Materials Research in Thailand
Cattleya Petchsingh, Voravee Hoven, Sujitra Wongkasemjit
Materials Research in Thailand
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- Popular areas of research
- Active institutes and universities
- Research culture
- Typical difficulties
- Case studies
- Possible collaborations
Areas of research

- Thin films
  - Inorganic sensors & solar cells
- Polymers
  - Sensors, rubber packaging
- Ceramics
- Textiles
- Composites
- Nanomaterials
- Others
- Characterisation
- Bio
- Metal

What?
Universities
- Chulalongkorn
- Mahidol
- Silapakorn
- Kasetsart
- Thammasat
- KMITL
- KMUTT
- RIT
- AIT
- Chiangmai
- Naresuan
- Prince of Songkla
- Walailak
- Suranaree
- Khonkhan

Research centres
- MTEC
- NECTEC
- NANOTEC
- BIOTEC
- Rubber Research Institute
- NSRC

Where? 80-20
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
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

- 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)

Nanomaterials Research Unit
Dept. of Physics, Science, CMU

Case study 1: Nanomaterials

SEM, AFM, TEM
Raman spectroscopy
Excitation spectroscopy
X-ray based methods
Case 2: 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)

Supporting staff: 45
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 Voltammetry
- X-ray Diffractometer
Research Unit

Natural Products
Bioorganic Chemistry
Sensor
Chromatography and Separation
Computational Chemistry
Chemical Education
Environmental Analysis
Functional Polymer & Petrochemistry
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
Polymer Brushes: Previous work

Poly(2-Methacryloyloxyethyl phosphorylcholine) (PMPC)

- High stability
- High graft density
- Reduction of protein adsorption
- Suppression of platelet adhesion and activation
Polymer Brushes: Previous work

- UV irradiation
- ATRP of MPC
- Incubate with FITC-bovine serum albumin/PBS(4.5g/dL) for 30 min at 37 °C

Photo-mask

Si/SiO₂

λ = 185 nm, 3.5h

Fluorescence image

Non-irradiated region

UV-irradiated region

λ = 185 nm, 3.5h
Polymer Brushes: Previous work

Mesh size of photo-mask

L M S

Thickness ~12 nm

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
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

INSTITUT FRANÇAIS DU PÉTROLE (IFP), FRANCE

announces its

International Master and Doctor of Philosophy Degree Programs

in

Petroleum Technology
Petrochemical Technology

and

Polymer Science
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
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
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

**Research Equipment**

🌟 **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
**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
Polymer Processing and Testing Labs

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

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

The Petroleum and Petrochemical College
### Variety of Synthesized Catalysts/Catalyst Supports

<table>
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<tr>
<th>Support</th>
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<tr>
<td>K-H Zeolite</td>
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<td>Fe-ZSM-5</td>
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*The Petroleum and Petrochemical College*
Hydrogen Production By Autothermal System Over Ce/Zr Mixed Oxides

- Promote steam reforming and water-gas shift reactions
- Decrease coke formation
- Catalyst preparation - Sol-Gel technique
Mixed Matrix Membrane (MMX)

- Alter permeability and selectivity of the original membrane (olefin/paraffin)
- $C_2H_4/C_2H_6$ separation

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 Cotton

***Patent Pending***

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

Untreated cotton  
Modified cotton

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$_2$S

Doping Process

Insulating Polymer

Chargers are removed or added

Conducting Polymer

Polyaniline

Protonic acid Doping

Oxidative Doping

$s = 10^{-10}$ S/cm

$s > 100$ S/cm

$s = 10^{-10}$ S/cm

The Petroleum and Petrochemical College
CONCLUSIONS: Possible collaborations

- 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 ?)