Materials Research in Thailand Cattleya Petchsingh, Voravee Hoven, Sujitra Wongkasemjit

MARKAR ALAMANA



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KKAKAKA

- Popular areas of research
- Active institutes and universities
- Research culture
- Typical difficulties
- Case studies
- Possible collaborations



Universities

- Chulalongkorn \bullet
- Mahidol 0
- Silapakorn •
- Kasetsart •
- Thammasat
- **KMITL** \bullet
- **KMUTT** 0
- RIT 0
- AIT
- Chiangmai
- Naresuan
- Prince of Songkla
- Walailak
- Suranaree
- Khonkhan

 $331/23^{\circ}$ laos • Chiangmai 0 • thailand • • Bangkok cambodía Koh samui Phuket

Research centres

- **MTEC**
- NECTEC
- NANOTEC
- BIOTEC
- **Rubber Research** Institute

Where ?

NSRC

80-20





Research culture

Various small research clusters: internationally educated and active members (600+)

Government → Applied and device-based research

Grants from government funding body to individual researchers/projects

Basic equipment: scattered in different institutes

Advanced equipment: some are available in research centres (high demand)

Many are not continued nor implemented in industries

How ?





Typical difficulties

- Many small research clusters
- Research directions are guided by available equipment, government strategies, and existing clusters
- No industries to back up
- No maintenance budget for equipment
- Imported technology: technical support is limited
- Limited access to advanced labs
- Lack of hi-tech/specific equipment Why ?

Physics at Thammasat



- 17 academic staff 4 research active
- 60 students/yr → 20-30 graduates/yr
- MSc starting next year
- No Doctoral programme (yet)

Current research includes

- X-ray diffraction of small molecules
- Ag-Au nanoparticles
- Physical and Electrical Properties of PZT Ceramics
- Optical characterisation of QDs/CNTs

Case study 1: Nanomaterials





P A Shields et al. APL (2004)

- MOCVD
- Sample preparation (lithography, bonding etc.)
 PL/EL
- Magneto-optical spectroscopy
- Excitation spectroscopy



Case study 1: Nanomaterials

CMU, TU, NANOTEC

Multiwalled Carbon Nanotubes (MWNTs) Nanomaterials Research Unit, Physics, CMU (ID=2-3 nm, OD=5-20 nm)



P Singjai et al, Chem Phys Lett 366/1-2 p51 (2002)

Case study 1: Nanomaterials



Case2: Polymer-related Research in Thailand





Active Fields I

- Natural Polymer : NR, chitin-chitosan
 - Chemical Modification
 - Processing

Synthetic Polymer

- Synthesis : i.e. conducting, biodegradable
- Characterization and Processing
- Blends and composites
- Recycling



Active Fields II

- Polymer for Biomedical Application
 - Drug Delivery
 - Tissue Engineering

Polymer for Nanotechnology

- Thin Film
- Nanocomposite
- Biosensor and Chemical Sensor
- Textiles

Chulalongkorn University





- 1st University established in 1917
- 18 Faculties + 11 research institutes
 + 3 teaching institutes
 + 3 affiliated institutes
- 500-acre campus located in the heart of Bangkok
- 30,000 students and 2,800 faculty



Faculty of Science



- Chemistry
- Physics
- Mathematics
- Biology
- Biochemistry
- Botany
- General Science
- Geology
- Marine Science
- Microbiology
- Chemical Technology
- Food Technology
- Materials Science
- Photographic Science & Printing Technology

Department of Chemistry



Facts and Figures

Curriculum

Undergraduate Level : 400 B.Sc.

- Service Courses: 45 lectures, 22 labs, ~3,000 students/year in Medical Science and Engineering, Science Major
- Regular: major/minor program, honor program
- International Program in Applied Chemistry

■ Graduate Level : 250 M.Sc., 80 Ph.D.

- Basic Fields : analytical, inorganic, organic, physical
- Applied Fields : Petrochemistry, Polymer Science, Biotechnology, Environmental

Faculty and Staff

Faculty members: 78 (46 members aged 25-40)



Facility

 $7^{\text{th}} - 15^{\text{th}}$ Floor

Computer Room

Classroom

Library

Computer Room

Mahamakut Bldg

MANZ MAN

M/N/ /TJ/N

Instrument

- 400 MHz NMR Spectrometer
- MALDI-TOF
- GC-MS Spectrometer
- LC-MS Spectrometer
- Atomic Absorption Spectrometer
- HPLC
- IR Spectrometer
- UV-Vis Spectrophotometer
- Capillary Electrophoresis
- Potentiometric Titrator + Cyclic Votammetry
- X-ray Diffractometer

Research Unit

Environmental Analysis

Functional Polymer & Petrochemistry

Natural Products

Bioorganic Chemistry

Sensor

Chromatography and Separation

Computational Chemistry

Chemical Education

Materials Chemistry and Catalysis

Organic Synthesis

Supramolecular Chemistry

Surface Chemistry and Beyond

- Chemical Modification and Characterization of Polymer Surface
- Functional Organic Thin film for Biotechnology and Nanotechnology
 Polymer for Biomedical Application

12/1/2005

Polymer Brushes : Previous work

- High stability
- High graft density

Poly(2-Methacryloyloxyethyl phosphorylcholine) (PMPC)

- Reduction of protein adsorption
- Suppression of platelet adhesion and activation

Polymer Brushes : Previous work

Polymer Brushes : Previous work

Mesh size of photo-mask

After seeding with Mouse fibroblasts (L-929 cells), 20h, 5x10⁴ cells/mL

Polymer Brushes : Current work

A novel precursor sensing layer :Carboxyl-containing polymer brushes (linear and branched)

Responsive 'Smart' surface : Semifluorinated Block Polymer Brushes

Limitation : Fabrication Facilities, XPS

Biosensor

Peptide-nucleic Acid – Based Biosensor

Peptide Nucleic Acid

• DNA-mimic

- Peptide linkage
- Superior binding stability & specificity

Quartz Crystal Microbalance (QCM)

Limitation : Fabrication Facilities, SPR

Case Study 3: The Petroleum and Petrochemical College Chulalongkorn University

INSTITUT FRANÇAIS DU PÉTROLE (IFP), FRANCE announces its **International Master and Doctor of Philosophy Degree Programs** in **Petroleum Technology Petrochemical Technology** and **Polymer Science**

THE PETROLEUM AND PETROCHEMICAL COLLEGE

CHULALONGKORN UNIVERSITY

in academic partnership with

THE UNIVERSITY OF MICHIGAN (UM), USA

THE UNIVERSITY OF OKLAHOMA (OU), USA

CASE WESTERN RESERVE UNIVERSITY (CWRU), USA

and

The Petroleum and Petrochemical College

PETROLEUM TECHNOLOGY

- **Core Courses (Total 12 credits):**
- Petroleum Refining: Technology and Economics Natural Gas Processing Advanced Chemical Engineering Thermodynamics Advanced Fluid Mechanics
- **Elective Courses (Total 12 credits):**

Petroleum Business: Structure, Logistics and Economics Oil and Gas Process Safety and Environment Advanced Equilibrium Stage Operations Advanced Combustion Process Process Simulation and Design Heterogeneous Catalysis PETROCHEMICAL TECHNOLOGY

Core Courses (Total 12 credits): Transport Phenomena Advanced Chemical Engineering Calculations Advanced Chemical Engineering Thermodynamics Chemical Reaction Engineering

Elective Courses (Total 12 credits): Heterogeneous Catalysis Natural Gas and Upstream Petrochemicals Processing Colloid and Surface Science Petrochemical Industry: Technology and Economics Process Simulation and Design Others

POLYMER SCIENCE

Core Courses (Total 12 credits): Polymer Synthesis Physical Chemistry of Polymers Polymer Physics Polymer Processing

Elective Courses (Total 12 credits):

Polymer Characterization Rheological Properties of Polymers Inorganic and Organometallic Polymers Science and Technology of Fibers Advanced Polymers and Composite Materials and Others

FACULTY

The programs are taught jointly by the College's faculty and professors from the partner institutions who also supervise students' thesis work in collaboration with the College's faculty.

Research Facilities and Equipment

> 300 Million baht (US\$ 6 M) 8 floors - 7,000 m² <u>Research Equipment</u>

***** Chromatography

HPLC, GC, GC-Headspace, GC (Simdist), GPCs (RT-HT)

***** Spectroscopy

AAS, ICP, UV-VIS, UV –VIS Colorimeter, GC/MS (HR and Quadrupole), FTIR, FTIR-Raman, Laser Raman, XRD

***** Microscopy

SEM, Polarizer, Zoom Stereo

The Petroleum and Petrochemical College

***** Surface and Interfacial Analysis

Physi-Chemisorption, TPD/TPR, Particle size analyzer, Sorptomatic, TPDRO/MS, Tensiometers (DuNouy, Spinning drop, Drop shape analyzer, Bubble pressure), Zeta-meter

* Thermal Analysis

TGA, DSC, STA, EA, TG-DTA, DSC, DMA

*****Petroleum Testing

Environmental Analysis TOC, Microwave

***** Polymer Testing

***** Polymer Processing

The Petroleum and Petrochemical College

Catalysis Lab

- Environmental Catalysis
 - NO_X & CO reductions
 - VOC reduction
- Methane Reforming
- Photocatalytic Reactions
- Hydrocarbon Processing
 & Catalysis
- Thermal Conversion: Gasification, Pyrolysis
- Bio Fuels

Colloid and Surface Science Lab

- Admicellar Catalysis & Polymerization
- Microemulsions
- Foaming & Detergency
- Froth Floatation
- Surfactant-Based
 Separation
 - **Processes**
- Bio Surfactants

The Petroleum and Petrochemical College

Polymer Processing and Testing Labs

- Universal testing machine (Instron & Lloyd)
- Stress cracking tester
- Fiber/film shrinkage tester

- Injection molding
- Blow molding
- Blown film extruder
- Twin screw extruder

Rheology Lab & Central Instrument Lab

Gas Sensor Unit

Rheometer

TGA

SEM

Optical Polarizing Microscope

The Petroleum and Petrochemical College

Industrial Short Courses

- Applied Surfactant Science and Technology
- Natural Gas Processing
- Heterogeneous Catalysis
- Petroleum and Petrochemical Industries:
- **Technology and Economics**
- Hazardous Waste Management
- Plastics: Materials, Processing and
- Testing
- Blow/Injection Moulding Technology
- Rheology and Industrial Applications
- GAS and LNG

Variety of Synthesized Catalysts/Catalyst Supports

K-H Zeolite

FAU

LTA

ZSM-5

ZSM-5

GIS

Silica Fiber

MCM-41

ANA

Fine Silica

TS-1

Fe-ZSM-5

Hydrogen Production By Autothermal System Over Ce/Zr Mixed Oxides

- Promote steam reforming and watergas
 - shift reactions
- Decrease coke formation
- Catalyst preparation Sol-Gel technique

The Petroleum and Petrochemical College

Mixed Matrix Membrane (MMX)

• Alter permeability and selectivity of the original membrane (olefin/paraffin)

C₂H₄/C₂H₆ separation

Zeolite/Cellulose Acetate Mixed Matrix Memebrane

The Petroleum and Petrochemical College

Carbon Nanotubes

Nanotubular structure of carbon

- Strongest fiber known to human
 - with excellent electronic properties
- Applications: New composite material Nanocircuit Nanotechnology

Modification of Cotton Properties -> Hydrophobic Cotto

*****Patent Pending*****

<u>Untreated</u> <u>cotton</u>

<u>Modified</u> <u>cotton</u>

Sample of untreated cotton and modified cotton by using admicellar polymerization technique.

Water-repellent

Soil-resistant

Fire-retardant

The Petroleum and Petrochemical College

Development of Chitosan for Drug Controlled Release System

Development of Conductive Polymer for Gas Sensor

• Polymer which exhibits electrical conductivity higher than 10⁻¹⁰ S/cm

- (Agbor, 1989).
- Detect CO, SO_2 , NO_X , NH_3 , H_2S

Polyaniline

RHEOLOGY OF IMMISCIBLE POLYMER

BLENDS

The breakup behavior of Pbd thread in PDMS media

• Exchange of staff/students with Thai universities – access of existing facilities

- Thailand should be a good base for trainings and workshops
- Funding for post-graduate students

 Technology transfer and know-how on advanced equipment / techniques

Joint projects (funding ?)