZO) BENZOPHENANTHROLINE) NANOFIBERS

Jian Zhu[1,2], Shaohua Jiang[1], Haoqing Hou[2]*, Seema Agarwal[1] and Andreas Greiner[1]*

[1] Macromolecular Chemistry II, University of Bayreuth, Universitätsstraße 30, 95440 Bayreuth, Germany

[2] Department of Chemistry and Chemical Engineering Jiangxi Normal University, Nanchang, 330022, China.

Polybisbenzimidazobenzophenanthroline-dione (BBB, synthesized from a polycondensation of 1,4,5,8 -naphthalene tetracarboxylic acid (NTCA) and 3,3'-diaminobenzidene (DAB) is a ladder type rigid-rod polymer with a lot of aromatic and heterocyclic rings in backbone which make it a thermal resistance robust material. Unfortunately, the polymer is not processable due to its very high melting point and insolubility in organic solvents. Therefore, indirect methods need to be developed for processing into fibers and sponges. We would like to present high performance BBB nanofibers (tensile strength 1.43 GPa and modulus 34.16 GPa) prepared by electrospinning and solid state polymerization use of the corresponding fibers in making light weight thermally stable sponges. Recently, our group has shown polymeric sponges for different applications and BBB nanofibrous spong is an addition to existing sponges with a very high thermal stability.

References

[1] G. Duan, S. Jiang, V. Jerome, J. H. Wendorff, A. Fathi, J. Uhm, V. Altstaedt, M. Herling, J. Breu, R. Freitag, S. Agarwal, A. Greiner, Ultralight, soft polymer sponges by self-assembly of short electrospun fibers in colloidal dispersions, Adv. Funct. Mater 2015, 25 , 2850 -2856.

[2] G. Duan, S. Jiang, T. Moss, S. Agarwal, A. Greiner, Ultralight open cell polymer sponges with advanced properties by PPX CVD coating, Polym. Chem. 2016 , 7, 2759 , 2759 –2764.

[3] G. Duan, M. Koehn-Serrano, A. Greiner, Highly Efficient Reusable Sponge-Type Catalyst Carriers Based on Short Electrospun Fibers , Macromol. Rapid Commun. 2016, DOI: 10.1002/marc.201600511.

[4] S. Jiang, B. Uch, Agarwal, A. Greiner, Ultralight, thermally insulating, compressible polyimide fiber assembled sponges, Appl. Mater. Interf. 2017, DOI: 10.1021 acsami.7b11045.

[5] S. Jiang, G. Duan, U. Kuhn, M. Mörl, V. Altstädt, A. L. Yarin, Greiner, Spongy Gels by a Top-Down Approach from Polymer Fibrous Sponges, Angew. Chem., Int. Ed. 2017, DOI: 10.1002/anie.201611787.

2. CAN POLY(N-ISOPROPYL ACRYLAMIDE) BE ELECTROSPUN FROM WATER? YES!

Ella Schoolaert[1], Dagmar R. D'hooge[2], Richard Hoogenboom[3] and Karen De Clerck[1]

[1] Centre for Textile Science and Engineering, Department of Materials, Textiles and Chemical Engineering, Faculty of Engineering and Architecture, Ghent University, Tech Lane Science Park Campus A 907, 9052 Ghent, Belgium

[2] Laboratory for Chemical Technology (LCT), Faculty of Engineering and Architecture, Ghent University, Tech Lane Science Park Campus A 907, 9052 Ghent, Belgium

[3] Supramolecular Chemistry Group, Department of Organic and Macromolecular Chemistry, Faculty of Sciences, Ghent University, Krijgslaan 281 S4, 9000 Ghent, Belgium

Abstract

With increasing toxicity and environmental concerns, electrospinning from water, i.e. waterborne electrospinning, is crucial to further exploit the resulting nanofiber potential.[1] Most water-soluble polymers have the inherent limitation of resulting in water-soluble nanofibers and a tedious chemical cross-linking step is required to reach stable nanofibers. An interesting alternative route is the use of thermoresponsive polymers, such as poly(N-isopropyl acrylamide) (PNIPAM), as they are water-soluble beneath their lower critical solution temperature (LCST) allowing low temperature electrospinning while the obtained nanofibers are water-stable above the LCST. Moreover, PNIPAM nanofibers show major potential to many application fields, including biomedicine, as they combine the well-known on-off switching behavior of PNIPAM, thanks to its LCST, with the unique properties of nanofibers. In the present work, based on dedicated turbidity and rheological measurements, optimal combinations of polymer concentration, environmental temperature and relative humidity are identified allowing, for the first time, the production of continuous, bead-free PNIPAM nanofibers electrospun from water (Figure 1).[2] More specifically, PNIPAM gelation was found to occur well below its LCST at higher polymer concentrations leading to a temperature regime where the viscosity significantly increases without compromising the polymer solubility. This opens up the ecological, water-based production of uniform PNIPAM nanofibers that are stable in water at temperatures above PNIPAM's LCST, making them suitable for various applications, including drug delivery and switchable cell culture substrates.

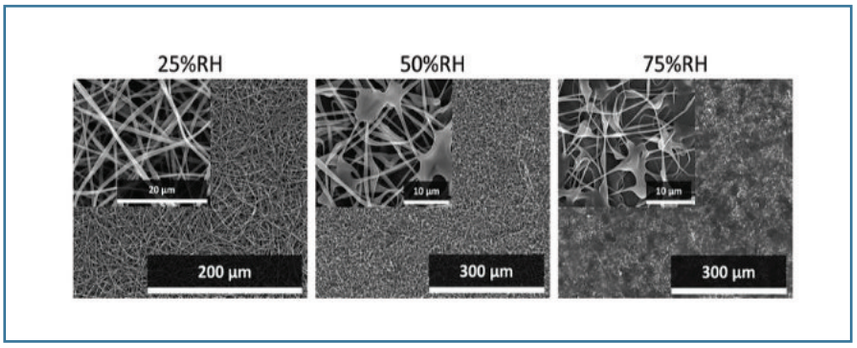


Figure 1. SEM of PNIPAM nanofibers clearly indicate a major influence of relative humidity on electrospinnability.

References

[1] L. Persano, A. Camposeo, C. Tekmen, D. Pisignano, Macromol. Mater. Eng. 2013, 298, 504.

[2] E. Schoolaert, P. Ryckx, J. Geltmeyer, S. Maji, P. H. M. Van Steenberge, D. R. D'Hooge, R. Hoogenboom, K. De Clerck, ACS Appl. Mater. Interfaces 2017, 9, 24100.

3. SILVER NANOPARTILES EMBEDDED IN THE FIBERS OF PVA/CHITOSAN BLENDS

Nompumelelo Kubheka, Makwena Moloto and Dikeledi More

Vaal University of Technology, Department of Chemistry, Private Bag X021, Vanderbijlpark, 1900, South Africa

Abstract

Electrospinning is a versatile technique commonly used by many researchers to fabricate polymer nanofibers as well as nanocomposites embedded on the polymer fibers[1,2]. In this study chitosan/ poly(vinyl alcohol) blended polymer fibers and the CS/PVA blends were incorporated with silver nanoparticles produced by electrospinning technique. The morphology, diameter and structure of the electrospun nanofibers were investigated by scanning electron microscopy (SEM), X-ray diffraction and Fourier transform infrared (FT-IR).SEM images showed that the morphology of the nanofibers were affected by the concentration of the blend solution and weight ratios prepared from 2 wt % chitosan and 20 wt % poly(vinyl alcohol) and voltage variation from 15 kV to 19 kV. The results showed that as the ratio of CS/PVA solution increased, the average fiber diameter decreased and the increment of voltage had an effect on fiber size distribution. Therefore higher voltage applied increased the charge density on the CS/PVA solution which ultimately favoured the narrowing of fiber diameter. The formation of the silver nanoparticles on the surface of the electrospun fibers were confirmed by scanning electron microscope, X-ray diffraction, ultraviolet visible spectroscopy and Fourier transform infrared.

References

[1] Mazoochi, T. and Jabbar, V. (2011). International Journal of Polymer Analysis and Characterization, (16) 277–289.

[2] More, D.S, Moloto M.J, Moloto N, Matabola K.P. (2015). Materials Research Bulletin, (65) 14–22.

4. CONTROLLING CRYSTALLINE PHASES IN ELECTROSPUN PVDF NANOFIBRES WITH ALTERING VOLTAGE POLARITY

Piotr K. Szewczyk and Urszula Stachewicz*

International Centre of Electron Microscopy for Materials Science and Faculty of Metal Engineering and Industrial Computer Science AGH University of Science and Technology, Kraków Poland

**ustachew@agh.edu.pl*

Piezoelectric polymers show a lot of potential in many materials based technologies. For instance, harvesting ambient mechanical energy at the nanometer scale holds a great promise for powering small electronic devices. Polyvinylidene fluoride (PVDF) is a semi-crystalline polymer exhibiting piezoelectric properties thanks to its crystalline content [1], which is attributed to β-phase [2]. Volume of crystalline phases in polymer nanofibres can be altered up to 80% [3] of β-phase content. In our study β-phase content in PVDF nanofibres is controlled mainly by voltage polarity during electrospinning, where we reorient F^- groups according to the charges accumulated at surfaces of polymer solution jet. PVDF crystallinity is verified using Transmission Electron Microscopy (TEM), Differential scanning calorimetry (DSC) and X-ray diffraction (XRD). Within this study we show possibility of enhancing piezoelectric properties of PVDF via voltage polarity controlled electrospinning.

References

[1] P. Sajkiewicz, A. Wasiak, and Z. Gocłowski, Eur. Polym. J., vol. 35, no. 3, pp. 423– 429, 1999.

[2] P. Martins, A. C. Lopes, and S. Lanceros-Mendez, Prog. Polym. Sci., vol. 39, no. 4, pp. 683–706, 2014.

[3] P. Taylor, C. Ribeiro, V. Sencadas, J. Luís, and G. Ribelles, no. May 2013, pp. 37–41, 2010.

Acknowledgments

The study was conducted within the funding from SONATA BIS 5 project granted by National Science Centre in Poland, No 2015/18/E/ST5/00230.

5. FORMATION OF POLYMER FIBERS BY PROTOTYPE MELT ELECTROSPINNING SYSTEM

Edvinas KRUGLY, Dalia BUIVYDIENE, Linas KLIUCININKAS and Dainius MARTUZEVICIUS

Department of Environmental Technology, Kaunas University of Technology, Kaunas, Lithuania

edvinas.krugly@ktu.lt

Melt electrospinning has emerged as an alternative polymer processing technology to alleviate concerns associated with solvents in traditional electrospinning. This has resulted in the fabrication of ultrafine fibers from an increasing range of synthetic polymers and composite systems, driving new applications in technical areas such as textiles, filtration, environment and energy as well as biomedicine [1]. Decreasing fiber diameter is one of the most challenging and important issues in melt-electrospinning. It has been demonstrated that the final fiber diameter can be decreased by decreasing melt temperature, nozzle tip diameter, flowrate, and working distance. A fiber diameter can also be decreased by increasing voltage between the nozzle and collector [2].

The prototype of melt electrospinning apparatus was made at Kaunas University of technology. Polymer was purchased from Evonik industries (Vestamid L 1600). Main variables for experiment was applied voltage, filament feeding speed and diameter of nozzle tip.

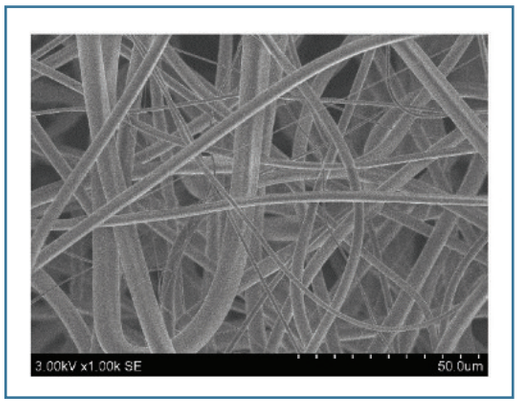


Fig. 1. The SEM image of fiber morphology

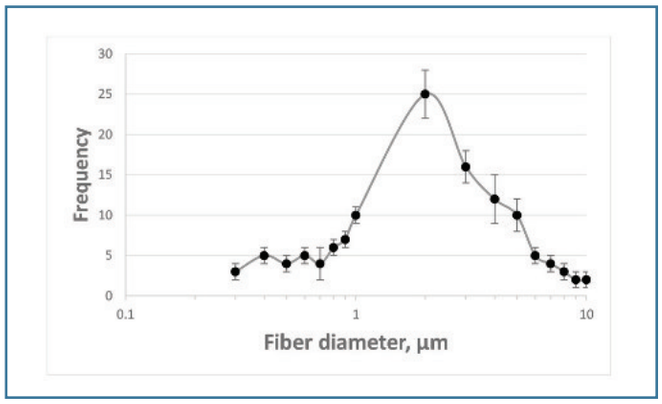


Fig. 2. The histogram of Fiber diameter

The fibers diameter was ranging from 0.29 to 10.3 μm, with average of 2.2 μm. In the near future we plan to improve melt-electrospinning system and test newly developed polymer materials to achieve average diameter of less than 1 μm.

References

1. Brown T.D., P.D. Dalton, D.W. Hutmacher, Melt electrospinning today: An opportune time for anemerging polymer process. Progress in Polymer Science, 2016. 56: p. 116–166.

2. Thompson C. J., G.G. Chase, A.L. Yarin and D.H. Reneker, Effects of parameters on nanofiber diameter determined from electrospinning model Polymer. Polymer, 2007. 48(23): p. 6913–22.

6. IMMOBILIZATION OF TITANIUM DIOXIDE NANOPARTICLES ON ELECTROSPUN CA AND PAN POLYMER NANOFIBERS FOR ANTIMICROBIAL ACTIVITY STUDY.

Sibongile C. Nkabinde[1], Makwena J. Moloto[1], Kgabo P. Matabola[2]

[1] Department of Chemistry, Faculty of Applied and Computer Sciences, Vaal University of Technology, Private Bag X021, Vanderbijlpark 1900, South Africa

[2] Nanotechnology Innovation Centre, Advanced Materials Division, Mintek, Private Bag X3015, Randburg 2125 South Africa

Abstract

Electrospinning is a method that has gained more attention due to its capability in spinning a wide variety of polymeric fibers and nanoparticles embedded polymer fibers [1]. Polymer blending has been considered the most appropriate way for creating new materials with fused properties which improve poor chemical, mechanical, thermal and dynamic mechanical properties of each polymer [2]. Hence, in this study electrospinning technique has been utilized for the preparation of single polymer composite of polyacrylonitrile (PAN) and cellulose acetate (CA) as well as the immobilization of TiO_2 nanoparticles on the polymer blended fibers. The electrospinning parameters such as polymer solution concentration (10-20wt%), spinning distance (10cm-15cm) and applied voltage (16-24kV) were investigated. The effect of the electrospinning parameters on the diameter and morphology of the electrospun polyacrylonitrile (PAN) and cellulose acetate (CA) was investigated in order to obtain optimum polymer fibers diameter for the immobilization of the TiO_2. It was observed that the solution concentration has more effect on the diameter of the polymer fibers as compared to the other electrospinning parameters. The sol-gel method was used to synthesize the TiO_2 nanoparticles. The immobilization of TiO_2 nanoparticles on the suitable polymer fibers by electrospinning technique improved antibacterial properties of TiO_2. The synthesized nanometerials and polymer nanocomposite were characterized using SEM and TEM to display their morphological features. XRD analysis were performed for revealing the chemical structure. FTIR, UV-Vis and thermal analysis confirmed the formation and composition of the nanoparticles, polymer fibers and nanofibers. The CA-TiO_2 nanofibers and PAN-TiO_2 will be tested against strains of *E. coli* and *P. aeruginosa* and *C. albicans* to observe their antibacterial activity.

References

1. MORE, D.S., MOLOTO, M.J., MOLOTO, N. & MATABOLA, K.P. (2015). TOPO-capped silver selenide nanoparticles and their incorporation into polymer nanofibers using electrospinning technique. Journal of Materials Research Bulletin. 65. p. 14-22.

2. JYOTISHKUMAR, P., SABU, T. & YVES, G. (2015). Characterization of polymer blends: miscibility, morphology, and interfaces. Priyadarshini Hills P.O. 686-560 Kottayam, Kerala India: Wiley-VCH Verlag GmbH & Co. KGaA.

7. CELL RESPONSE ON FIBRES' SURFACE PROPERTIES INDUCED BY PROCESS PARAMETERS AND POST-TREATMENT OF ELECTROSPUN NONWOVENS

Olga Urbanek*, Paweł Sajkiewicz, Filippo Pierini

Institute of Fundamental Technological Research, Polish Academy of Sciences, A. Pawińskiego 5b, 02-106 Warsaw, Poland

**Corresponding author: ourbanek@ippt.pan.pl*

Cellular response on materials characteristics depends on various factors eg. chemical composition, topography, wettability, mechanical properties etc.[1, 2, 3]. Materials' surface properties may be optimized by both selection of proper forming method and process parameters as well as post-processing treatment. In electrospinnig, the polymer solution jet is elongated by electrostatic forces occurring between a needle connected to high voltage supply and a grounded collector. In this case various parameters may influence final material surface properties, eg. solvent, voltage, flow rate, humidity, temperature etc. Most of them were widely studied [4, 5]. However, in case of processing polyelectrolytes by this method, like chitosan, also charge polarity applied to the spinning nozzle may play a significant role for surface properties [6, 7]. Repulsive forces between polycations/polyanions and charge accumulated on the spinning nozzle may cause multi-jet electrospinning or phase separation within the fibres' bulk [6, 7].

In this research polycaprolactone/ chitosan (PCL/CHT) blends were processed by electrospinning. In order to vary surface properties of obtained nonwovens two techniques were used: process parameters were changed (positive and negative charge polarity was applied to the spinning nozzle) and post-processing treatment was

conducted (embedding of chondroitin sulphate (CS) to fibres' surface was conducted by layer-by-layer technique (LbL)). Finally, cell response on this changes was analyzed.

The data revealed that fibres' morphology varied depending on charge applied to the spinning nozzle, ultimately influencing mechanical properties of obtained nonwovens. Moreover, depending on the applied charge polarity different wettabilities of the same PCL/CHT blend was obtained. XPS data showed that negative charge polarity caused higher efficiency of further post-processing treatment. Also AFM images proved changes in fibres' surface topography. In order to study the effect of process parameters and post-processing treatment by CS, cell studies with fibroblasts and chondrocytes were conducted. Our results revealed that mitochondrial activity of analyzed cells was sensitive to both features, however, their effect may be observed in different time points of cell culture. All described changes in cell proliferation of the fibres occurred in the range of high biocompatibility of the materials.

Acknowledgment

The project was supported by the National Science Centre Grant No. PRELUDIUM 2014/15/N/ST8/03757.

References

1. Gong Y, ZhuY, Liu Y, Ma Z, Gao C, Shen J. Acta Biomaterialia 2007; 3(5) : 677e685.
2. Silva JM, Georgi N, Costa R, Sher P, Reis RL, Van Blitterswijk CA, Mano JF. PLoS One 2013; 8 (2) : e55451.
3. Liu Y, He T, Gao Ch, Colloids and Surface B: Biointerfaces 2005; 46 : 117-126.
4. Haider S, Haider IK, Kang. Arab. J. Chem. 2015; https://doi.org/10.1016/j.arabjc.2015.11.015.
5. Kołbuk D, Guimond-Lischer S, Sajkiewicz P, Maniura-Weber K, Fortunato G. Int. J. Polym. Mater 2015; 64 (7) : 365e377.
6. Terada D, Kobayashi H, Zhang K, Tiwari A, Yoshikawa C, Hanagata N. Sci Tech Adv Mat 2012; 13 : 015003.
7. Stachewicz U, Stone CA, Willis CR, Barber AH. J. Mat. Chem. 2012; 22 : 22935- 22941.

8. SUPERHYDROPHOBIC SURFACES VIA GREEN ELECTROSPINNING FROM AQUEOUS DISPERSIONS

Lu Chen[a], Seema Agarwal[a], Andreas Greiner[a]

[a] *University of Bayreuth, Macromolecule Chemistry and Bavarian Polymer Institute, Universitätsstraße 30, 95440 Bayreuth, Germany*

Superhydrophobic surfaces are well-studied and widely applied like self-cleaning textiles, biomedical, and antifouling coatings. [1,2] By combination of rough surface morphologies, which could be produced by green electrospinning, and low surface energy materials, this multifunctional surfaces could be generated from aqueous formulations. [3, 4]

In our work [5, 6], as-spun fiber mats were obtained by green electrospinning of aqueous fluoroacrylate dispersions and coated with siloxane via sol-gel treatment. The nanofibers had very rough porous surface morphology. As a result, contact angle to water increased from less than 50° for untreated fiber mats up to 165° for siloxane coated nonwovens. In addition, the roll-off angle was less than 5°. Therefore the nonwovens showed excellent self-cleaning properties and are ready for other applications in combination with a green approach.

Fig. Water droplets on superhydrophobic nonwovens prepared by green electrospinning.

[1] Z. Guo, W. Liu. Biomimic from the superhydrophobic plant leaves in nature: Binary structure and unitary structure. Plant Science. 2007, 172, 1103.

[2] Y. Yan, N. Gao, W. Barthlott. Mimicking natural superhydrophobic surfaces and grasping the wetting process: A review on recent progress in preparing superhydrophobic surfaces. Advances in Colloid and Interfaces Science, 2011, 169, 80.

[3] S. Agarwal, A. Greiner. On the way to clean and safe electrospinning—green electrospinning: emulsion and suspension electrospinning. Polym. Adv. Technol. 2011, 22, 372.

[4] K. Bubel, Y. Zhang, Y. Assem, S. Agarwal and A. Greiner. Tenside-Free Biodegradable Polymer Nanofiber Nonwovens by "Green Electrospinning". Macromolecules 2013, 46, 7034.

[5] M. Doimoto, S. Agarwal, A. Greiner, in preparation.

[6] L. Chen, A. Greiner, in preparation.

9. TOWARDS ANTIMICROBIAL, BIOCOMPATIBLE, BIODEGRADABLE SCAFFOLDS: A STUDY ON POLYCAPROLACTONE

Feziwe Bathabile Mamba; Bert Klumperman, Rueben Pfukwa, Nonjabulo Prudence Gule*

University of Stellenbosch, Department of Chemistry and Polymer Science, Stellenbosch, South Africa

Abstract

Poly (ϵ-caprolactone) (PCL) has gained a lot of attention in recent years, and has shown great potential in biomedical applications. Among synthetic polymers, PCL is one of the easiest to process and manipulate into a large range of shapes and sizes due to its low melting temperature and its superior viscoelastic properties [1-2]. PCL is also biodegradable and biocompatible [2]. In this study, a block copolymer of ϵ-caprolactone and a functionalized derivative of caprolactone was synthesized via ring opening polymerization (ROP). The block copolymer was functionalized using alkyl halides to induce antimicrobial properties. The synthesized polymers were characterized using gel permeation chromatography (GPC) to determine their molecular weight distribution. Nuclear magnetic resonance (1H NMR and 13C NMR) as well as Fourier transform infra-red spectrometry were used to elucidate the structures of the polymers. The electrospinning technique was used to fabricate the scaffolds. These scaffolds were characterized using scanning electron microscopy (SEM) and transmission electron microscopy (TEM). These scaffolds will be evaluated for their potency against methicillin Resistant Staphylococcus aureus (MRSA) and Pseudomonas aeruginosa which are very persistent bacteria in the clinical environment [3]. The scaffolds will also be investigated for their ability to naturally degrade.

Corresponding author: njabu@sun.ac.za

References

1. Mohammed Abedalwafa, Fujun Wang, Lu Wang and Chaojing (2013) Rev. Adv. Mater. Sci. 34 123-140

2. Bret D. Ulery, Lakshmi S. Nair, and Cato T. Laurencin (2011) Biomedical Applications of Biodegradable Polymers, J Polym Sci B Polym Phys. 49(12): 832–864.

3. Christopher Attinger and Randy Wolcott (2012), Clinically Addressing Biofilm in Chronic Wounds Adv Wound Care (New Rochelle). (3) 127–132.

10. NOVEL ANTIMICROBIAL SILK-CELLULOSE COMPOSITE FOR APPLICATION IN WATER TREATMENT

Priscilla Nyakombi[1]; Fritz Vollrath[2], Bert Klumperman[1], Nonjabulo Prudence Gule[1]*

[1] University of Stellenbosch, Department of Chemistry and Polymer Science, Stellenbosch, South Africa

[2] Department of Zoology, University of Oxford, Oxford OX13PS, UK

Abstract

In 1600, the first record of the electrostatic attraction of a liquid was observed by William Gilbert [1]. Since its genesis, this process has undergone tremendous development and is continuing to reach new ground in recent years. Electrospinning is a simple and yet versatile technique to fabricate unique nanostructured membranes with fascinating properties for a wide spectrum of applications. Electrospinning of biopolymers down to nanoscale sizes has received a lot of interest to address most of the millennia issues. This includes the medical fields and fields related to water treatment. The main aim of this study was to fabricate silk fibroin-cellulose (SF/CE) nanofiber composites via the electrospinning method to be evaluated as water filtration applications. Both cellulose and silk are natural fibres which degrade naturally. They have exceptional mechanical properties. Therefore from an environmental friendliness point of view this would be advantageous. Additionally, both materials are mechanically strong and therefore can withstand the pressures associated with water treatment. As a bonus, silk fibres are known to be antimicrobial, hence it is envisaged that fibres from these two biopolymers will be antimicrobial which opens up a whole range of applications for the fibres. Randomly oriented SF/CE nanofibrous mats were developed with average diameters averaging at about 153 ± 28 nm. The mats were characterized for morphology using scanning electron microscopy and transmission electron Microscopy, structurally using X-ray diffraction and Fourier Transform Infra-red spectrometry. To establish thermal stability of the fabricated composites when compared to the pure polymers, differential scanning calorimetry and thermal gravimetric studies were conducted. Activity against gram negative and gram positive bacteria as well as biodegradability experiments are underway.

Corresponding author: njabu@sun.ac.za

References

1. Nick Tucker, Jonathan J. Stanger, Mark P. Staiger, Hussam Razzaq, Kathleen Hofman, (2012) The History of the Science and Technology of Electrospinning from 1600 to 1995. Journal of Engineered Fibers and Fabrics SPECIAL ISSUE-FIBERS 63-73.

11. MODIFIED CHITOSAN AND STYRENE-ALT-MALEIC ANHYDRIDE NANOFIBERS AS MTB AFFINITY SUBSTRATES

[1]Marica Smit, [2]Marietjie Lutz

[1,2] Department of Chemistry and Polymer Science, Stellenbosch University, Private Bag X1, 7602 Matieland, South Africa.

The World Health Organization (WHO) found that 10.4 million people died of tuberculosis (TB) in 2015 which makes TB the number one cause of death from a preventable infectious disease worldwide.[1] *Mycobacterium tuberculosis (Mtb)* is the causative pathogen of tuberculosis and a frequent lack of clinical symptoms hampers the pathogen's detection. Current diagnostic tests are limited when applied to low populations of bacteria in biological fluids, such as blood.[2] A large volume of biological fluid is needed for a positive diagnosis. Obtaining multiple samples are however difficult, especially from children under six years. A smaller amount of biological fluid is needed if the *Mtb* can be captured and concentrated within the sample. Nanofibers with affinity for the pathogen can be used as capturing substrates for *Mtb* followed by diagnosis via fluorescence microscopy.

In this study polymers and functional moieties with known *Mtb* affinity was investigated as capturing substrates. Chitosan, a natural polysaccharide, possesses favourable properties, such as non-toxicity, antibacterial activity and bacterial adhesion. The quaternary derivatives of N-alkyl chitosan have shown to have a higher bacterial activity than pristine chitosan.[3] Poly(styrene-*alt*-maleic anhydride)(SMA) can be used as biological substrate due to its low toxicity, bacterial adhesion and good biocompatibility. Concanavalin A (Con A) immobilized to chitosan and SMA is a well-studied carbohydrate-binding protein and human receptor for the carbohydrate-based structures on the surface of *Mtb*, such as mannose. The interaction between these human receptors and mycobacterial mannose can facilitate the capture and concentration of *Mtb*. These polymers can be incorporated into nanofibers that were produced via single needle electrospinning and used as *Mtb* capturing platforms. A dilution study utilizing fluorescent plasmid tagged bacillus calmette-guerin (BCG-mCherry) strain of *Mtb* determined which polymer and functional moiety combination had the best capturing capability. Quaternized SMA and Con A functionalized chitosan nanofibers has illustrated favourable bacterial adhesion, as seen by fluorescence microscopy of the BCG-mCherry treated nanofibers Fig 1.

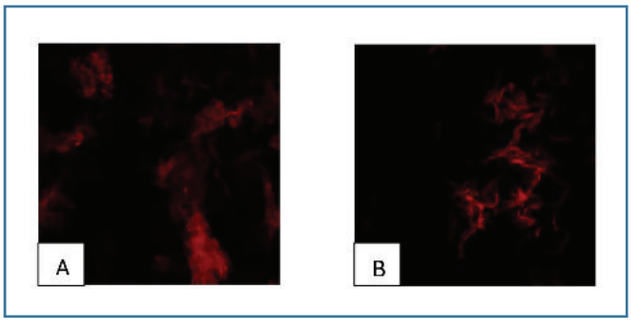


Fig 1: Fluorescence microscopy images of A) SMI-qC_{12} and B) chitosan-Con A nanofibers treated with BCG-mCherry (OD7)

Acknowledgements

This work is based on the research supported by the National Research Foundation (NRF) of South Africa.

References

[1] Schito, M., Hanna, D. & Zumla, A. Tuberculosis Eradication versus Control. Int. J. Infect. Dis. (2016).

[2] Kaittanis, C., Santra, S. & Perez, J. M. Emerging nanotechnology-based strategies for the identification of microbial pathogenesis. Adv. Drug Deliv. Rev. 62, 408–423 (2010).

[3] Sahariah, P. et al. Impact of chain length on antibacterial activity and hemocompatibility of quaternary N-alkyl and N, N-dialkyl chitosan derivatives. Biomacromolecules 16, 1449–1460 (2015).

12. HIERARCHICAL ORGANIC/INORGANIC COMPOSITE HOLLOW FIBROUS ARCHITECTURES COMPOSED OF FE2O3 HOLLOW GRAINS AND IN -SITU GROWN CARBON NANOTUBES FOR LITHIUM -OXYGEN BATTERIES

Ji-Soo Jang,[a] Ji-Won Jung,[a] and Il-Doo Kim*,[a]

[a] Department of Materials Science and Engineering, Korea Advanced Institute of Science and Technology (KAIST), 291 Daehak-ro, Yuseong-gu, Daejeon, 34141, Republic of Korea

Lithium-oxygen batteries (LOBs) have been considered as one of the most viable energy source options for electric vehicles (EVs) due to their high-energy density. However, they are still faced with technical challenges such as low round-trip efficiency and short-cycle life; these mainly originate from cathode part in battery. In this work, we designed 3D nanofibrous air electrode consisted of hierarchically structured CNT bridged hollow Fe_2O_3 nanoparticles (H-Fe_2O_3/CNT NFs). The immiscible co-polymer (PAN/PMMA)/Fe presursors based electrospining was intentionally set up for rationally designing the porous structures as well as in-situ growing multiple CNT nanobranches on surface of catalytic Fe_3C NPs. Due to the selective thermal decompostion of PMMA during 1st heat treatment, highly porous structures as well as CNT growth was simultaneously achieved. Furthermore, Kirkendall effect driven phase conversion of Fe_3C NPs to hollow Fe_2O_3 NPs occurred during 2nd step air heat treatment, forming H-Fe_2O_3/CNT NFs. Composite nanofibers consisted of hollow Fe_2O_3 NPs anchored by multiple CNTs offered enhanced catalytic sites (interconnected hollow Fe_2O_3 NPs) and fast charge transport highway (bridged CNTs) for facile formation and decomposition of Li_2O_2, leading to outstanding cell performance: (1) Swagelok cell exhibited highly reversible cycling characteristics for 250 cycles with a fixed capacity of 1000 mAh g^{-1} at a current density of 500 mA g^{-1}. (2) A module composed of two pouch-type cells stably powered a LED lamp operated at 5.0 V.

13. PREPARATION AND CHARACTERIZATION OF ELECTROSPUN NANOCOMPOSITE PHOTO-CATALYSTS FOR VOCS PHOTO-OXIDATION

Michele Modesti*[1], Martina Roso[1], Carlo Boaretti[1] and Alessandra Lorenzetti[1]

[1] University of Padova, Department of Industrial Engineering, Italy

Email: michele.modesti@unipd.it, +39-0498275541

Abstract

Composites catalytic systems based on Graphene oxide, TiO_2 and Ag_2CO_3 are produced in order to enhance the photocatalytic performance of the neat TiO_2. The effect of semiconductors coupling and graphene addition can be explained looking at e^-/h^+ pairs that are generated both in TiO_2 and Ag_2CO_3 under UV light irradiation. In presence of graphene oxide, upon excitation of TiO_2, the photo-generated electrons in the conduction band (CB) of TiO2 can easily transfer to the CB of Ag_2CO_3 and in turns to GO while holes can transfer from the valence band (VB) of the TiO_2 to that of Ag_2CO_3, leading to charge separation.

Three different composites were developed for further characterization:

- a binary composite containing TiO_2 and Ag_2CO_3 both by coupling (TiO_2 + Ag_2CO_3) and by simple mixing (TiO_2-Ag_2CO_3), with a relative composition of 70:30 on mass basis in order to obtain the same ratio of the two components as in the ternary composite
- a ternary composite containing TiO_2, Ag_2CO_3 and graphene oxide (TiO_2 + Ag_2CO_3 + GO) with the proportions 70:29.5:0.5 on mass basis to obtain a similar composition with respect to previous case and analyse the effect of the addition of graphene oxide
- a binary composite containing Ag_2CO_3 and graphene oxide (Ag_2CO_3 + GO) with a 2% content of graphene oxide on mass basis in order to obtain the same mass ratio of the two components as in the case of the ternary compound

The single TiO_2 and composites photocatalysts selected for the subsequent work have been analyzed by XRD and FT-IR techniques to identify their successful synthesis and coupling, analyzed by UV-visible diffuse reflectance spectroscopy to identify their light absorption characteristics and investigated by electron microscopy to evaluate their coupling and morphological features. All the catalytic systems were subsequently electrospun, with a proper amount of polymer, in order to obtain an “active” filter media for VOCs abatement.

14. DEVELOPMENT OF ULTRA/NANOFILTRATION COMPOSITE MEMBRANES BASED ON CHITOSAN COATING ON CROSSLINKED NANOFIBROUS ALGINATE SCAFFOLD

T.C. Mokhena[1,2], A.S. Luyt[3].

[1] CSIR Materials Science and Manufacturing, Polymers and Composites, Port Elizabeth, South Africa

[2] Department of Chemistry, University of the Free State (Qwaqwa Campus), Private Bag X13, Phuthaditjhaba, South Africa

[3] Center for Advanced Materials, Qatar University, PO Box 2713, Doha, Qatar

The disparity between the current population growth and water availability/supply necessitates novel strategies to either reduce wastewater discharge or decontaminate the available water without generating harmful by-products. Electrospinning affords the production of nanofibrous membranes from synthetic and natural polymers. The resulting fibres have diameters ranging from a few nanometers to a few micrometers with unique properties such as high porosity, interconnectivity and large-surface-to-area ratio which enticed researchers to explore their utilization in various filtration applications. In this study a high flux three-tier composite membrane composed of a coating layer based on chitosan and chitosan with silver nanoparticles, electrospun alginate nanofibres as a midlayer and nonwoven as a mechanical support substrate was developed. Electrospinnable synthetic polyethylene oxide (PEO) was used to enhance the spinnability of alginate, and ionically crosslinked with calcium chloride followed by chemical crosslinking using glutaraldehyde. The silver nanoparticles were synthesized by a simple and environmentally friendlier method using chitosan as a stabilizing and reducing agent with the aid of thermal treatment. In comparison with the commercially available membrane, the chitosan and silver nanoparticles containing chitosan coated membrane displayed a higher flux rate and oil rejection. Furthermore, the presence of silver nanoparticles improved the dye rejection with more 95% rejection throughout the filtration cycles test.

15. METAL-ORGANIC FRAMEWORK DERIVED HETEROGENEOUS CATALYSTS LOADED ON WO_3 NANOFIBERS ACETONE GAS SENSORS

Won-Tae Koo, Pyo-Huck Kwon, Ji-Soo Jang, Dong-Ha Kim, and Il-Doo Kim*

Department of Materials Science and Engineering, Korea Advanced Institute of Science and Technology (KAIST), 291 Daehak-ro, Yuseong-gu, Daejeon 34141, Republic of Korea

Semiconductor metal oxide (SMO)-based volatile organic compound sensors are getting much attention due to its future possibilities for portable applications with the low cost fabrication. Increase of surface area and catalytic sensitization should be accompanied to achieve highly sensitive and selective gas sensors using SMO-based materials. In this work, we propose PdO catalyst-functionalized Co_3O_4, loaded on WO_3 nanofibers (PdO-Co_3O_4-WO_3NFs) by using Co based zeolite imidazole framework (ZIF-67) templates. Catalytic Pd NPs (2–3 nm) were encapsulated in the cavities of the ZIF-67 by the reduction of Pd ions. Then, electrospinning solution solution was prepared by di prepared by dispersing Pd-functionalized ZIF-67 (Pd-ZIF-67) and polyvinylpirrolidone (PVP), and dissolving tungsten precursor $[(NH_4)_6H_2W_{12}O_{40}{\cdot}xH_2O]$ in DI-water. PdO-Co_3O_4-WO_3 NFs were finally achieved by electrospinning and following calcination at 500°C for 1 h. The calcination of Pd-ZIF-67 produced PdO-Co_3O_4 heterogeneous catalysts and mesopores in sensing materials, which are essential for superior gas sensors. PdO-Co_3O_4-WO_3 NFs exhibited 5-fold higher acetone response (Rair/Rgas = 13.1 to 5ppm at 350°C) compared with that (Rair/Rgas = 2.6) of pristine WO_3 NFs. In addition, PdO-Co_3O_4 -WO_3NFs exhibited improved sensing characteristics, in terms of detection limit, response time, recovery time, and selectivity. These results demonstrate that the facile synthesis of heterogeneous catalyst loaded SMO NFs by using MOF template, which can shed light on next-generation gas sensors.

16. A POLYMER/MWCNT/C60 FIBER NANOCOMPOSITE WITH ELECTRICAL SWITCHING BEHAVIOR

Fabricio N. Molinari[1], Anahí V. Medrano[2], Leandro N. Monsalve[2,3]

[1] INTI Textiles Av. Gral. Paz 5445 (B1650WAB), San Martín, Bs.As, Argentina.

[2] INTI CNMB Av. Gral. Paz 5445 (B1650WAB), San Martín, Bs.As, Argentina.

[3] CONICET- INTI Av. Gral. Paz 5445 (B1650WAB), San Martín, Bs.As, Argentina.

fabricio@inti.gob.ar

Electrospinning technique allows the production of functional nanofibers that can be deposited as thin and lightweight layers for the fabrication of electronic devices. For instance they have been already used for the fabrication of strain gages[1] and field effect transistors[2]. On the other hand, fullerene C60 is a semiconductor carbon allotrope that can be applied as active material in electronic devices. For example, composite materials of C60 syndiotactic polymethylmethacrylate (PMMA) showed electrical switching behavior[3]. This material has been used as thin layer deposited by spin coating technique. The functional properties of this material are due to the formation of nanostructured complexes between the PMMA and C60.

In this work, we decided to explore the possibility of fabricating a resistive switching device using electrospun composite fibers made of polycaprolatone(PCL), multiwalled carbon nanotubes (MWCNT) and C60 as active material. The composite material was prepared and characterized by DSC, Raman, SEM and their electrical properties. Resistive switching behavior of PCL/MWCNT/C60 fibers has been addressed as a permanent increase of fiber conductivity upon the application of electric potential that can be adjusted to different levels of conductivity. This effect has been achieved using less than 1.5% MWCNT and 1% C60.

In conclusion, a functional composite material with electric switching behavior has been processed by electrospinning and characterized. This material can be applied as thin layers for economic and large area fabrication of memory devices.

[1] Molinari, F.; Escobar, G.; Mass, M.; Lio, A.; Delgado Simao, C.; Lacharmoise, P.; Monsalve, L. "Production of flexible strain sensor using PCL/MWCNTs electrospun fibers. Electrospin 2016 28/6-02-7, Otranto, Italy

[2] Lee, S. W.; Lee, H. J.; Choi, J. H.; Koh, W. G.; Myoung, Jae M; Hur, Jae H; Park, Jong J; Cho, Jeong H; Jeong, Unyong Periodic array of polyelectrolyte-gated organic transistors from electrospun poly(3-hexylthiophene) nanofibers. Nano Lett. 10 (2010) 347 – 351

[3] S. Qi, H. Iida, L. Liu, S. Irle, W. Hu, E. Yashima "Electrical Switching Behavior of a [60]Fullerene-Based Molecular Wire Encapsulated in a Syndiotactic Poly(methyl methacrylate) Helical Cavity". Angew. Chem. Int. Ed. 2013, 52, 1049 –1053

17. FABRICATION OF ALIGNMENT-CONTOLLED NANOFIBERS AND ITS AIR FILTRATION PERFORMANCE

Wontae Hwang, and Il-Doo Kim†,*

Department of Materials Science and Engineering, Korea Advanced Institute of Science and Technology 291 Daehak-ro, Yuseong-gu, Daejeon 34141, Republic of Korea

Electrospinning is the most widely used one in the research community due to its low cost and simple configuration [1]. However, a conventional electrospinning has shown limitations due to its non-woven structure, and it has been an obstacle for electrospun nanofibrous membranes to be adopted into various applications which need to control its pore size accurately. In the case of air-filtration field, nanofibers have been considered as a next generation material of filtration medium, but the performance which only consist of non-woven nanofibers have shown worse typically [2]. In this work, alignment-controlled nanofibers as a medium of air-filter have been fabricated by insulating-block electrospinning [3], and its air filtration performance was characterized. Various nanostructures of the samples with alignment-controlled nanofibers have been fabricated by controlling the process variables including nanofiber stacking method and collector moving speed. The results indicate that there is an optimal structure of nanofiber filter media for better air filtration performance.

References

1. X. Lu, C. Wang, and Y. Wei, "One-Dimensional Composite Nanomaterials: Synthesis by Electrospinning and Their Applications," Small, vol. 5, no. 21, pp. 2349–2370, 2009.

2. Si, Y., Tang, X., Yu, J. & Ding, B. Electrospun Nanofibers for Energy and Environmental Applications. Nanostructure Sci. Technol. 525 (2014). doi:10.1007/978-3-642-54160-5

3. W. Hwang, C. Pang, and H. Chae, "Fabrication of aligned nanofibers by electric-field-controlled electrospinning: insulating-block method," Nanotechnology, vol. 27, no. 43, p. 435301, 2016.

18. NANOSTRATEGIES IN FE SUPPLY TO PLANTS

F. De Cesare[a,b], F. Pietrini[c], V.Patti[c], M. Zacchini[c], G. Scarascia Mugnozza[a], A. Macagnano[b]

[a] *Department for Innovation in Biological, Agro-food and Forest Systems (DIBAF), University of Tuscia, 01100 Viterbo, Italy*

[b] *Institute of Atmospheric Pollution Research (IIA), National Research Council (CNR), 00016 Monterotondo (Rome), Italy*

[c] *Institute of Agro-Environmental and Forest Biology (IBAF), National Research Council (CNR), 00016 Monterotondo (Rome), Italy*

Modern agriculture is characterised by the employment of novel approaches, strategies, implements, products and tools aimed at improving crop yields to fulfil the need for food of the increasing human population and reducing the impact on environment and natural resources. To achieve this goal, novel types of fertilisers with greater efficiency and lower impact are necessary. Recently, more natural strategies and eco-friendly materials have been employed. Iron is a metal element that is essential for the metabolic activities of living organisms, especially in mitochondria and chloroplasts. It is required by organisms in traces and for this reason it is considered a micronutrient but beyond thresholds, depending on the organism, iron results toxic. The chemical species of iron depend on the redox condition of the environment. In the prevalently oxic conditions of terrestrial ecosystems, iron is mostly present in the ferric form Fe(III). This oxidised form, however, is mostly insoluble in water solutions, except for very acidic conditions. The absorption of this essential element is then difficult for plants and microorganisms; however, the latter have evolved various mechanisms on purpose, under iron limited conditions. In a case, organic compounds named siderophores are released, which act as specific and efficient ferric iron chelating agents that can be transported into the cytoplasm where they release iron. Plants can also release organic compounds with similar attitude (phytosiderophores).

Electrospinning is a versatile nanotechnology providing the possibility to create fibrous matrices in both free-standing and film coating forms for a large number of applications. Such versatility results from the multitude of polymers (potentially mixed in blends either) that can be electrospun to obtain fibres in the range from nano to microscale, arranged in 2D and 3D frameworks. These nanofibrous scaffolds can retain a variety of properties (physical, chemical and biological) that can be further implemented by post-processing functionalisations. In the present study, a PCL/PHB biodegradable electrospun matrix was used to load various classes of siderophores to be used as biostimulants to provide iron to plants. Specifically, duckweeds (*Lemna gibba L.*), the smallest representative of vascular plants and ecological indicator of chemical contaminations in aquatic environments, were used to evaluate the potential toxic effects of the nanofibrous products (NSs) created. Distinct treatments were fixed to test the effectiveness and toxicity of the NSs in hydroponic culturing conditions. Plants were tested for limiting iron (Fe^{3+}) concentrations and starved plants were resupplied with soluble Fe^{3+} to test the recovery capacity of plants. Two strategies for nanoproducts were investigated for their capacity to provide iron to starved plants: i) addition of siderophore-loaded NSs (SLNSs); ii) addition of Fe-chelating SLNSs (FeSLNSs). Spatio-temporal changes in photosynthetic efficiency were monitored by imaging chlorophyll fluorescence to evaluate Fe deficiency and the potential toxic effects of the nanoproducts on plants. Results are here reported and discussed.

19. ELECTROSPUN NANOFIBERS: POST AND PRE FUNCTIONALIZATION, CHARACTERIZATION AND APPLICATION

Omolola E. Fayemi[1,2]

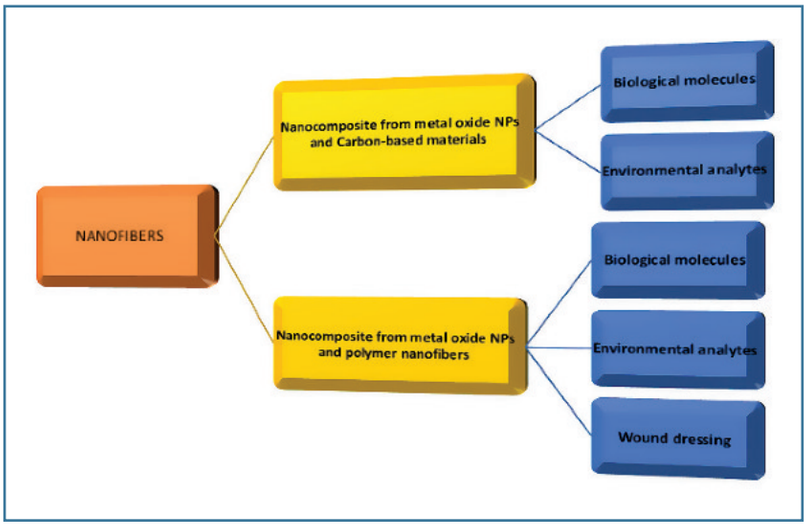
[1] *Department of Chemistry, School of Mathematics and Physical Sciences, Faculty of Agriculture, Science and Technology, North-West University (Mafikeng Campus), Private Bag X2046, Mmabatho 2735, South Africa.*

[2] *Material Science Innovation and Modelling (MaSIM) Research Focus Area, Faculty of Agriculture, Science and Technology, North-West University (Mafikeng Campus), Private Bag X2046, Mmabatho 2735, South Africa.*

**Corresponding author: 25704168@nwu.ac.za; Material Science Innovation and Modelling (MaSIM) Research Focus Area, Faculty of Agriculture, Science and Technology, North-West University (Mafikeng Campus), Private Bag X2046, Mmabatho 2735, South Africa; Tel: +27183892440*

Abstract

Nanotechnology is playing an increasing important role in separation science and also the development of biosensor. Recently, electrochemical biosensors based on nanostructured metal oxides gained much attention in the field of health care for the management of various important analyte in a biological system. This work present different electrospun nanofibers used in the research group for various applications. It also explore the unique properties of nanostructured metal oxides in the area of their excellent catalytical properties for biological molecules. In this highlight, various nanostructured metal oxides were used for fabrication of electrochemical biosensor and assembling procedures of these nanosensors. The evaluation showed that they can be used for detection of various biological and environmental molecules and achievement of high sensitivity and selectivity with low detection limits. It has been observed that the sensitivity and performance of nanostructured metal oxide based biosensors is improved when incorporated into the nanofiber. The use of these metal oxide nanostructured materials has allowed the introduction of many new signal transduction technologies in biosensors.



20. NOVEL METHOD FOR THE ELECTROSPINNING OF (+)-CAMPHOR-10-SULFONIC ACID DOPED POLYANILINE FIBERS

Maryanne Ellen Spiers, Daniel Eldridge and Peter Kingshott
Faculty of Science, Engineering & Technology, Swinburne University of Technology, John Street, Hawthorn, Victoria 3122, Australia

David Nielsen and Karl Pavey
Land Division, Defence Science and Technology Group, 506 Lorimer Street, Fishermans Bend, Victoria 3207, Australia

Yen Bach Truong
Manufacturing Unit, Commonwealth Scientific and Industrial Research Organization, Research Way, Clayton South, Victoria 3168, Australia

Gregory C. Rutledge
Department of Chemical Engineering, Massachusetts Institute of Technology, 77 Massachusetts Avenue, Cambridge, Massachusetts 02134, United States

A novel method is presented for the dissolution and electrospinning of high molecular weight polyaniline doped with (+)-camphor-10-sulfonic acid. This work builds on recent advances in emeraldine base (polyaniline) solubility, which use small amounts of a secondary amine ‘gel inhibitor’ to prevent self-association and precipitation in common organic solvents [1]. For direct processing of the acid-doped polyaniline, a tailored solvent system is proposed, where a gel inhibitor facilitates undoped polyaniline dissolution, while a small fraction of non-solvent

inhibits self-association after conversion to the emeraldine salt form. The resulting polymer solution was used to produce novel 50:1 doped polyaniline/polyethylene oxide fibers, with a diameter that approaches the nanoscale (5-8 μm). By increasing the purity, molecular weight and surface area of electrospun doped polyaniline fibers, improvements over previously reported conducting nanofiber's chemiresistive properties may be accessed.

References

1. DALI, Y & MATTES, BR 1999. Investigation of Gel Inhibitor Assisted Dissolution of Polyaniline: A case study for Emeraldine Base, 2-Methyl-Aziridine, and N-Methyl-Pyrrolidone. Synthetic Metals, 101, 746-749

21. CROSSLINKING OF BICOMPONENT NANOFIBRES FROM ALTERNATIVE SOLVENT SYSTEM

Judyta Dulnik, Paweł Sajkiewicz

Laboratory of Polymers and Biomaterials, Institute of Fundamental Technological Research, Polish Academy of Sciences; Pawińskiego 5B, 02-106 Warsaw, Poland

jdulnik@ippt.pan.pl, psajk@ippt.pan.pl

Abstract

Synthetic polymers exhibit good and tunable mechanical properties and can be easily processed, but they lack bioactivity that only natural polymers can provide. Combining the two types of polymers – synthetic and natural, when designing scaffolds for tissue engineering, can be an answer to this problem.

In our laboratory, we optimized the method of obtaining bicomponent nanofibers made of polycaprolactone (PCL) with an addition of gelatin, through electrospinning from a green, cheap and safe for the operator solvent system – a mixture of acetic and formic acid [1]. Unfortunately, further *in vitro* biodegradation studies showed fast biopolymer leaching from the fibres. With loss of gelatin in the fibre structure and on its surface the biofunctionality if a material decrease. It is reflected in its hydrophilicity and can be observed in scanning microscope images (SEM) [2].

The solution to this predicament is crosslinking of gelatin within the fibre. We decided to investigate a set of different chemical crosslinking methods to discern which is the optimal one. Four crosslinking agents were chosen: genipin, 1-ethyl-3-(3-dimethylaminopropyl) carbodiimide hydrochloride (EDC), ether 1,4-butanediol diglycidylether (BDDGE) and transglutaminase. One material type, PCL with gelatin in 7:3 ratio underwent crosslinking with all these compounds. For each of the crosslinking agents a number of configurations of crosslinking conditions was applied with different concentrations in crosslinking solution, types of solvent, duration.

Crosslinking was than assessed by measuring the weight change of a sample (and by that the loss of gelatin mass) after crosslinking process and again after 24 hours of biodegradation test. SEM imaging and wettability measurements were also performed to determine how different crosslinking methods and conditions influence samples' morphology and surface properties. The results let as to optimize some of crosslinking conditions and decide which of those methods are more effective in preserving gelatin in bicomponent fibres.

Acknowledgement

This work was funded by the Polish National Science Center (NCN) under the Grant No.: 2015/17/N/ST8/02027.

[1] P. Denis, J. Dulnik, P. Sajkiewicz, "Electrospinning and Structure of Bicomponent Polycaprolactone/Gelatin Nanofibers Obtained Using Alternative Solvent System", International Journal Of Polymeric Materials and Polymeric Biomaterials, 64 (2015), 354-364.

[2] J. Dulnik, P. Denis, P. Sajkiewicz, D. Kołbuk, E. Choińska, "Biodegradation of bicomponent PCL/gelatin and PCL/collagen nanofibers electrospun from alternative solvent system" Polymer Degradation and Stability, 130 (2016), 10-21.

22. ELECTROSPINNING OF CHITOSAN/PLA BASED NANOCOMPOSITE FIBER MATS REINFORCED WITH CHITIN NANOWHISKERS FOR WOUND DRESSING APPLICATIONS

Mauritz Pretorius, Marietjie Lutz

Department of Chemistry and Polymer Science, Stellenbosch University, Stellenbosch, South Africa

Abstract

Chitosan has been widely studied for use in the biomedical industry. This natural, biodegradable polymer, isolated from crustacean shells that exhibit excellent biocompatibility, anti-microbial properties and scar reduction properties is thus an attractive polymer for use in possible wound dressing applications. Neat chitosan however exhibits poor mechanical properties which makes it unsuitable for certain applications. In order to improve these properties, reinforcement fillers such as chitin nanowhiskers (Figure 1) and non-toxic crosslinking agents such as genipin was used as well as blending with a synthetic polymer such as poly(L-lactide) (PLA).

PLA is an example of a biodegradable and biocompatible polymer with a suitable mechanical properties and degradation rate for musculoskeletal applications. Blending and thus combining the advantageous properties of these two polymers is thus a promising strategy for the production of nanofibrous materials suitable application in the biomedical industry.

Fabrication of these composites involves the development of electrospun chitosan/PLA membranes with various loadings of chitin nanowhiskers as well as the crosslinking with genipin in order to improve its water resistance and pH stability.

Single needle electrospinning was facilitated by a syringe pump, a syringe with a blunt needle tip, and a high voltage power supply. The positive electrode was connected to the conductive needle whilst the negative electrode was connected to the collector plate. Electrospun nanofibers can be observed in Figure 2.

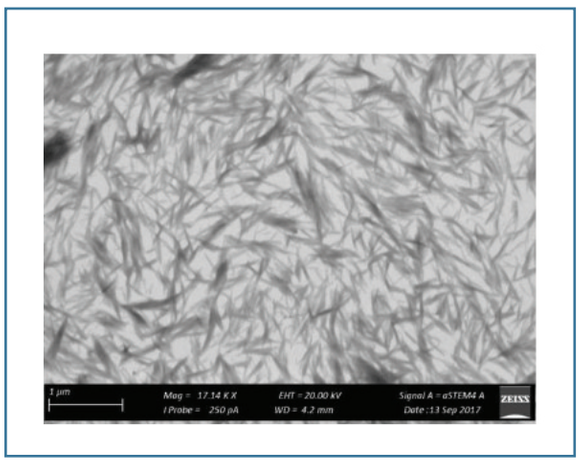


Figure 1: STEM image of chitin nanowhiskers prepared by the hydrolysis of chitin.

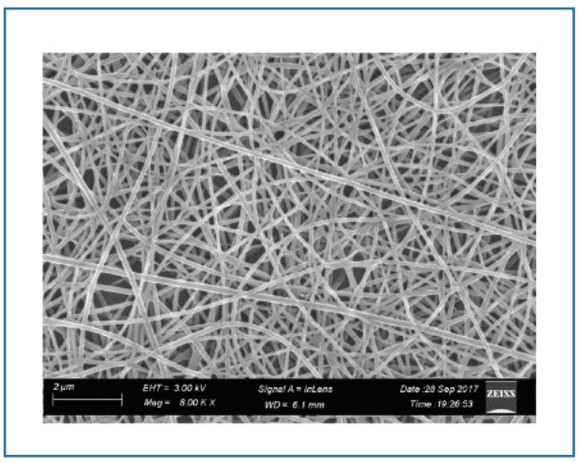


Figure 2: SEM image of defect free chitosan/PLA nanofibrous mat produced by single needle electrospinning with 0.5 vol.% chitin nanowhiskers

23. MAPPING THE DEGRADATION OF HYDROLYTICALLY DEGRADABLE ELECTROSPUN SCAFFOLDS FOR TISSUE ENGINEERING

Rumbidzai Damita Zireva[a], Siew Tai[b], Peter Zilla[a], Deon Bezuidenhout[a]

[a] *Cardiovascular Research Unit, Chris Barnard Division of Cardiothoracic Surgery, University of Cape Town, Cape Town, South Africa*

[b] *Centre for Bioprocess Engineering Research, Department of Chemical Engineering, University of Cape Town, South Africa*

Abstract

Tissue engineering has numerous applications in regenerative medicine,[1] for example in vascular or heart valve diseases. Electrospinning is one of the techniques used to fabricate porous scaffolds with micro- or nanofibrous structures. These scaffolds mimic the natural extracellular matrix (ECM), cytocompatibility and porous nature of native tissue that allow for cell ingrowth.[2] Biodegradable polymers can be electrospun to produce templates for cell ingrowth, which can be stimulated for tissue regeneration. Knowledge of the degradable behaviour of such polymers is important, because it gives an indication of the material's life span in the body.

The aim of this study was to investigate the degradation mechanism of two types of DegraPol® (a biodegradable polymer), DP15 & DP30, and predict their degradability over time. DP15 and DP30 were dissolved in chloroform then electrospun and incubated in PBS at 37°C. The incubated samples were analysed for molecular weight (Mw) and mechanical strength at different time points. Four degradation models were used to investigate the degradation mechanism of each group.

Mw and mechanical strength decreased over time in each group. Three of the degradation models reasonably predicted the degradation of each group, however, the fourth model predicted unrealistic loss of material from the bulk matrix of the scaffolds. Two of the models were successfully combined to produce a hybrid model, which was also used to predict the degradation of the polymers.

Acknowledgements

NRF, AB Medica S.P.A.

References

[1]Mendelson, K.; Schoen, F. J. Heart valve tissue engineering: concepts, approaches, progress, and challenges, Ann Biomed Eng. 2006, 34, 1799-1819.

[2]Vacanti, J. P.; Langer, R. Tissue engineering: the design and fabrication of living replacement devices for surgical reconstruction and transplantation, Lancet. 1999, 132-134.

24. NEEDLELESS ELECTROSPINNING OF PGS/PVP BLENDS FOR SKIN TISSUE SCAFFOLD FABRICATION

Antonios Keirouz[1]*, Anthony Callanan[2], Giuseppino Fortunato[3], Norbert Radacsi[1]

[1] The School of Engineering, Institute for Materials and Processes, The University of Edinburgh, Robert Stevenson Road, Edinburgh, EH9 3FB, U.K.

[2] The School of Engineering, Institute for Bioengineering, The University of Edinburgh, The King's Buildings, Edinburgh, EH9 3JL, U.K.

[3] Empa, Swiss Federal Laboratories for Materials Science and Technology, Laboratory for Protection and Physiology, St. Gallen, CH-9014, Switzerland

**Corresponding author. Tel.: +44 (0) 131 651 7112. E-mail address: a.keirouz@ed.ac.uk*

Biomimetic electrospun scaffolds, as skin substitutes, permit for the development of structures that closely resemble the physical characteristics present by the native extracellular matrix, where cells can adhere, proliferate, freely migrate and, ultimately induce neo-tissue formation at the injured site.

The human skin is a non-linear, anisotropic and viscoelastic organ, where distinct areas differ greatly in regard to mechanical behaviour [1]. Hence, the mechanical properties of specific sites, based on the anatomical attributes of the human body, must be taken under consideration during fabrication, in order to advance the currently available products in the market.

Poly(glycerol sebacate) (PGS)/Polyvinylpyrrolidone (PVP) blends have yet to be exploited for such applications. In the present study, the effect of PGS/PVP blending in the development of electrospun scaffolds with tunable properties was examined.

PGS is an FDA approved thermoelastic polymer and an ideal candidate for soft tissue engineering, as it is vastly biocompatible and gradually biodegradable [2]. PGS was synthesized via polycondensation, by mixing equimolar of glycerol and sebacic acid at 120°C under inert nitrogen atmosphere, as initially reported by Wang et al. [3]. The synthesized PGS was characterized and the degree of esterification was measured using FT IR spectroscopy.

A home-made apparatus, comprised of a rotating cylinder electrode inside a Teflon pool, where the polymer solution was placed, and a biased rotating collector electrode under constant hot air flow, was used for this study. Potential difference of 70kV was applied between the two rotating electrodes (+35/-35 kV), resulting in the formation of multiple Taylor cones on the rotating electrode surface immersing in the solution bath, from which jets stretched to form fibres in an upwards motion.

Electrospinning thermosetting polymers, such as PGS, can be an arduous process due to its insolubility in organic solvents and its low glass-transition temperature [2]. To overcome this burden, PGS was dissolved in HFIP and blended with PVP (1.3M $g.mol^{-1}$) in a 1:1:0.25 ratio of DMF/Ethanol/Water, to provide the needed mechanical support for fibre formation. As the PGS to PVP ratio increased, so did the elasticity of the corresponding scaffolds. Due to this, the mechanical properties of the fibre mats improved significantly, while forming highly porous nets – however, fibre uniformity was not preserved at greater proportions of PGS. The fibers' diameter ranged from 500 nm to 2 μm.

The present findings provide important insights for tuning the elastic properties of electrospun scaffolds by incorporating this unique elastomer. Fibroblast and keratinocyte biocompatibility are currently under investigation.

[1] A. Ní Annaidh, K. Bruyère, M. Destrade, M. D. Gilchrist, and M. Otténio, "Characterization of the anisotropic mechanical properties of excised human skin," J. Mech. Behav. Biomed. Mater., vol. 5, no. 1, pp. 139–148, 2012.

[2] E. M. Jeffries, R. A. Allen, J. Gao, M. Pesce, and Y. Wang, "Highly elastic and suturable electrospun poly(glycerol sebacate) fibrous scaffolds," Acta Biomater., vol. 18, pp. 30–39, 2015.

[3] Y. Wang, G. A. Ameer, B. J. Sheppard, and R. Langer, "A tough biodegradable elastomer.," Nat. Biotechnol., vol. 20, no. 6, pp. 602–606, 2002.

25. COMBINATION OF EXTRUSION BASED 3D PRINTING WITH ELECTROSPINNING FOR THE FACILE FABRICATION OF 3D MICROFIBROUS OBJECTS

Michel Vong[1], Ewan Speirs[1], Chanakan Klomkliang[1], Ibukun Akinwumi[1], Wiwat Nuansing[2,3], Norbert Radacsi[1]*

[1] The School of Engineering, Institute for Materials and Processes, The University of Edinburgh, Robert Stevenson Road, Edinburgh, EH9 3FB, U.K.

[2] School of Physics, Institute of Science, Suranaree University of Technology, Nakhon Ratchasima, 30000, Thailand

[3] SUT CoE on Advanced Functional Materials (SUT-AFM), Suranaree University of Technology, Nakhon Ratchasima, 30000, Thailand

**Corresponding author. Tel.: +441316513571. E-mail address: n.radacsi@ed.ac.uk*

Electrospinning is a method that allows fabrication of polymer fibres in the micro- and nano-scale. It is capable of assembling 3D structures with little control over the shape or requiring additional template to force the 3D build-up. [1] Extrusion based 3D printing provides excellent control over the geometry of the printed item due to the high flexibility of its process parameters. The limitations of extrusion-based 3D printing lie in its resolution as well as its fabrication speed. [2]

This work reports on the use of a 3D electrospinner, a device combining the simplicity of electrospinning with the manoeuvrability of extrusion-based 3D printing. With this technology, it is possible to assemble 3D macrostructures with internal microfibrous features. The shape of the 3D structure is controlled via the precise movement of the nozzle head during electrospinning. Within 10 minutes of electrospinning a structure height of 3~4 cm could be achieved. The produced structures were still self-standing after 4 months of storage at ambient conditions. Size and morphology of the fibrous bulk were investigated using Scanning Electron Microscopy (SEM). The electrospun fibres had mean diameters between 0.5-2 μm. The effect of the process parameters (solution concentration, applied voltage, working distance, flow rate, nozzle moving speed) on the shape and size of the 3D macrostructure and the electrospun fibres has been investigated. Improper tuning of any of these parameters can lead to a flat deposition instead of the desired 3D build-up. The formation mechanism of the 3D system has been investigated, rapid solidification of the fibres as well as their fast charge induction and polarization being the main factors driving the build-up of the electrospun material. The results obtained here provide a facile and fast method to electrospin 3D macrostructures without the aid of auxiliary templates.

[1] B. Sun, Y. Z. Long, H. D. Zhang, M. M. Li, J. L. Duvail, X. Y. Jiang and H. L. Yin, Prog. Polym. Sci., 2014, 39, 862–890.

[2] J.-Y. Lee, J. An and C. K. Chua, Appl. Mater. Today, 2017, 7, 120–133.

The content of this research has been submitted to Nanoscale.

26. APPROACH TO COAT PHOSPHATE FERTILIZERS BY ELECTROSPINNING TECHNOLOGY

Yousra Boukacheni

2nd year of Ph.D

The use of huge quantity of fertilizers with the conventional agriculture leads to some important environmental problems. One of these problems is the overconsumption of fertilizers to fight against the natural leaching leading to a loss and causes the pollution of ground water by nitrates in addition to others sources of pollution.

The solution of this problem is the encapsulation of fertilizers by layers produced by Electrospinning technology to control the release of water-soluble active agent. Moreover, the use of bio-degradable polymers will increase ecological effects of this procedure. So actually the coating of fertilizers has already be done before, but it's for the first time that we were thinking about doing it by Electrospinning technology.

The aim of my research is to determine the rheological and dielectric properties of polymer fibers produced by Electrospinning in order to obtain artificial scaffolds to coat fertilizers.

The synthesis parameters of this polymer will be studied, as well as its electrospinning parameters, to obtain scaffolds of well-controlled morphology. The main objective of my research is to find the most suitable coater biopolymer for phosphate fertilizers.

Electrospinning technology has attracted a great deal of interest in academic research laboratories in recent years, and it is increasingly interested in the R & D departments of the textile industry.

SPONSORS AND EXHIBITORS

We would like to thank the following companies for their generous sponsorship:

Platinum Sponsors

SNC STELLENBOSCH NANOFIBER COMPANY

UNIVERSITEIT iYUNIVESITHI STELLENBOSCH UNIVERSITY 100 1918 · 2018

IME TECHNOLOGIES

Gold Sponsor

Bioinicia Innovative Polymer Applications

Silver Sponsor

Genvolt high voltage power supplies

Exhibitors

Anton Paar

inovenso

NOTES