Evolution of Latent Print Development Techniques

INTERNATIONAL ASSOCIATION FOR IDENTIFICATION

Providence, RI

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U.S. Department of Homeland Security

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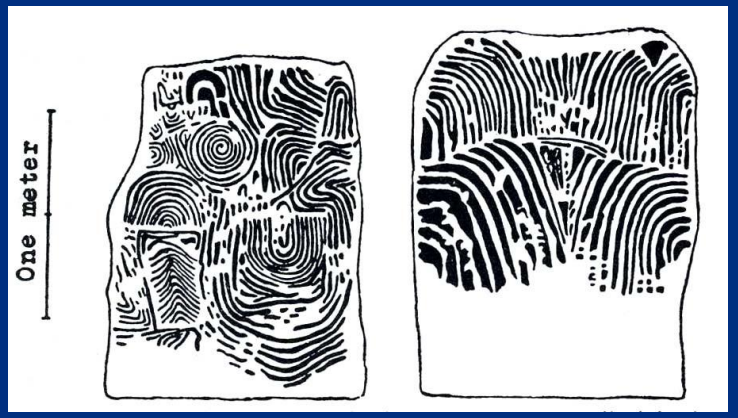
Introduction

- Homo sapiens have been aware of friction ridge skin on their hands for many thousands of years
- However, the deliberate use of chemical compounds for the visualization of latent prints dates back only about 150 years
- Most of these development techniques were discovered accidentally
- Some were refinements of existing biological, chemical, or photographic methods
- Only in past few decades have deliberate attempts been made to initiate research for which the primary goal was improved fingerprint development

Historical

Fingerprint History

- Carvings that resemble friction ridge skin on granite wall slabs of a Neolithic burial passage in L'Ile de Gavr'inis (Brittany) - ~9500 BC [1]
- Similar Neolithic carvings found in a tomb at Newgrange on the cost of Ireland [2]



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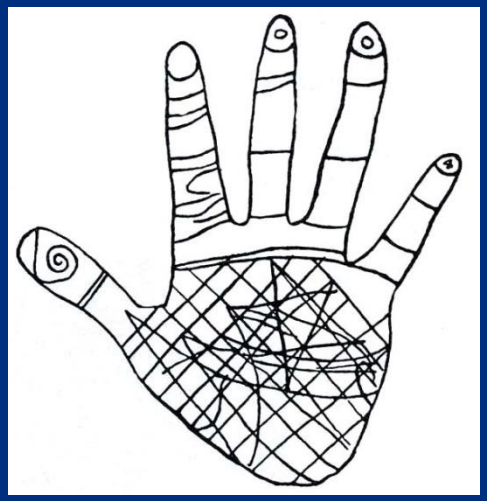
Fingerprint History

- An aboriginal Indian petroglyph from Nova Scotia, showing friction ridge skin and flexion creases (several hundred years old) [1]
- Diagram of the anatomy of dermatoglyphics by Bidloo (1685) [2]
- Dermatoglyphic diagram of the human hand by Grew (1684) [3]



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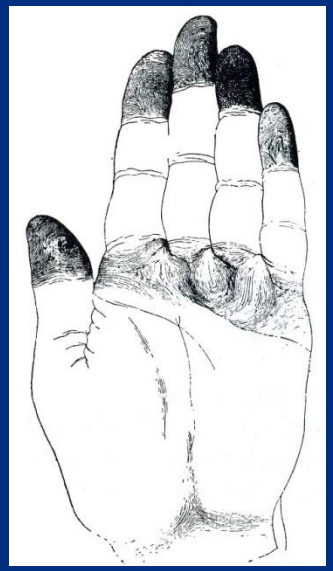

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Fingerprint History

- Fingerprints were sometimes used as a means of personal identification (similar to a signature)
- The famous engraver and author of works on natural history, Thomas Bewick (1753-1828) used a wood engraving of his print as an identity mark
- This image was taken of a Chinese deed of sale from 1839 – it is signed with an inked fingerprint

1

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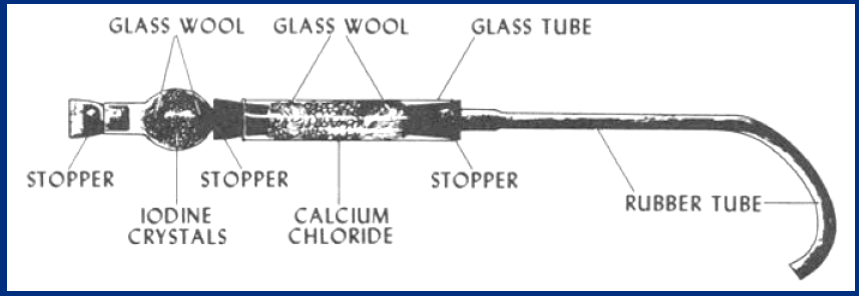
“Fingerprints found at crime scenes lead to more suspects and generate more evidence in court than all other forensic techniques combined.”

Interpol European Expert Group on Fingerprint Identification (IEEFG)
Methods for Fingerprint Identification Part 1 (2004)

19th Century Development Techniques

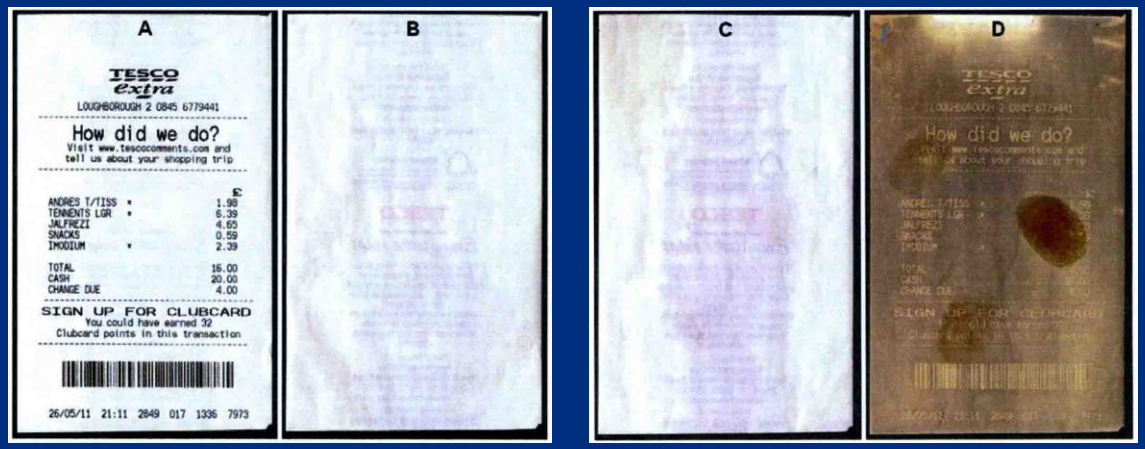
Iodine

- 1811 – discovered by Bernard Courtois (while trying to find a new source of KNO_3 during the Napoleonic Wars)
- 1863 – Paul Jean Coulier uses a mixture of sand and iodine to detect document alterations and notices LP developing
- 1876 – Pierre Aubert uses iodine to detect latent prints
- Used mostly in solid form during 19th and most of the 20th centuries



Iodine

- 2011 – new use for iodine
- Heating iodine crystals creates fumes that can restore printing on thermal papers that had faded or chemically removed (during processing)



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Rapid communication

The recovery of latent text from thermal paper using a simple iodine treatment procedure

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ABSTRACT

Faded, or actively removed text on thermally printed paper samples may be enhanced and retrieved through the use of a simple iodine fuming procedure. The recovery of printed documentation evidence in this fashion is neither affected by prior fingerprint enhancement techniques (such as ninhydrin or DFO), nor by sample age. This method allows, for the first time, evidence to be obtained from completely faded thermal paper samples (receipts, for example) as well as allowing deliberately removed printed text (a consequence of solvent washing pre-treatment in latent fingerprint enhancement procedures) to be recovered.

1. Introduction

The mainstream use of thermal printers has become an important part of everyday life. Their ease of use, convenience and fast throughput has encouraged a broad application base to be developed and thermal printers can now be found in most supermarkets, restaurants, petrol stations, modes of public transport, fax and ATM units. This method of printing involves the exclusive use of an impregnated paper type that bears a unique thermo-sensitive leuco-dye/acid coating. Typically, heating the coating above its melting point induces a reaction between the dye and the acid which results in the formation of a metastable coloured product. Characteristically, most thermal papers use a coating that turns black under such conditions, but the presence of substituted fluoran compounds within the matrix coating can also produce blue, red and yellow colour changes. Accordingly, this relatively stable, inexpensive and fast process has been exploited in the thermal paper industry since the late 1960s [1].

The natural tendency for thermally printed receipts to fade with time, often accelerated through ultraviolet exposure, means that both heavily and partially faded receipts are often commonplace. The ability to develop printed evidence, no longer visible to the naked eye, could significantly help provide a greater level of intelligence support within operational casework. In some instances, partially faded receipts can be digitally enhanced through the use of a scanner and appropriate photo-editing software. However, as is often the case, the level of natural fading, whether it is uniformly across the receipt or more localised, often results in total removal of the thermal printing itself.

Natural fading of such receipts is not the only scenario in which the data they contain could be lost; in some cases such data is deliberately "removed" when other forensic evidence is targeted. The presence of latent fingerprint evidence, for example, is of considerable interest and efficient detection methods have had to be developed accordingly. Recent findings by Jasuja and Singh have highlighted the plausibility of using a one-step iodine vapour exposure method to enhance fingermarks on thermal printer receipts, for example [2]. Despite various other 'effective' treatment methods having been suggested, such as the use of muriatic acid [3,4], DMAC [5], oil red O [6] and heat [7], the treatment method recommended by CAST (formerly Home Office Scientific Development Branch), and which will appear in the next edition of its fingerprint development handbook [8], involves the removal of the leuco dye coating, *via* an organic pre-dip, followed by fingerprint enhancement using either ninhydrin or 1,2-diazafluoren-9-one (DFO). The pre-treatment of thermal paper samples is required in order to eliminate dark staining that results from either simply treating these paper types with conventional ninhydrin and/or DFO working solution (through adverse reaction with acetic acid) or *via* the heat initiated step that is required to

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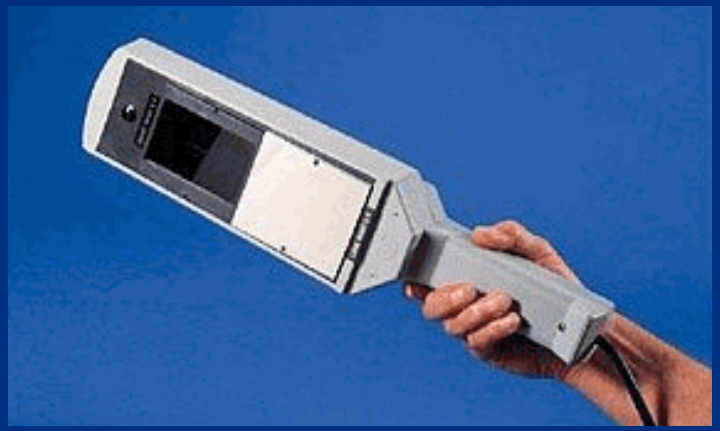
Silver Nitrate

- 1873 – Italian scientist Camillo Golgi used a mixture of potassium dichromate and silver nitrate to stain tissue samples
- 1877 – Pierre Aubert uses silver nitrate to detect latent prints
- Reagent concentrations varied between 1-10% w/v
- 1981 – Kerr et al. evaluate perchlorate and chromate silver salts

$AgNO_3 + NaCl \rightarrow AgCl + NaNO_3$



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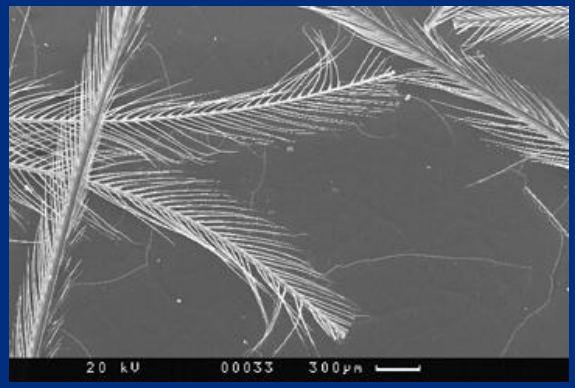
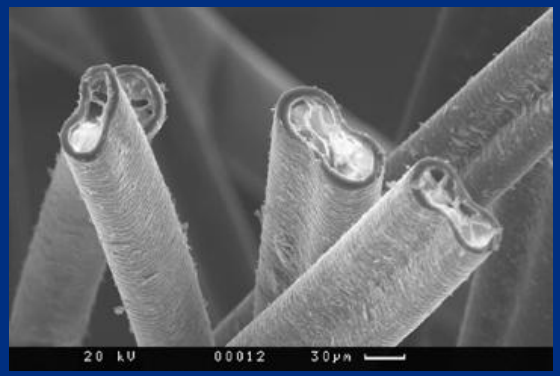
Powders

- Nearly all powders used in the 19th century were very toxic
- Colorants included lampblack (B), antimony trisulfide (B), lead iodide (Y), lead oxide (Y), mercuric oxide (Y), mercuric sulfide (R), lead sulfide (G), antimony metal (G)
- Adhesive materials included starch, kaolin, rosin, and silica gel
- Fine particulate dust was both an acute and chronic health hazard
- Brushes were animal hair (e.g., feather, squirrel, camel)





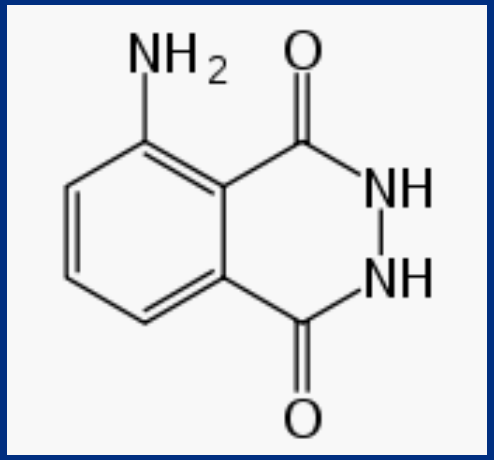
20th Century Development Techniques

Miscellaneous Methods

- Osmium/Ruthenium tetroxide
- Fuming methods (e.g., HBr, HCl, mercuric iodine)
- Lead acetate/carbonate powdering – hydrogen sulfide fuming
- HF (etching of glass)
- Soot method (burn camphor, pine tar, resinous pine to create a dark “soot”)
- Magnesium (burn to create a light-colored “soot”)

Luminol

- 1853 – first synthesized
- 1928 – chemiluminescence of luminol first reported
- 1937 – Specht was first to use luminol to detect blood at a crime scene
- 1951 – Grodsky formulation for luminol reported
- 2001 – Bluestar introduced as an improved luminol reagent



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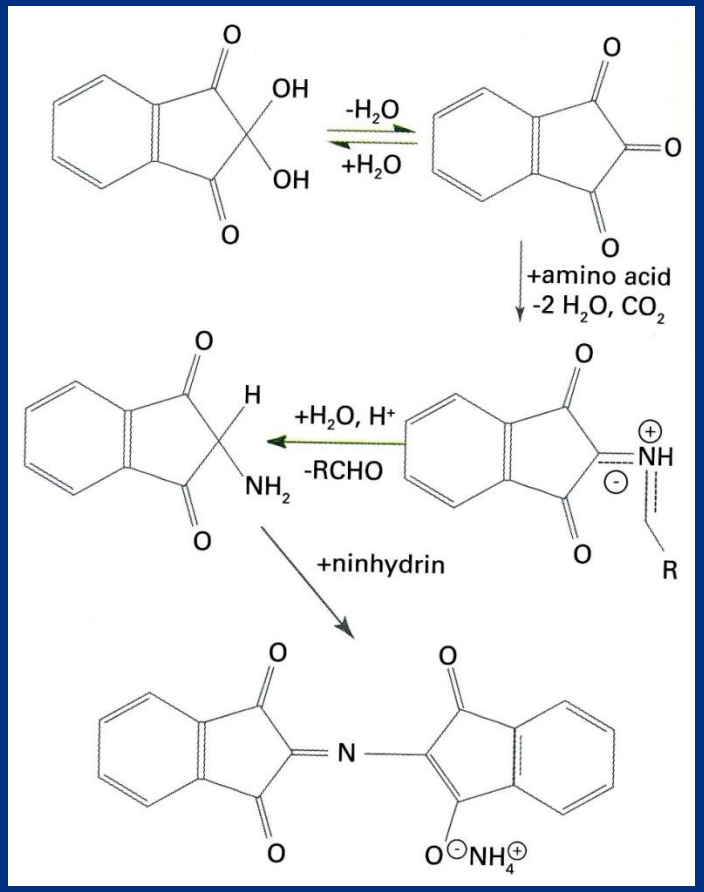
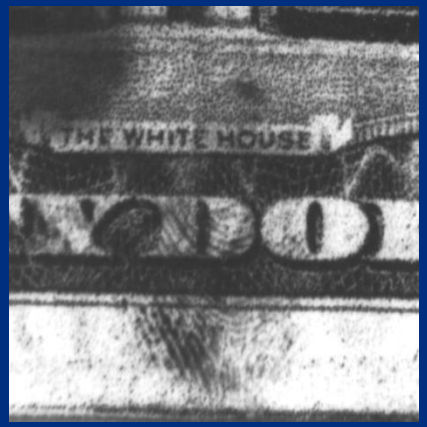
Ninhydrin

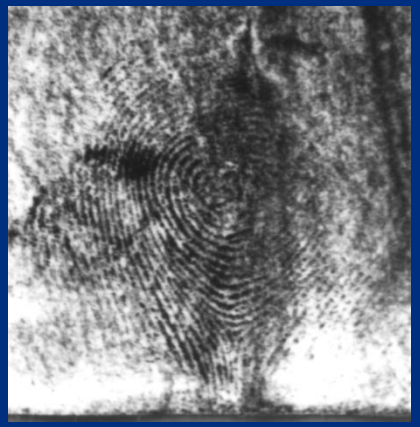
- 1910 – Siegfried Ruhemann synthesizes 1,2,3-indanetrione by accident (wanted to synthesize 1,2-indanedione)
- 1911 – Ruhemann gets a violet product with ammonia
- 1913 – Aberhalden and Schmidt note that the compound reacts with sweat (first to call it ninhydrin)
- 1954 – Oden and von Hofsten use a 0.2% ninhydrin/acetone solution to develop LP



Ninhydrin

- 1974 – Morris and Goode introduce the first non-flammable formulation– based on 1,1,2-trifluorotrichloroethane
- 1987 – Vienna Convention for the Protection of the Ozone Layer issues its Montreal Protocol, which phases out CFCs
- 1995 – UK HO PSDB recommends use of CFC replacements (ultimately HFE 7100 – 1-methoxynonafluorobutane - 1998)





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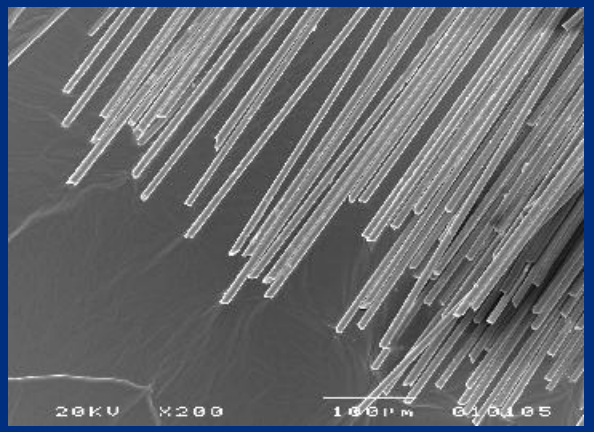
Synthetic Fiber Brushes

- Introduced in the 1950s
- Examples include glass fiber (1) and tapered polyester (2) types



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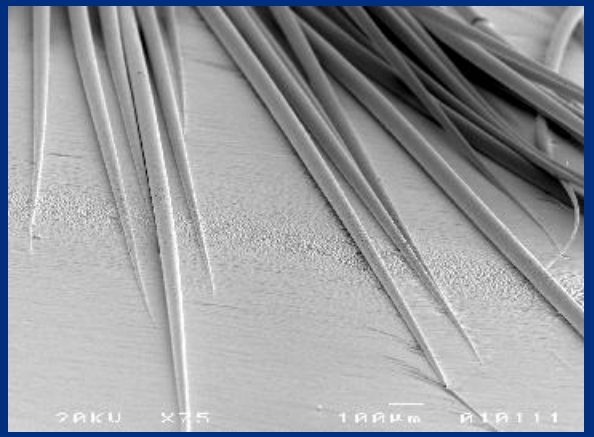

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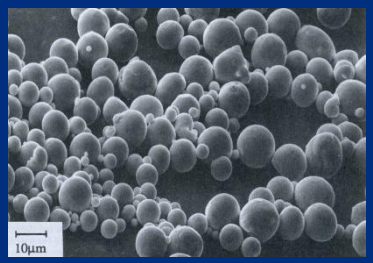
Magnetic Powders

- 1961 – MacDonnell introduces magnetic powders and the Magna Brush
- Most powders were composed of spherical magnetic particles as carriers and irregularly shaped powder particles for colorants
- 1991 – Wilshire et al. introduce magnetic flakes (marketed in the UK as Magneta Flake Powder)
- Powders contained only magnetic flakes – no carrier particles



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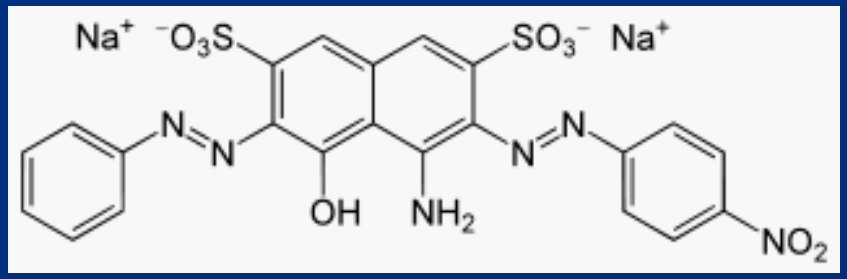
Amido Black

- 1957 – Oden mentions in a patent that amido black "…is especially suited as a protein indicator."
- 1962 – amido black (acid black 1) used to stain proteins
- 1970 – methanol-based AB solution reported in UK
- 1989 – Hussain et al. report a water-based AB reagent
- 2004 – UK HOSDB report on a water-ethanol-acetic acid (WEA) formulation



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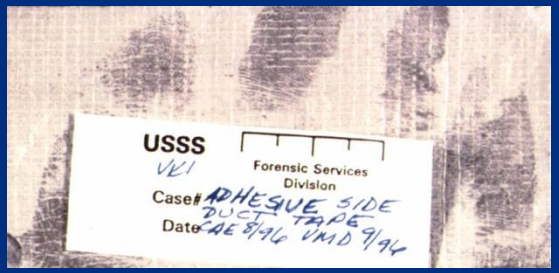
Vacuum Metal Deposition

- 1963 – Tolansky discusses the possibility of depositing thin metal films on latent prints with the UK Home Office
- 1968 Theys et al. used a mixture of metal powders (zinc/antimony/copper) to develop LP on paper
- 1972 – Hambley publishes work from his dissertation which described using gold and cadmium metal for LP on fabric/cloth
- 1991 – First print identified using VMD in North America (Canada)



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Physical Developer

- 1969 – Jonker and Molenaar develop stabilized physical developers
- 1972 – Collins/Thomas (HO/AWRE) use unstable physical developers to amplify VMD prints
- 1975 – Morris (HO/AWRE) is the first to use stabilized PD to visualize LP
- 1981 – First operational user's guide prepared by Hardwick (PSDB)
- 2000s – Improvements include addition of Tween 20 and RO/DI water

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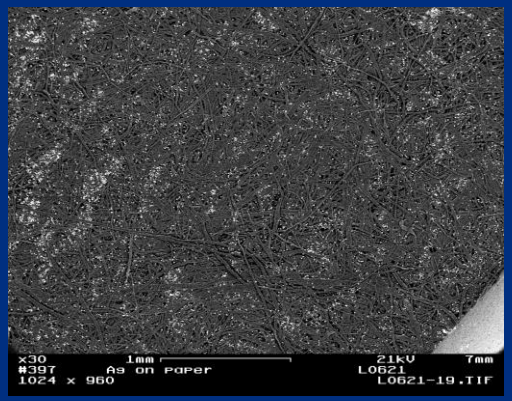
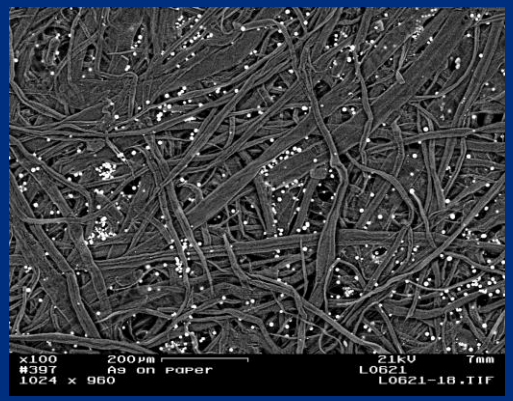
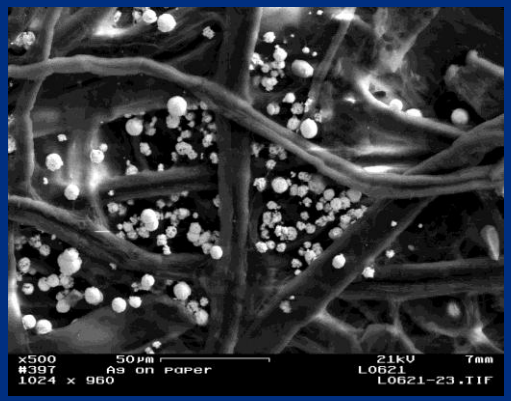
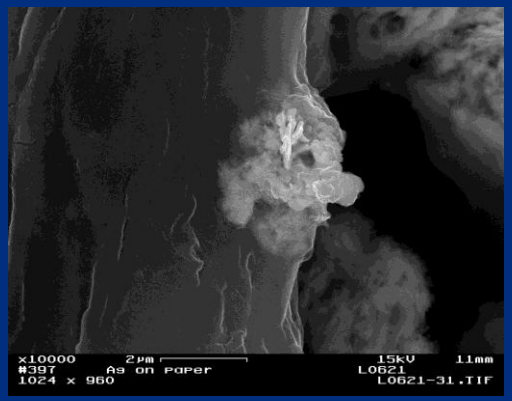
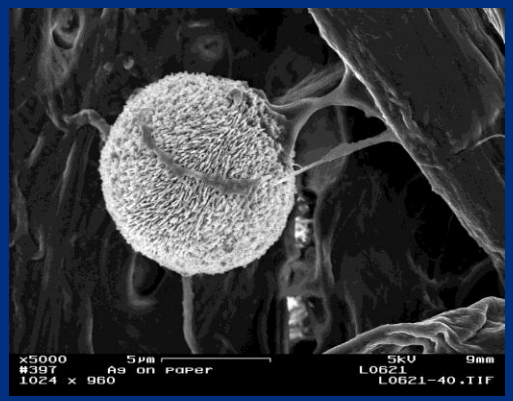
Physical Developer

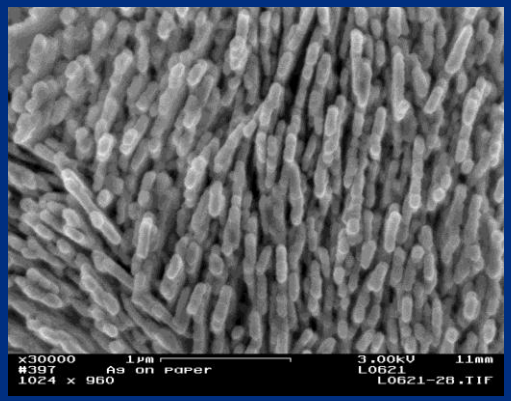












Laser/Alternate Light Sources

- 1977 – Dalrymple et al. first report the use of an argon ion laser [3] to visualize inherent LP fluorescence.
- Lasers were powerful but bulky – required large power sources and cooling systems
- Introduced in the 1980s (Lumalite in 1980), the ALS [1] was a portable and used a high intensity filtered white light source (e.g., Xenon, metal halide lamps)
- 2000s - Recently introduced optically-pumped semiconductor laser systems provide power and portability [2]

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Cyanoacrylate Fuming

- 1942 – Harry Coover works with CA monomers
- 1958 – Eastman markets new material as Super Glue
- 1977 – Fuseo Matsumura (Saga Prefecture) notices prints developed on CA mounted slides
- 1979 – LW Wood (Northampton Police) notices prints developed on film tank repaired with CA
- 1980 – Louis Bourdon (Ontario, Canada) applies for patent for the CA/LP process
- 1981 – U.S. patent 4,297,383 issued; injunction awarded to U.S. Army JAG

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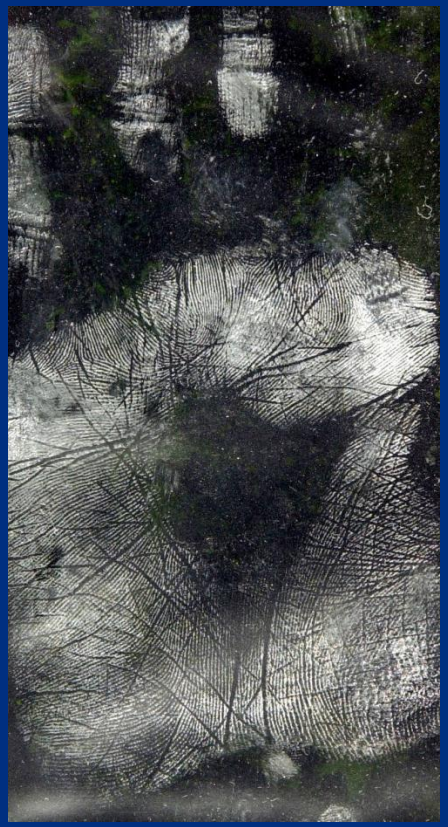
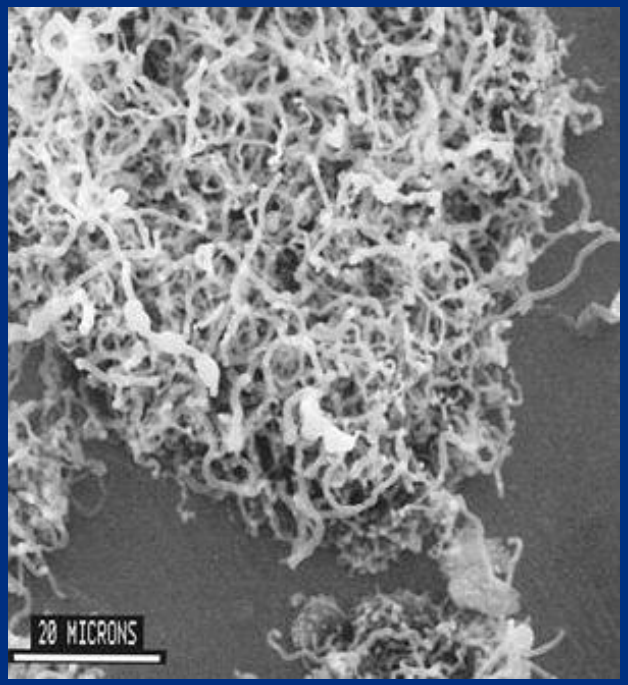
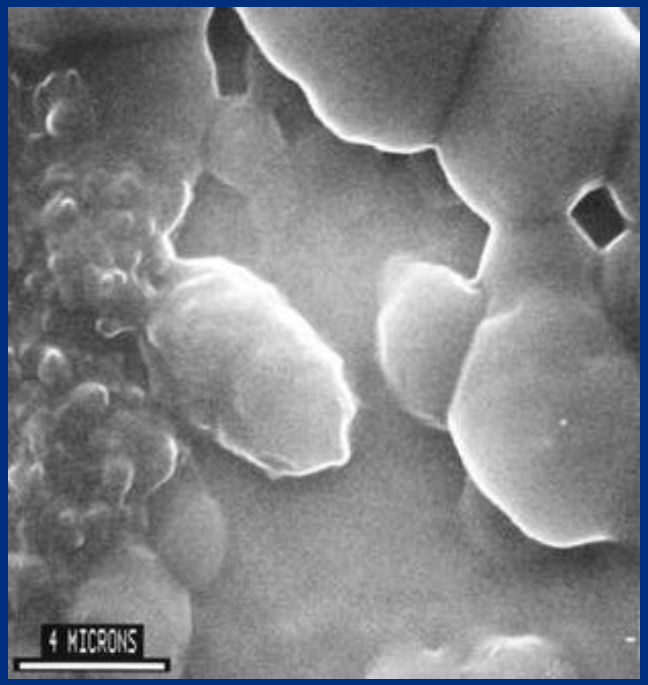
Cyanoacrylate Fuming







RUVIS

- 1910s – Physicist RW Wood created a LW UV source (Wood's lamp)
- 1970 – Ohki reported the first detection of LP in the UV region
- Mid-1980s – Ishiwata and Nakamura (NPA/Japan) use SW UV sensitive image intensifiers
- 1987 – German describes the use of a RUVIS device to directly image prints in the SW UV without film
- 2005 – People v. Jackson (Santa Barbara County)

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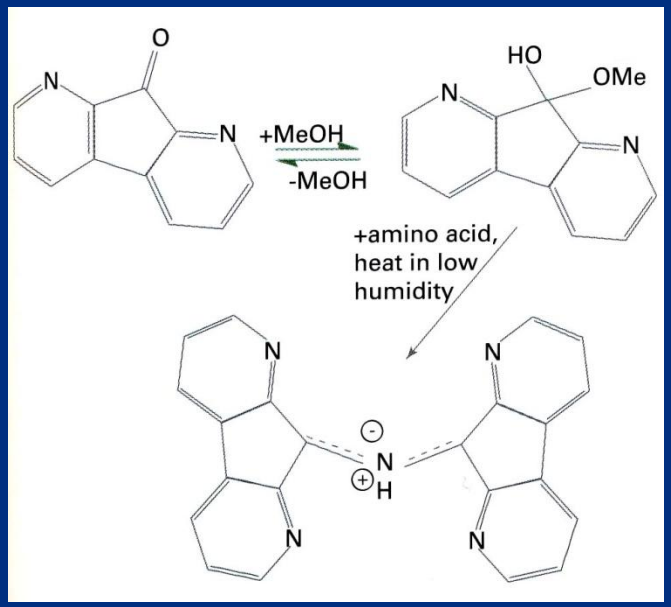
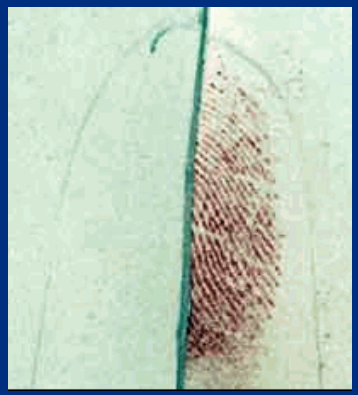
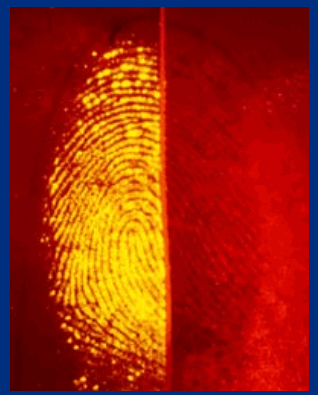
DFO

- 1950 – Druey and Schmidt synthesize diazafluoren-9-one
- 1990 – Pounds et al. (HOCRE) report the first use of DFO to develop fluorescent prints
- DFO was the most sensitive AA reagent until the early 21st century
- 1993 – Frank et al. report the synthesis of DFO analogs – none were found to be superior to DFO







Powder Suspensions

- 1977 – Morris and Wells (AWRE) patent a reagent called Small Particle Reagent (SPR)
- 1992 – a black powder suspension was demonstrated to Darren Burns (Morristown, NJ) by Atsushi Shirakami (Matsuyama City, Japan)
- This powder suspension would later be marketed by Lightning Powder Company as Sticky-side Powder™
- 1993 – $ZnCO_3$-based white PS introduced by Frank et al.
- 1995 – Springer et al. introduce a fluorescent PS

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21st Century Development Techniques

Chemical Imaging

- 2003 – Exline et al. introduce a specialized instrument for chemical imaging - the Condor (ChemImage)
- Combines molecular spectroscopy and digital imaging
- Data collected as a function of wavelength (spectroscopy) and location (imaging)
- Data processed using PCA
- Non-destructive

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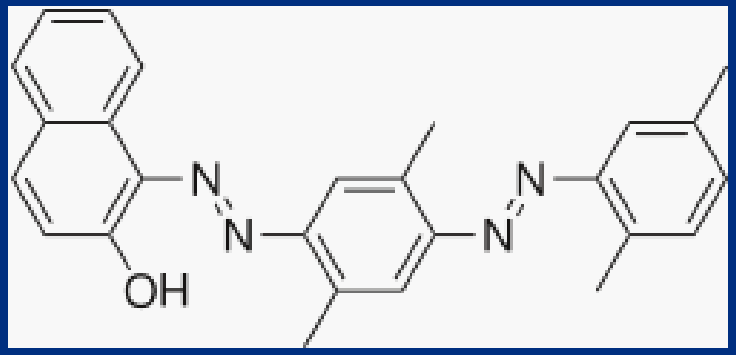
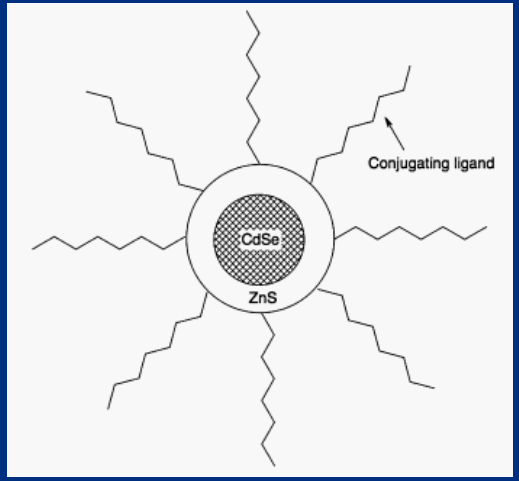
Oil Red O

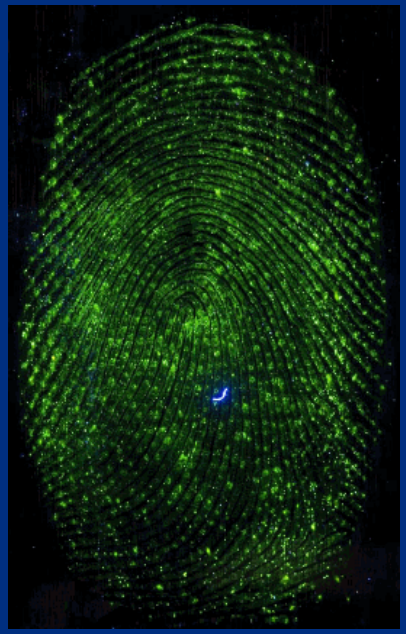
- 1926 – ORO recommended as a replacement for Sudan III
- 2002 – recommended for visualizing lip prints
- 2004 – Beaudoin introduces ORO as a latent print reagent
- 2006 – ORO compared to PD (possible replacement)
- 2011 – Beaudoin publishes a 21-year old print developed with ORO



Nanoparticles

- 2000 – Menzel et al. report the use of CdS nanoparticles as a post-CA dye stain
- Materials with particle sizes less than 100 nm
- MMD could be considered the first use of nanotechnology (~30 nm sized Au particles)
- Toxic CdS, CdSe, HgTe, PbSe particles have been largely replaced with ZnS or ZnO
- Enhanced reactivity can be achieved through functionalization (dendrimers)





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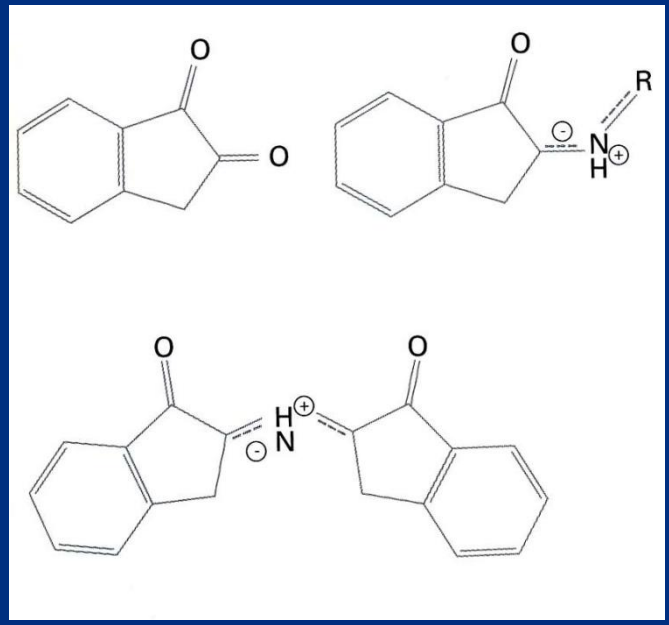
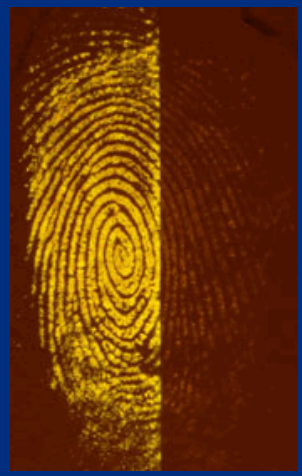
1,2-Indanediones

- 1958 – Cava et al. synthesize 1,2-indanedione
- 1996 – 5-methylthio-1,2-indanedione was the first analog prepared and evaluated
- 1996 – The parent compound was prepared and evaluated in September
- 1998 – IND and Zn mixing experiments initiated (not successful due to 1:1 mix)
- 2007 – Stoilovic et al. publish the first successful mixed IND-Zn reagent
- Currently the most sensitive AA reagent





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Where Do We Go from Here?

- Anti-Stokes powders/powder suspensions
- Modified cyanoacrylate fuming methods
- Quantum dots
- Non-stoichiometric reagents
- Chemical imaging for specific compounds (e.g., drugs, explosive residues)
- Bacteria profiles

Questions/Contact Information

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