Innovative Conversion of Biomass Derivatives to High Value Chemicals by Photocatalysis

Surawut Chuangchote[1]
Verawat Champreda[2]
Navadol Laosiripojana[3]
Takashi Sagawa[4]

E-mail: surawut.chu@kmutt.ac.th

[1] Department of Tool and Materials Engineering, Faculty of Engineering, King Mongkut's University of Technology Thonburi (KMUTT).
[2] National Center for Genetic Engineering and Biotechnology (BIOTEC), National Science and Technology Development Agency (NSTDA).
[3] The Joint Graduate School of Energy and Environment (JGSEE), KMUTT.
[4] Graduate School of Energy Science, Kyoto University.

Photocatalysis of Biomass Derivatives

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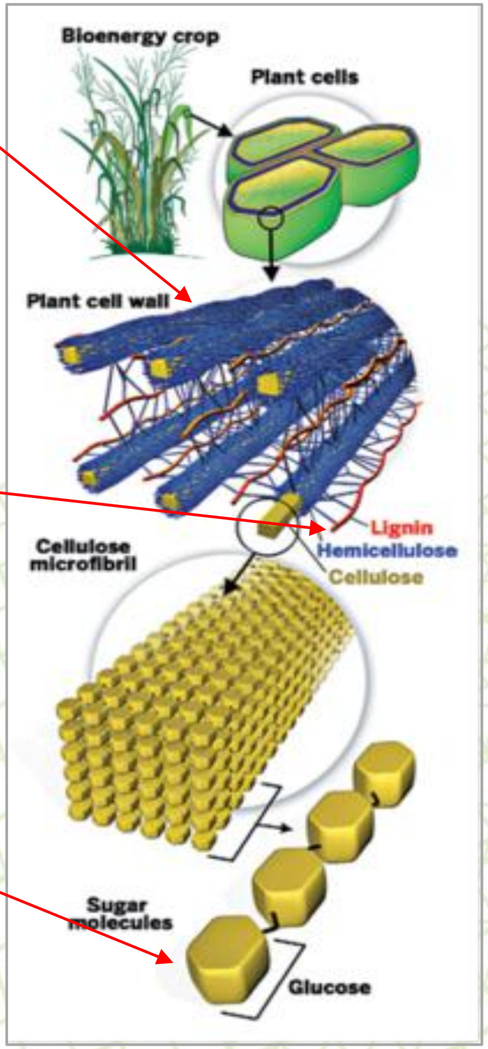
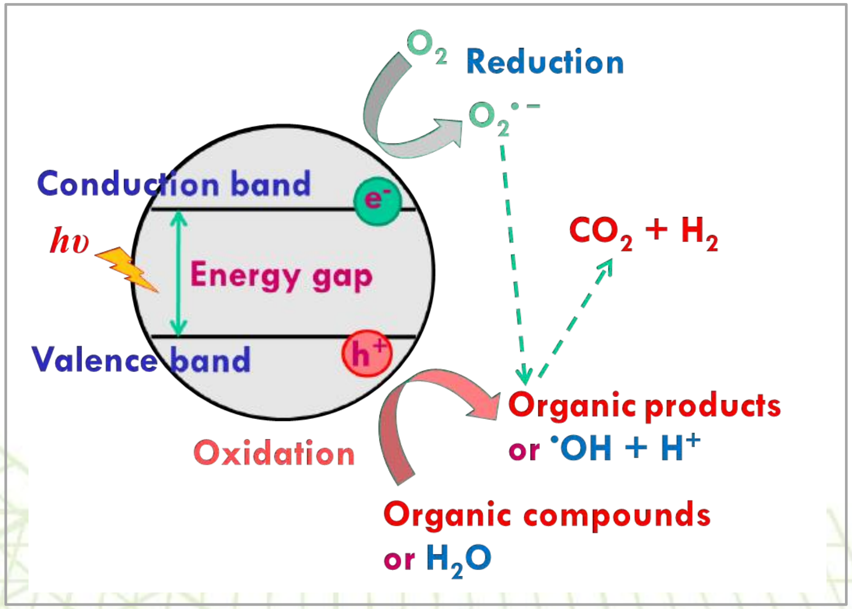
Derivative 3
Biomass Pretreatment

Derivative 2
Lignin Conversion

Derivative 1
Sugar Conversion

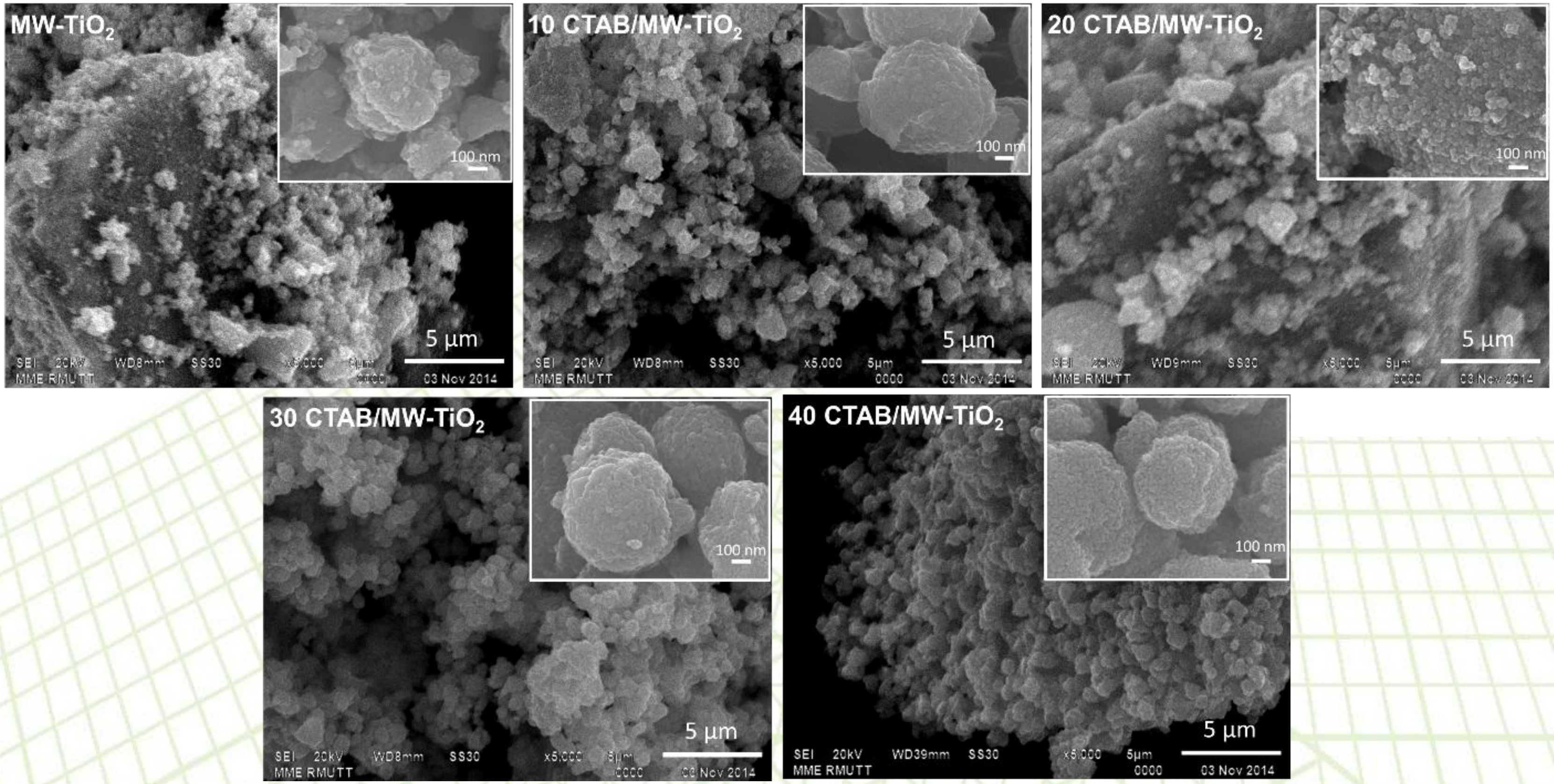




Value-added Fuels & Chemicals

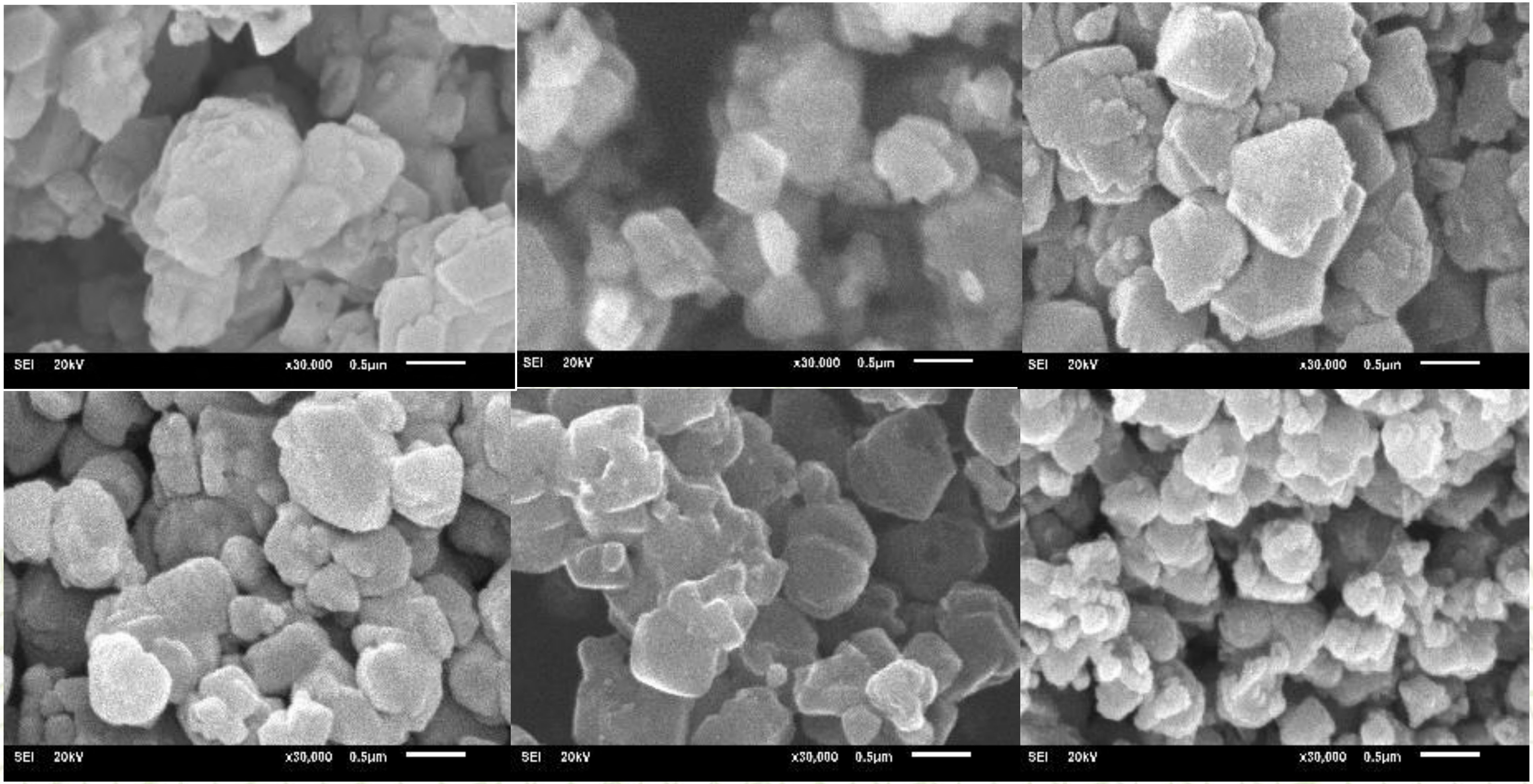
Development of Photocatalysts

Development of TiO_2 Fabrication with CTAB Surfactant



SEM and FESEM images of TiO_2 photocatalysts synthesized by different concentrations of CTAB

Modification of TiO_2 with Supporters

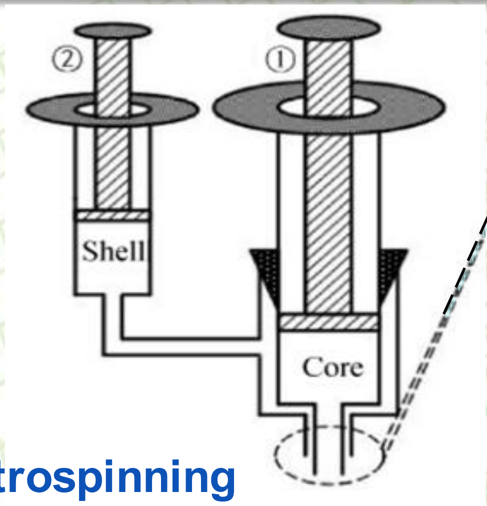


SEM images (30000x) of ZeY, TiO_2 (5%)/ZeY(95%), TiO_2 (15%)/ZeY(85%), TiO_2 (30%)/ZeY(70%), TiO_2 (45%)/ZeY(55%),and TiO_2.

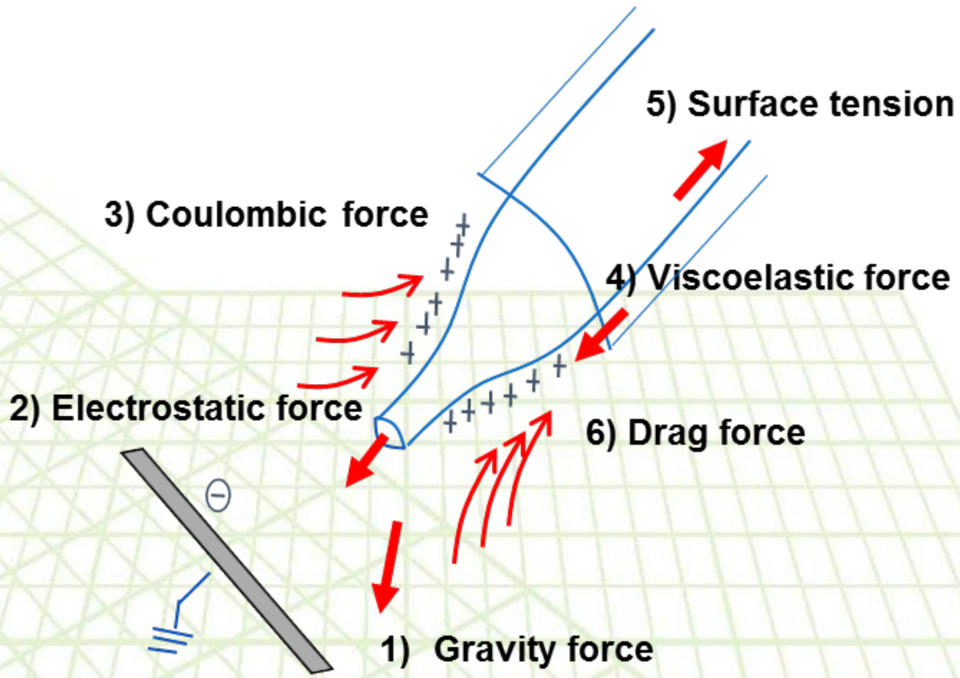
Electrospinning

Electrospinning is a technique to produce the polymer nanofibers from a wide variety of materials and versatile applications.
Different methods of electrospinning:

1. Direct electrospinning
2. Emulsion electrospinning
3. Coaxial electrospinning

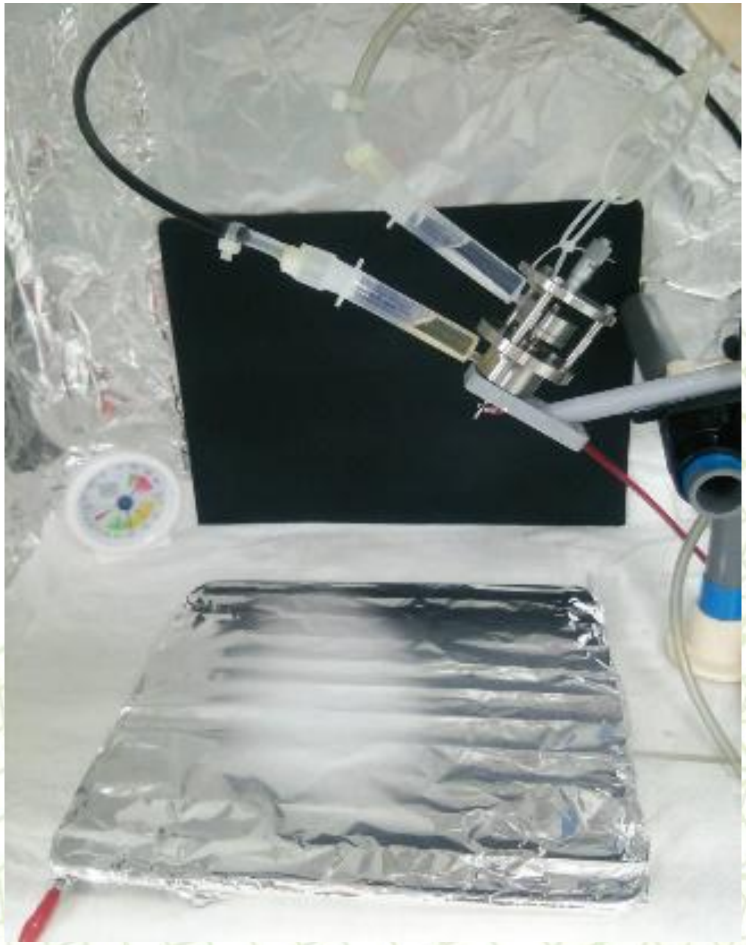


Coaxial electrospinning with two-capillary spinneret.



Electrospinning force balance

Electrospinning



Experimental setup

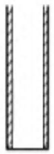
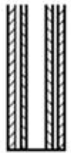
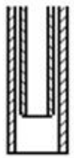
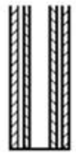
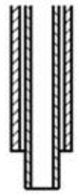
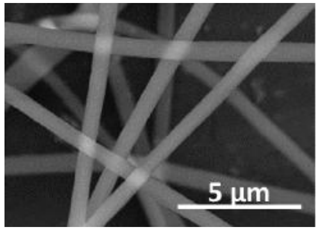
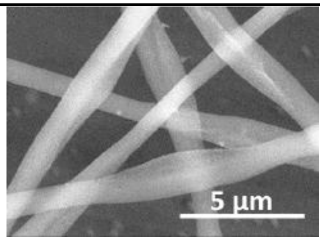
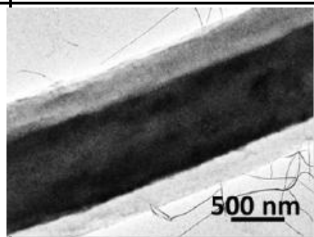
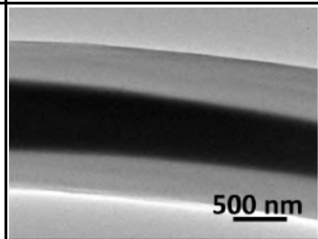
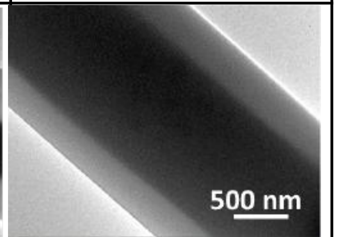
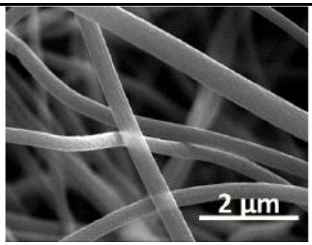
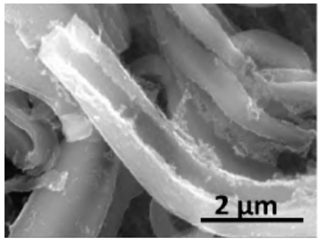
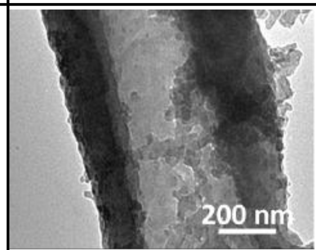
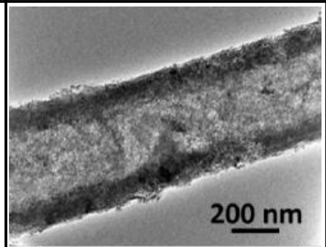
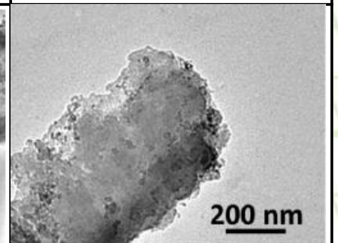
Internal factors:

- Type of polymer,
- Type of solvent,
- Solution concentration (viscosity),
- Solution conductivity*, etc.*

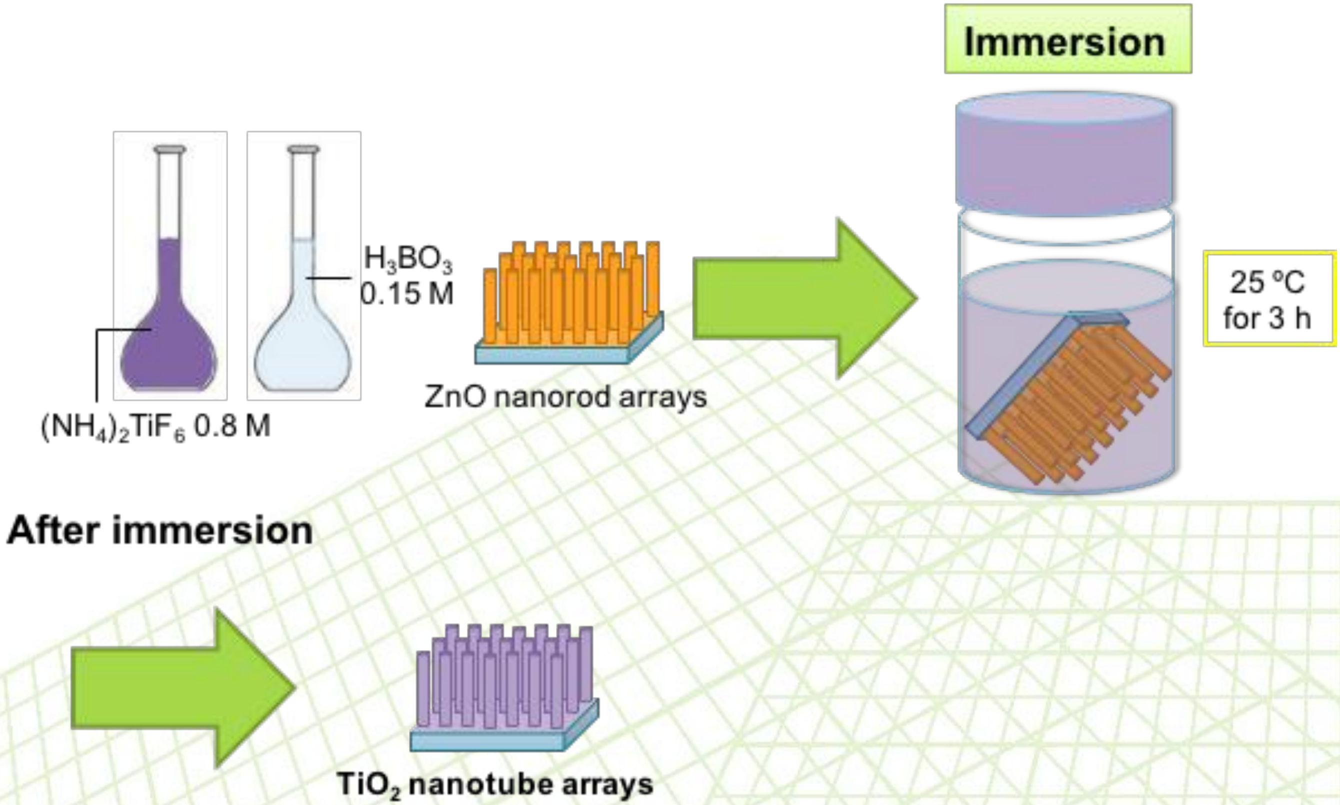
External factors:

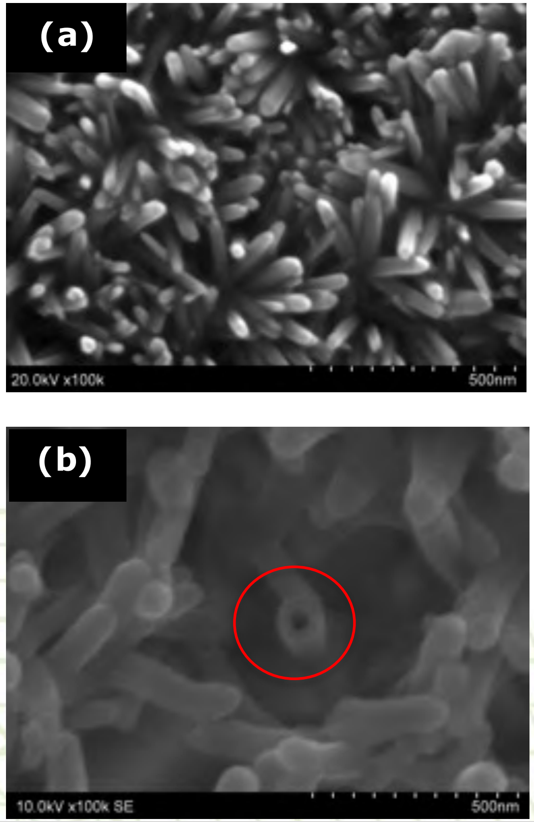
- Collecting distance,
- Applied voltage,
- Solution flow rate,
- Ambient temperature, humidity*, etc*

Balance of Inner/Outer Nozzle End

	SEM Images		TEM Images		
Nanofibers	**PAN**	**PAN/PMMA**	**PAN/PMMA**		
Nozzle	**Single nozzle**	**Coaxial nozzle**	**Inward**	**Normal**	**Outward**
Illustration					
As spun nanofiber ***(Before calcination)***					
Carbon Nanofiber ***(After calcination)***					

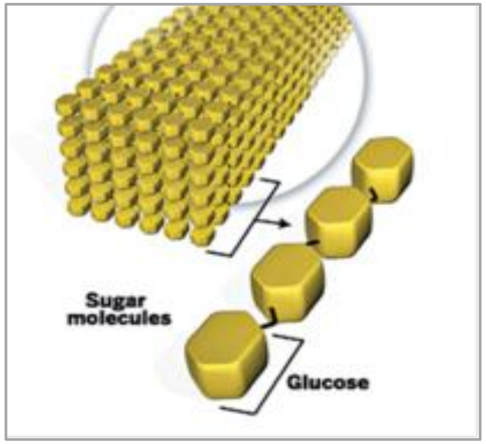
TiO_2 Nanorod Arrays





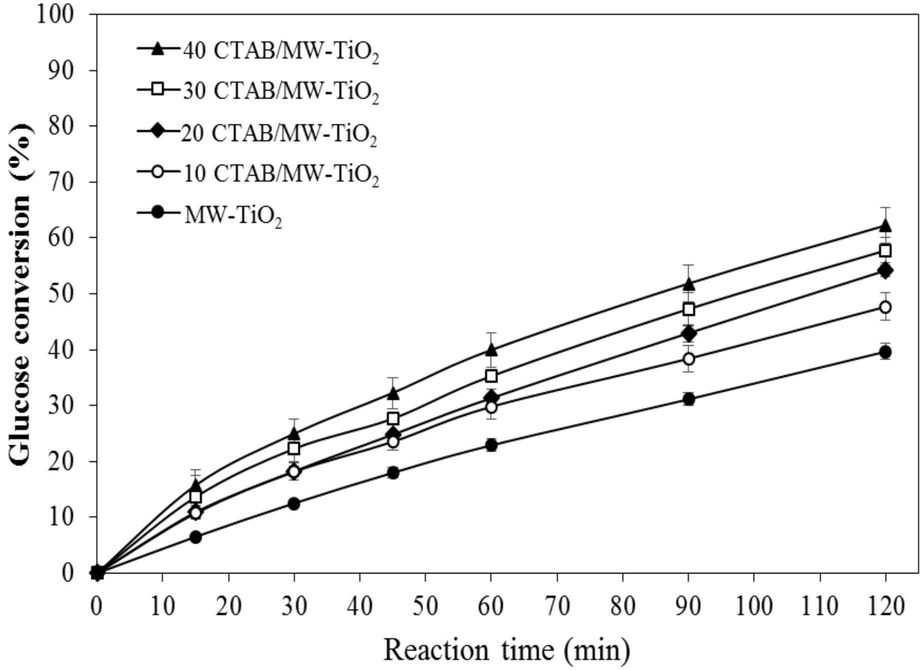
SEM images of (a) ZnO nanorods as templates for producing (b) TiO_2 nanotubes

Biomass Derivative 1:
Sugar Conversion

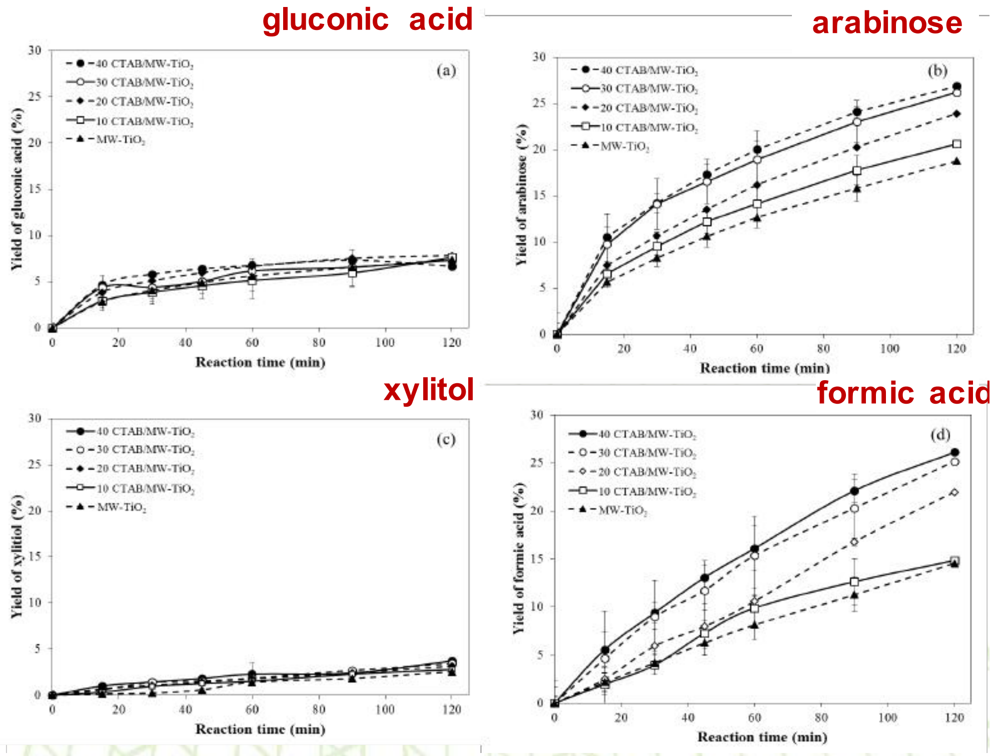


Photocatalytic Activity of TiO_2 Particles

The results of development of TiO_2 fabrication with CTAB surfactant



Photocatalytic conversion of glucose with TiO_2 synthesized with different concentrations of CTAB in MW.



Product yields of photocatalytic conversion of glucose with TiO_2 photocatalysts synthesized by different concentrations of CTAB

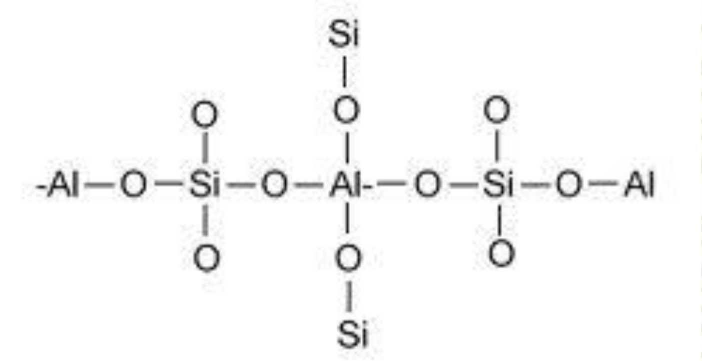
Modification of TiO_2 with Supporters

Zeolites

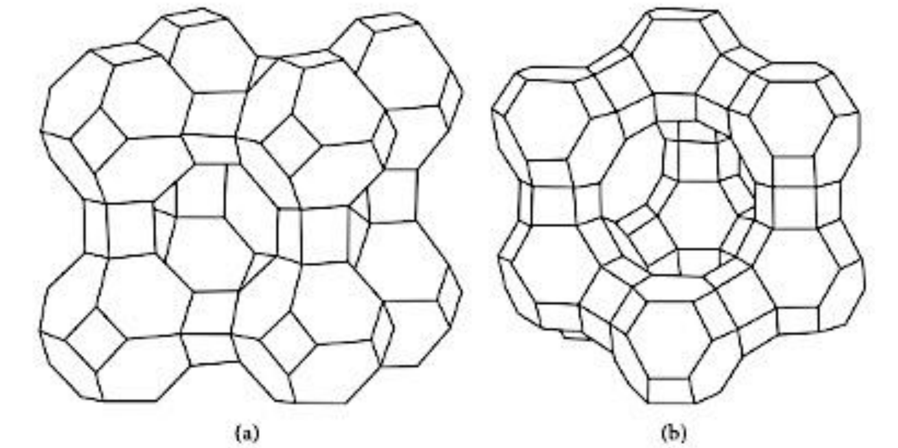
Zeolites are hydrated aluminosilicate minerals made from interlinked tetrahedral of alumina (AlO_4) and silica (SiO_4).

Advantages of Zeolites

✓ Improved selectivity
✓ High activity
✓ Excellent absorption ability



Basic Zeolite Structure



Structure of zeolite A (a) and faujasite-type zeolites X and Y (b) formed by sodalite cages

(Lutz, 2014).

Modification of TiO_2 with Supporters

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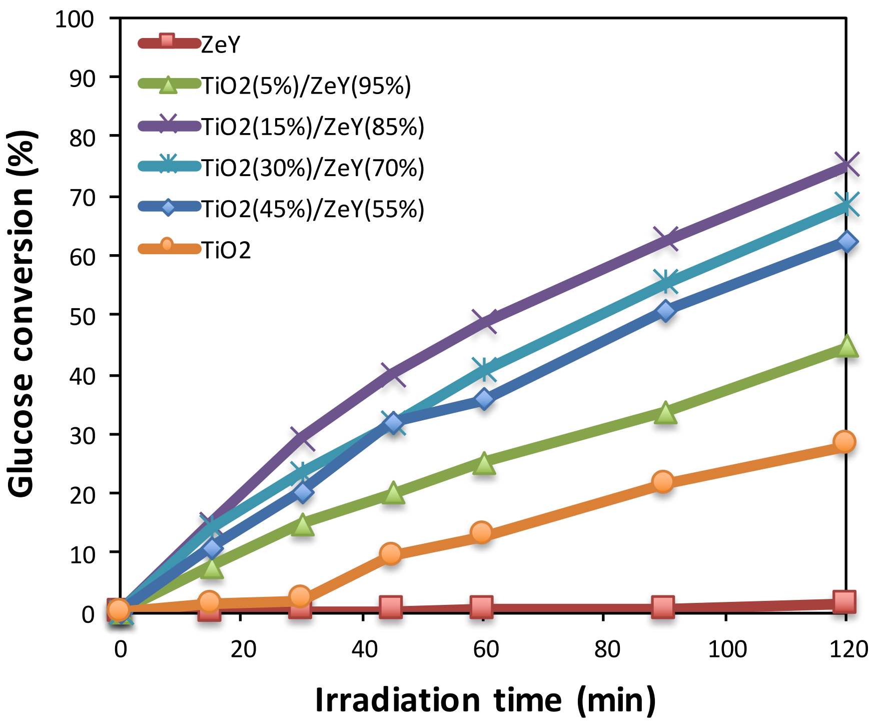
The results of modification of TiO_2 with zeolite supporter

Photocatalytic conversion of glucose

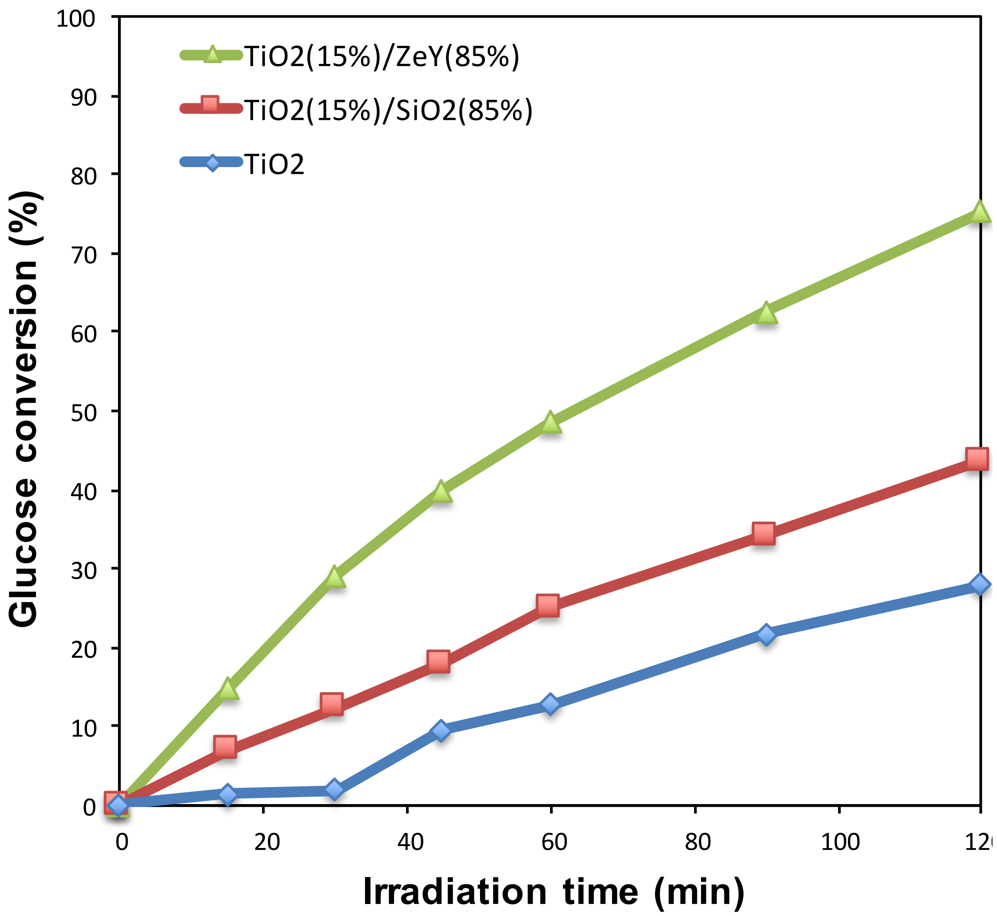


Photocatalyst	S_{BET} (m^2/g)
ZeY	590.76
TiO_2(5%) /ZeY(95%)	588.36
TiO_2(15%) /ZeY(85%)	524.41
TiO_2(30%) /ZeY(70%)	494.57
TiO_2(45%) /ZeY(55%)	419.44
TiO_2	34.38

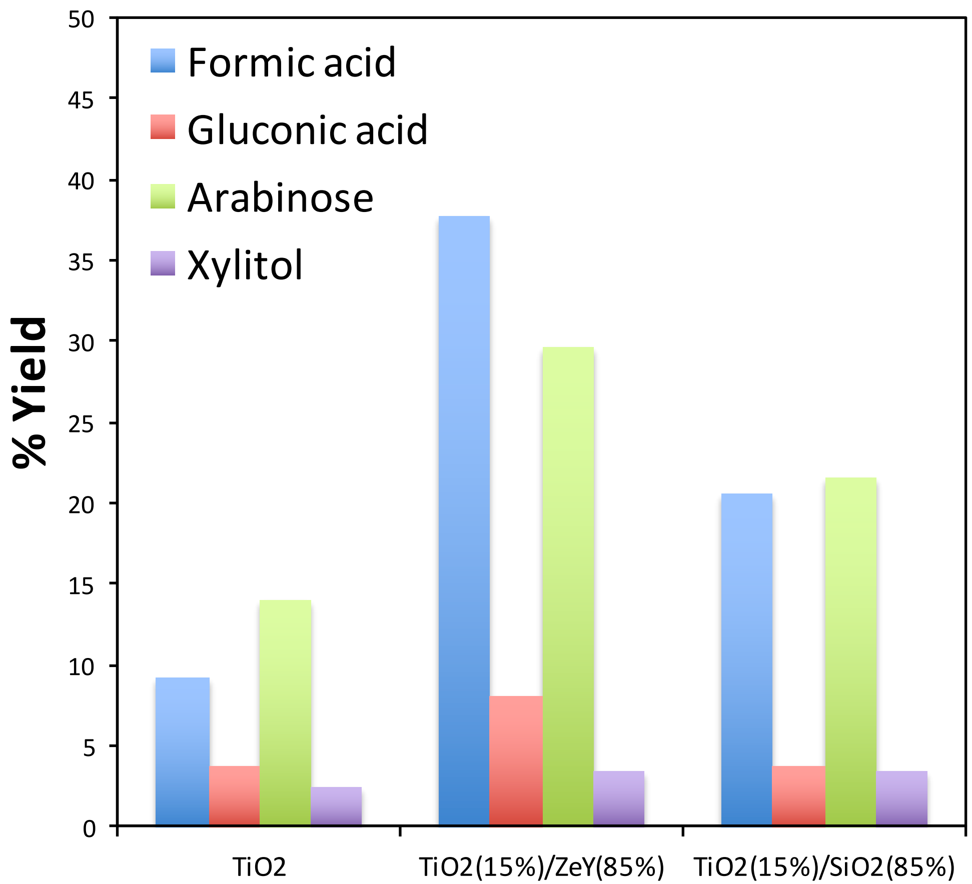
Modification of TiO_2 with Supporters

The results of modification of TiO_2 with zeolite supporter

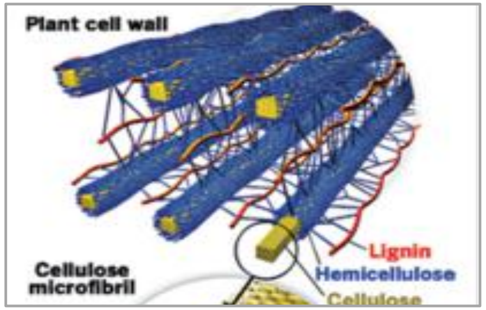
Photocatalytic conversion of glucose



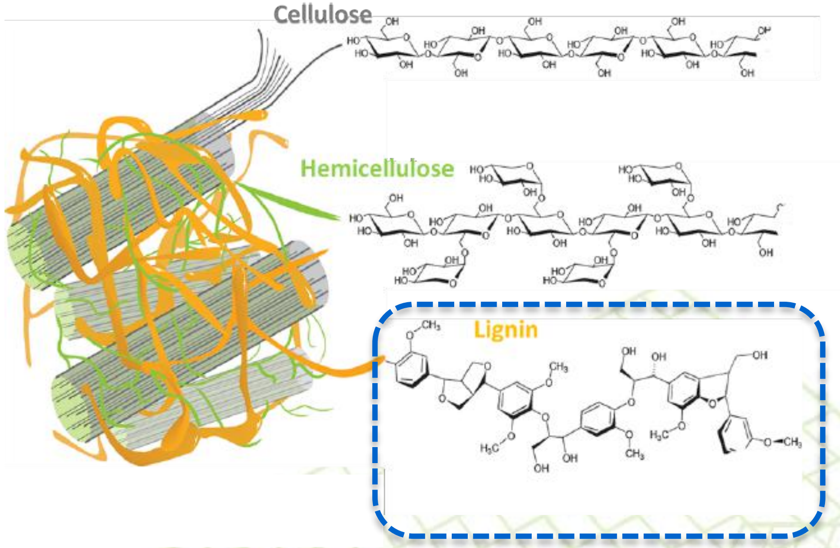
Product Yields



Biomass Derivative 2:
Lignin Conversion



Photocatalytic Conversion of Lignin to High-value Products



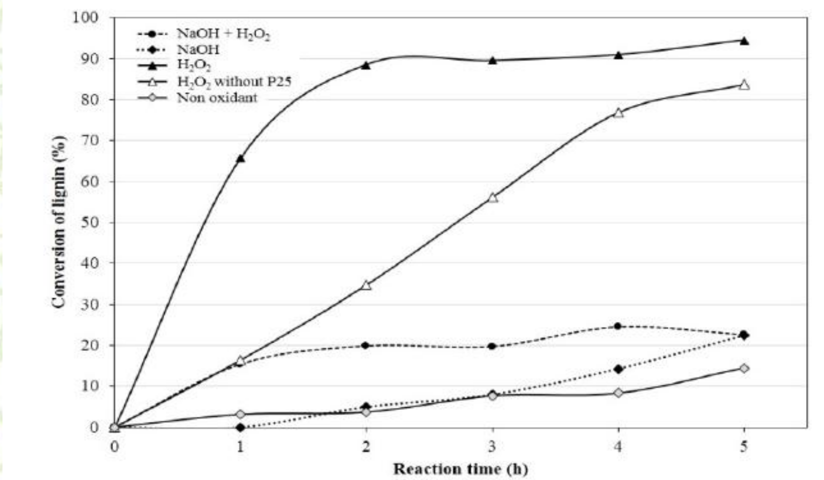
Composition of the biomass

http://www.psb.ugent.be/bio-energy/313-lignin

hv

TiO_2

Photocatalytic activity



Effect of kraft lignin concentration on photocatalytic conversion of kraft lignin (reaction conditions: 1g/L of P25, 100/0 v/v of water to ACN and 400 W of UV-lamp).

Price of High-value Chemicals

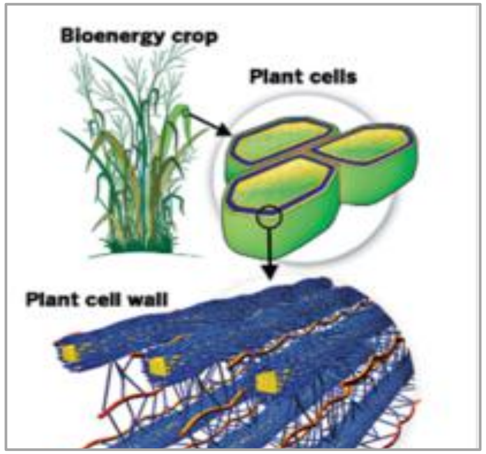
Chemicals from glucose conversion

Products	Price (THB)/kg	Applications
Gluconic acid	337	acidity regulator
Arabinose	1685-5055	sweetener
Xylitol	33.7-168.5	sweetener
Formic acid	16.513-18.53	preservative and antibacterial agent, use in cleaning products, dyeing and finishing textiles products, and use in direct formic acid fuel cell (DFAFC)

Chemicals from lignin conversion

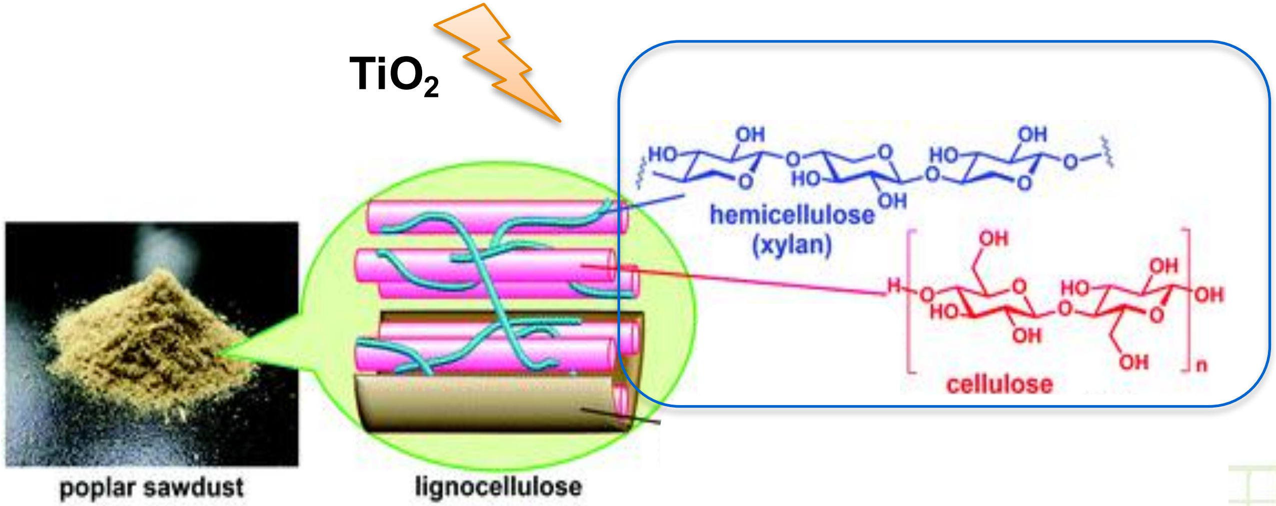
Products	Price (THB)/kg	Applications
2-methyl naphtalene	33.7-50.55	textile dyeing, printing and metal surface water treatment and chelating, used in organic synthesis,pesticide, pharmaceutical and dyne intermedite
4-hydroxy-benzaldehyde	33.7-3370	pharmaceutical intermediate, antiallergic agent blood system agent and anesthetic agents
Vanillin	33.7-505.5	synthetic flavor and fragrance
4'-hydroxy-acetophenone	3370	used in the manufacture of medicinal reagent

Biomass Derivative 3:
Biomass Pretreatment



Photocatalytic Pretreatment of Biomass

Concept of Photocatalytic Pretreatment of Biomass



Biomass structure

Enzymatic hydrolysis

Glucose, fructose, xylose

Photocatalytic process

High-value chemicals

Photocatalytic Pretreatment of Biomass

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① **Blank Pretreatment**

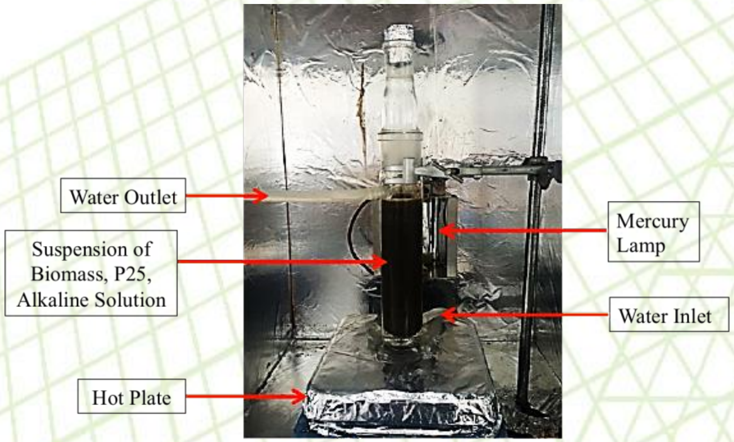
Pretreated suspension filtrated by vacuum filter

Filtration

Liquid Product

Further product analysis by HPLC

② **Photocatalytic Pretreatment**



Dilute with DI water until neutral

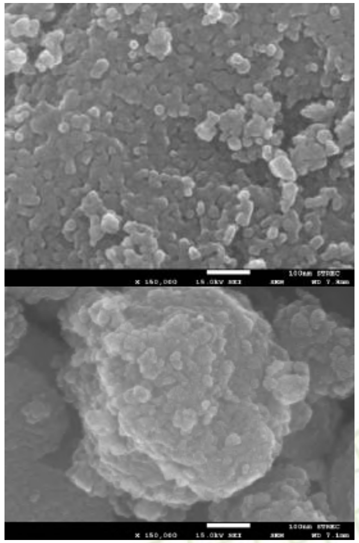
Solid Product (neutral)

Further enzymatic hydrolysis

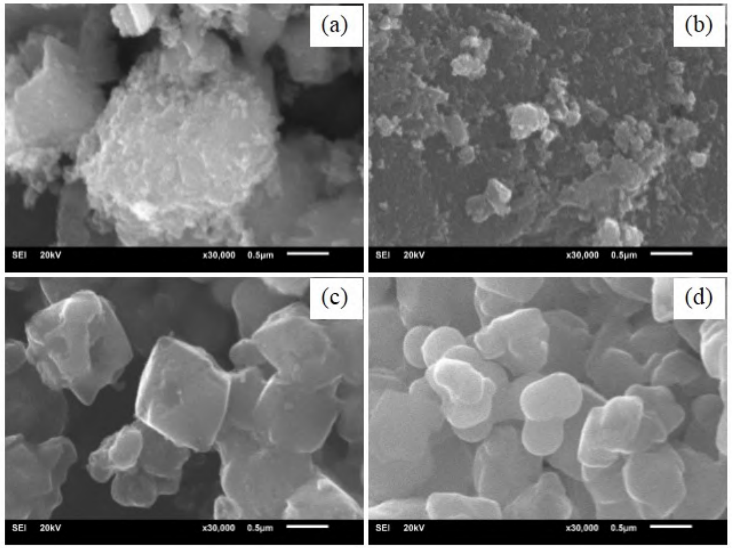
Conclusion

Conclusion

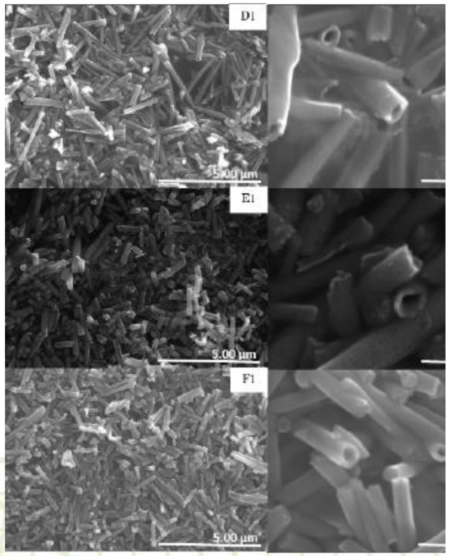
Synthesized Photocatalysts



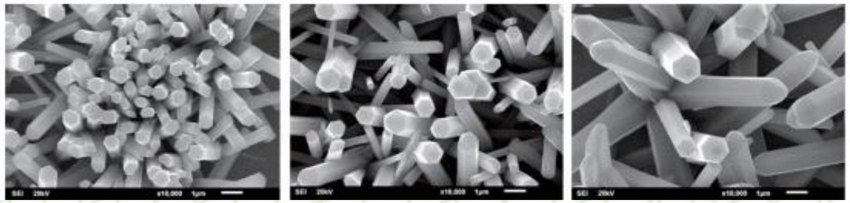
TiO_2 nanoparticles



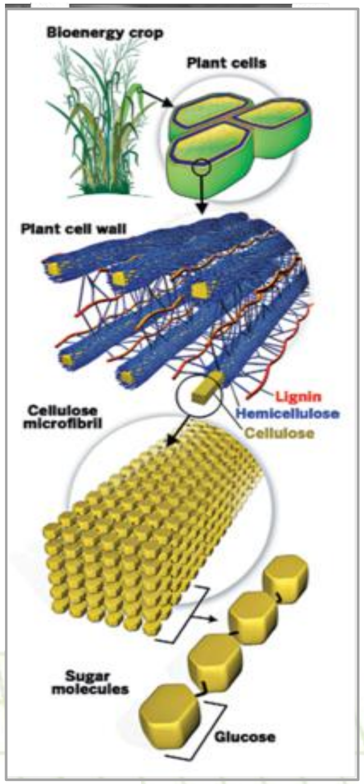
Zeolite supported TiO_2



TiO_2 nanofibers/tubes



TiO_2 nanowires



High-value chemicals

- Xylitol
- Gluconic acid
- Arabinose
- Formic acid
- Vanillin
- 2-methyl naphtalene
- 4-hydroxy-benzaldehyde
- *Etc.*

References

Papers

- J. Payormhorm, S. Chuangchote, K. Kiatkittipong, S. Chiarakorn, N. Laosiripojana, Xylitol and gluconic acid productions via photocatalytic-glucose conversion using TiO_2 fabricated by surfactant-assisted techniques: Effects of structural and textural properties, Materials Chemistry and Physics, 2017, 196, 29-36.
- N. Kaerkitcha, S. Chuangchote, and T. Sagawa (2016) "Control of physical properties of carbon nanofibers obtained from coaxial electrospinning of PMMA and PAN with adjustable inner/outer nozzle-ends," *Nanoscale Research Letters*, 11(1), 1-9.
- W. Arpavate, S. Chuangchote, N. Laosiripojana, J. Wootthikanokkhan, and T. Sagawa (2016) "ZnO Nanorod Arrays Fabricated by Hydrothermal Method Using Different Thicknesses of Seed Layers for Applications in Hybrid Photovoltaic Cells," *Sensors and Materials*, 28(5), 403-408.
- K. Roongraun, N. Laosiripojana, S. Chuangchote (2016) "Development of Photocatalytic Conversion of Glucose to Value-added Chemicals by Supported-TiO_2 Photocatalysts," *Applied Mechanics and Materials*, 839, 39-43.
- M. Wongaree, S. Chiarakorn, S. Chuangchote, and T. Sagawa (2016) "Photocatalytic Performance of Electrospun CNT/TiO_2 Nanofibers in a Simulated Air Purifier under Visible Light Irradiation," *Environmental Science and Pollution Research*, 23, 21395-21406.

Patent

- Xylitol Production from Glucose and Xylose Using Titanium Dioxide Photocatalyst," Patent Submission No. 1401007893.