Development of Carbons from Biomass for Energy Storage Applications

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B2EC Theme

- To develop carbons from Thai biomass for energy storage applications

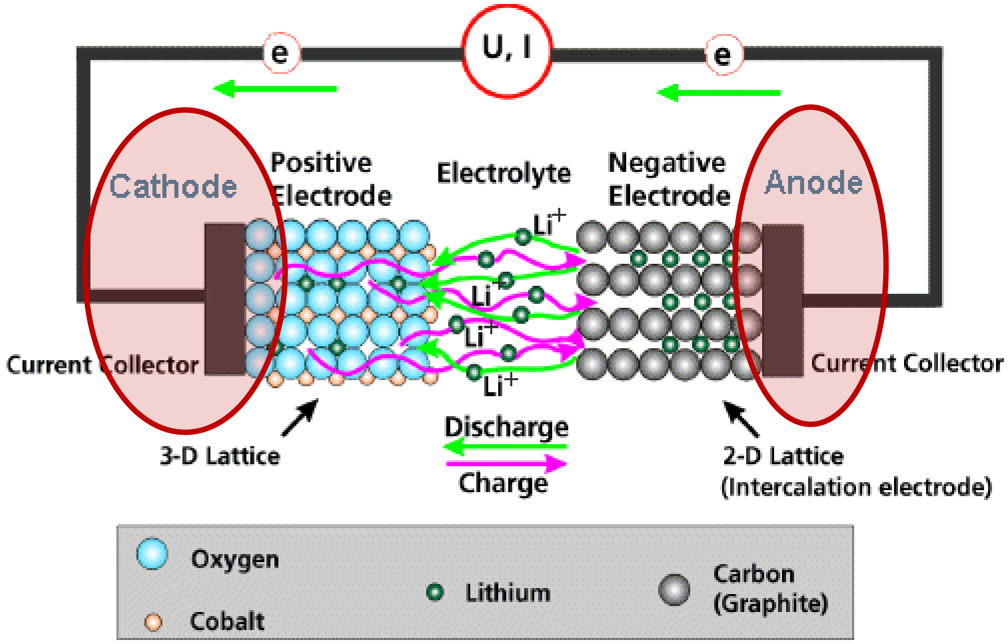
Carbon

Supercapacitors

Lithium-ion batteries

Lithium-ion Batteries

- Principle



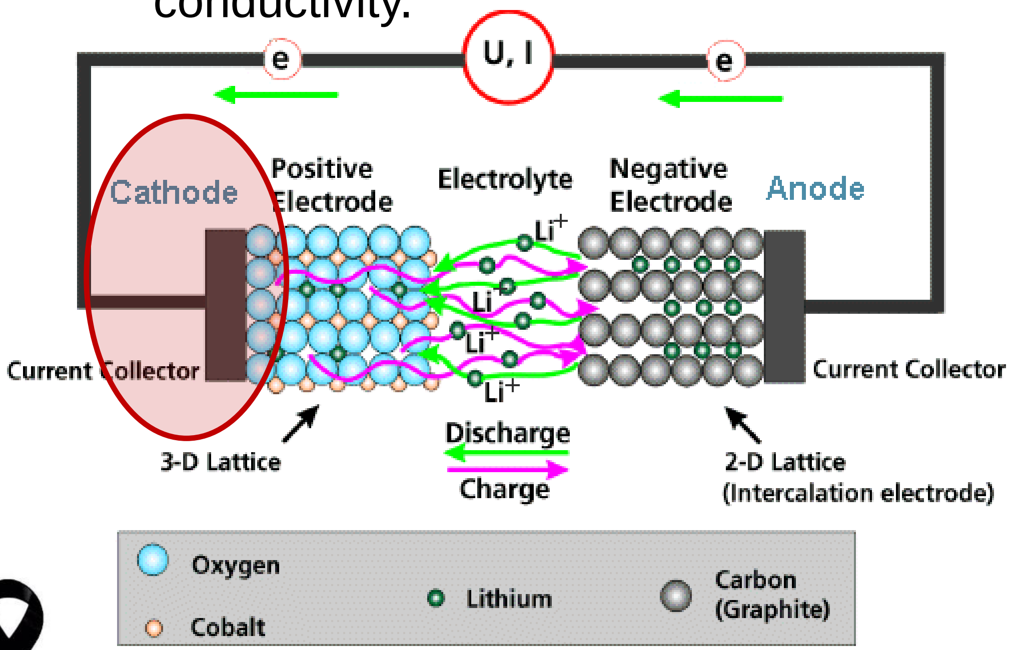
Positive electrode:	$\mathrm{LiMe}O_2 \leftrightarrow \mathrm{Li}_{1-x}\mathrm{MeO}_2 + x\mathrm{Li}^+ + xe^-$
Negative electrode:	$\mathrm{C}_6 + xLi^+ + xe^- \leftrightarrow \mathrm{Li}_x\mathrm{C}_6$
Total cell reaction:	$\mathrm{LiMe}O_2 + \mathrm{C}_6 \leftrightarrow \mathrm{Li}_{1-x}\mathrm{MeO}_2 + \mathrm{Li}_x\mathrm{C}_6$

When the battery charges and discharges, lithium ions move back and forth from one electrode to the other.

Lithium-ion Batteries

- Carbons in lithium-ion batteries - Cathode

Carbon is used in positive electrode or cathode as **conductive additive** to enhance the electrical conductivity.



Graphite conductive additives
can be produced from natural source of manufacturing synthesis (above 2,500 C under O_2-free environment)

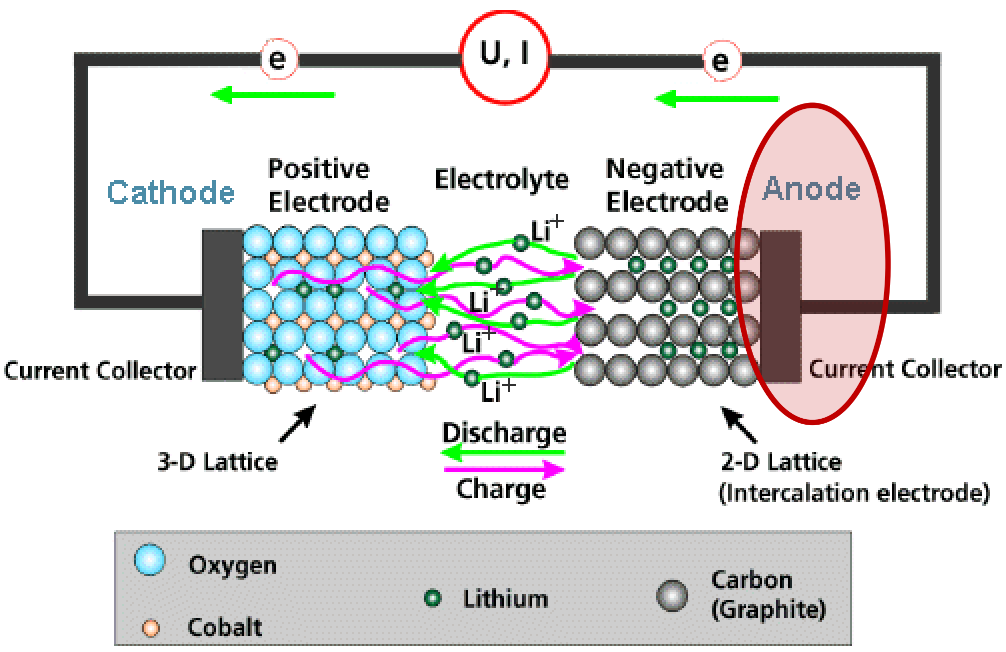
Conductive carbon blacks
can be produced by the thermal decomposition of acetylene at above 800 °C

Fibrous graphite materials
can be produced by the catalytic reaction between hydrocarbon gases and hydrogen at above 1,000 °C

Lithium-ion Batteries

- Carbons in lithium-ion batteries - Anode

Carbon is used in negative electrode anode as both **electrode** and **conductive additive**.



Hard carbons
can be produced from the carbonisation of organic materials, e.g. polymer, cellulose, biomass.

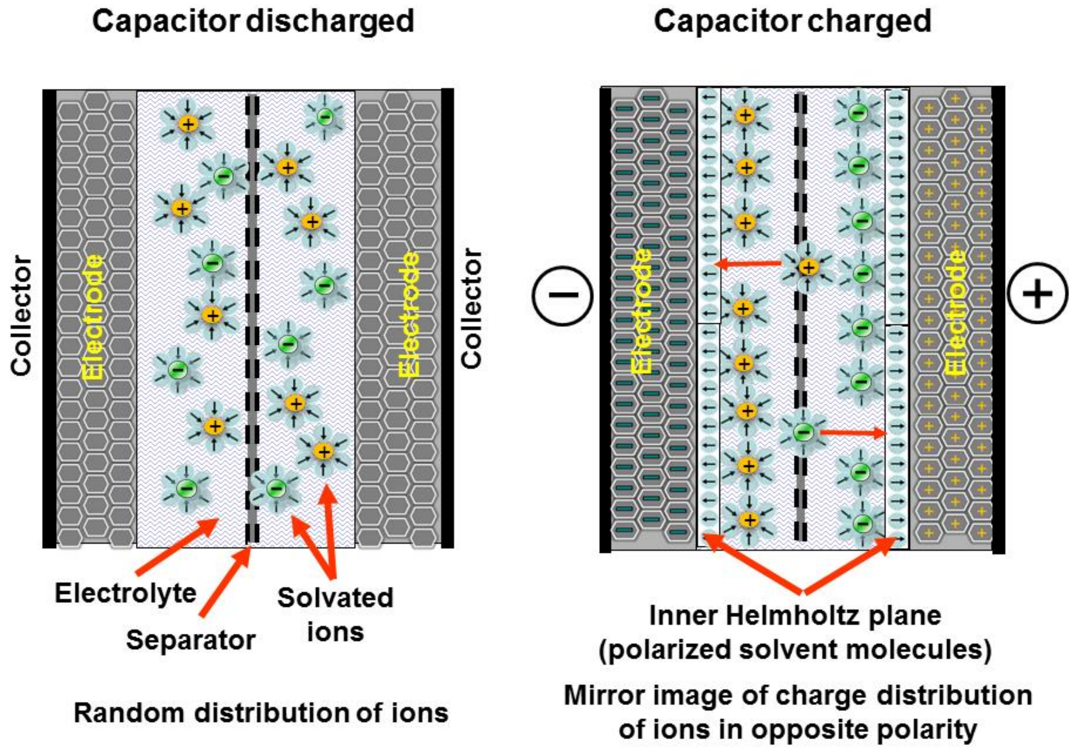
Graphitised mesocarbons (MCMB)
are the mostly used carbonaceous negative electrode materials; hence, it is considered as a benchmark for lithium-ion batteries

Coated natural graphites
is fabricated spherically and coated with a layer of hard carbon.

Synthetic graphites
can be produced by heat treatment of precursor carbon at high temperatures (2,800 °°C or higher)

Supercapacitors

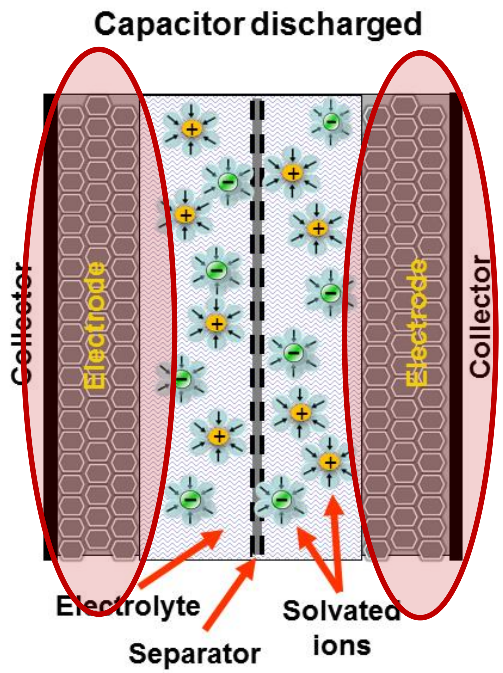
- Principle



Layers of ion is formed and segregated by the physical movement of ions

Supercapacitors

Carbon is employed as **electrodes**.



Activated carbon

is generally employed because of its low cost, good electrical conductivity and high specific surface area. It can be produced from carbonaceous precursors by either physical or chemical activation.

Templated carbons

Offers well-controlled pore size, large specific surface area and interconnected pore network. It is produced by the template method.

Carbon nanotubes

can be synthesised by are discharge, laser ablation and chemical vapour deposition.

Graphene-based materials

can be synthesised by mechanical cleavage of graphite, unzipping carbon nanotubes, chemical exfoliation of graphite, solvothermal synthesis, epitaxial growth on SiC surface and metal surface, chemical vapour deposition and bottom-up organic synthesis.

MTEC/NSTDA & Kyoto University

Mutual interests

- Carbon materials for energy storage applications, e.g. supercapacitors, lithium-ion batteries, etc.
- Usage of an abundant Thai agricultural residues
- Moderate conditions to synthesise carbons

MTEC/NSTDA

Production of carbon

Kyoto University

Application of carbon for energy storage applications

Selected biomass

Jatropha cake

Cashew nut shell

Coconut shell

Palm shell

Corn husk

Eucalyptus wood
Rubber wood

Palm empty fruit bunch

Expected outcome

- The usage possibility of PEFB in Thailand as raw materials for energy storage devices
- More understanding of how each biomass constituents plays a part in the properties of carbon in terms of energy storage application

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MINISTRY OF ENERGY

Thailand Integrated Energy Blueprint

TIEB
THAILAND INTEGRATED ENERGY BLUEPRINT

- **PDP** – Power Development Plan (Cabinet approve in Jun. 30, 2015)
- **EEP** – Energy efficient Plan (Cabinet approve in Oct. 6, 2015)
- **AEDP** – Alternative Energy Development plan (Cabinet approve in Oct. 27, 2015)
- **GAS** – Gas plan (Cabinet approve in Oct. 27, 2015)
- **OIL** – Oil plan (Cabinet approve in Oct. 27, 2015)

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AEDP 2015 - Targets

Overall Targets: 30% Renewable Energy in total energy consumption By 2036

Electricity	19,684.4 MW
Heat	25,088 ktoe
Fuel	11.3 MLPD Ethanol 14 MLPD B100

+0.53 MLPD Pyrolysis Oil
+4,800 TPD of CBG

Wind, Hydro, Waste, Solar, Biomass, Biogas, Ethanol, Biodiesel, CBG Compressed Biogas

To meet the AEDP 2015 target, the leftover of palm oil empty fruit bunch will definitely increase.

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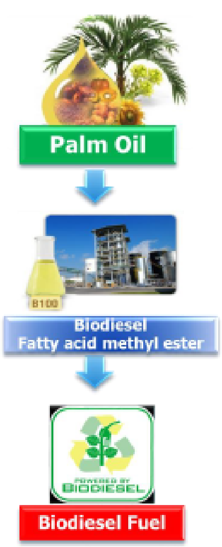
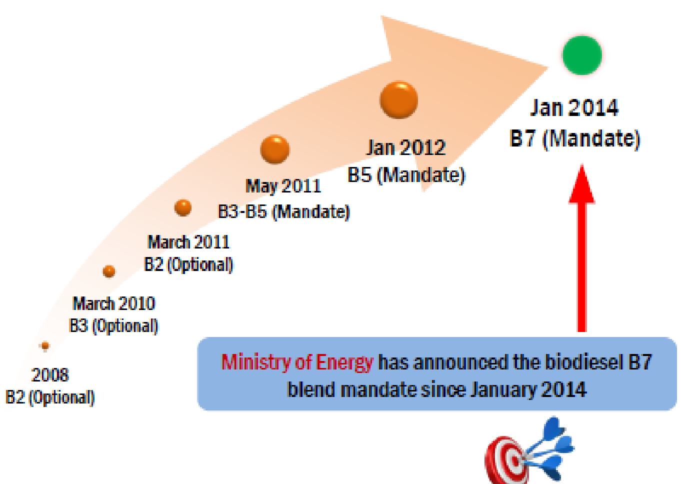
Thailand Biodiesel History



History of biodiesel blend in Thailand



Ministry of Energy has announced the biodiesel B7 blend mandate since January 2014

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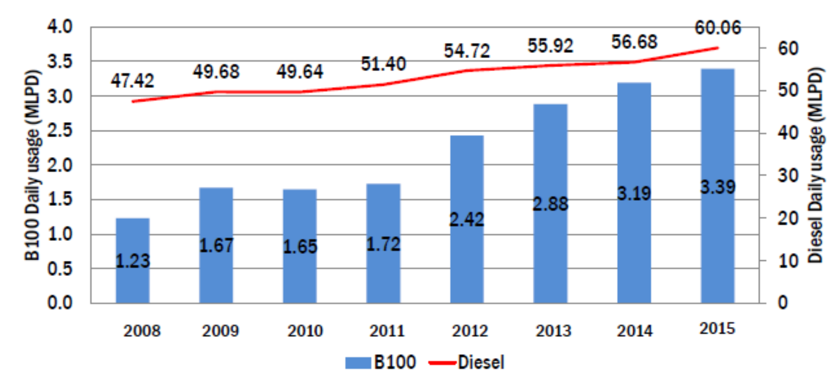
Biodiesel Usage

Thailand mandated 7% biodiesel (B7) blend for every liter of diesel sold since Jan 2014



- Thailand mandated B5 since Jan 2012 and B7 since Jan 2014
- Blending percentage can be adjusted in accordance with palm oil supply abundance

Sources – Department of Energy business

Department of Alternative Energy Development and Efficiency
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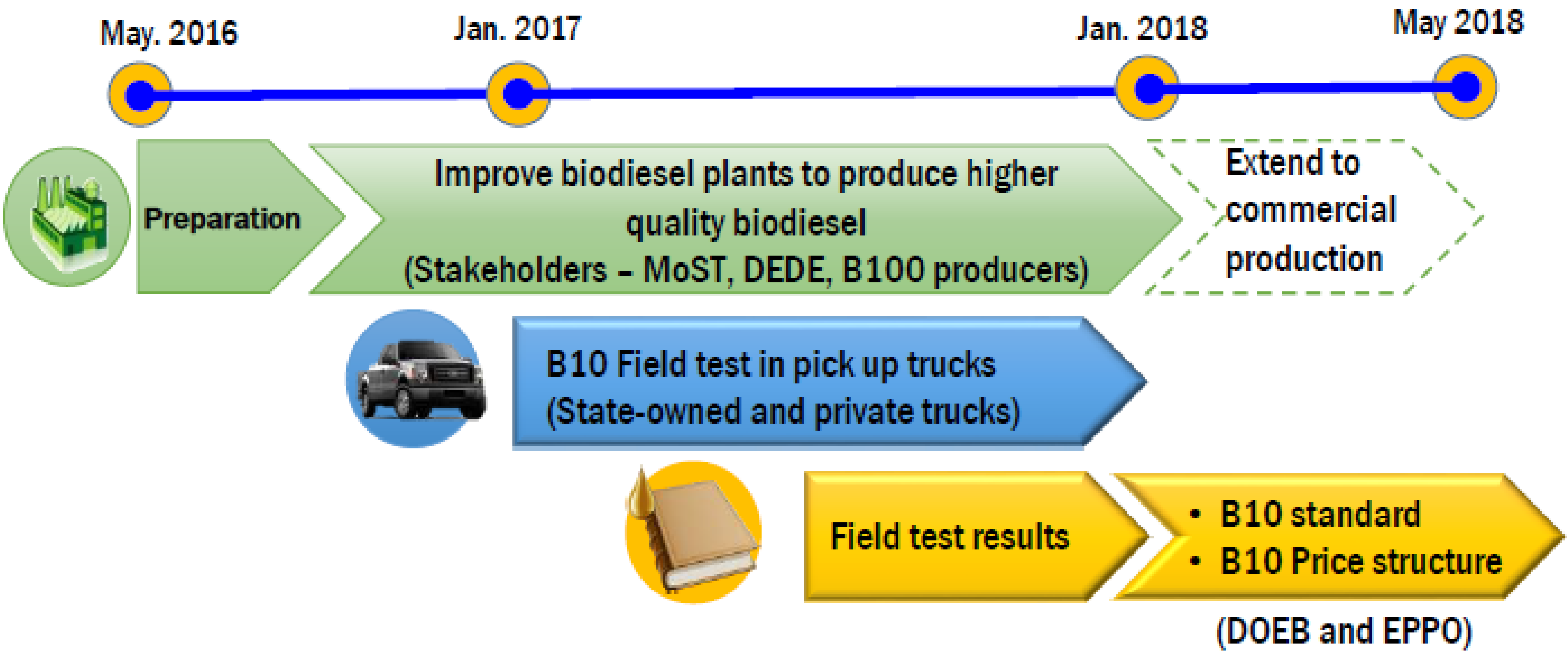
Near term plan for biodiesel

Target – Increase blending ratio from B7 to B10

Research targets : 1. Improve biodiesel quality
2. Field test with pick up trucks up to 50,000 KM



4-Year Research Scope

etc.

Pretreatment → Pyrolysis → Chemical Activation →

Pretreatment
- Separation of biomass constituents, i.e. cellulose, hemicellulose, lignin
De-ashing

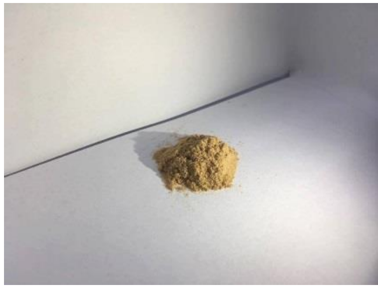
Pyrolysis
- Carbonisation
- Hydrothermal carbonisation

Chemical Activation
- $ZnCl_2$, H_3PO_4, KOH,

Biomass Preparation

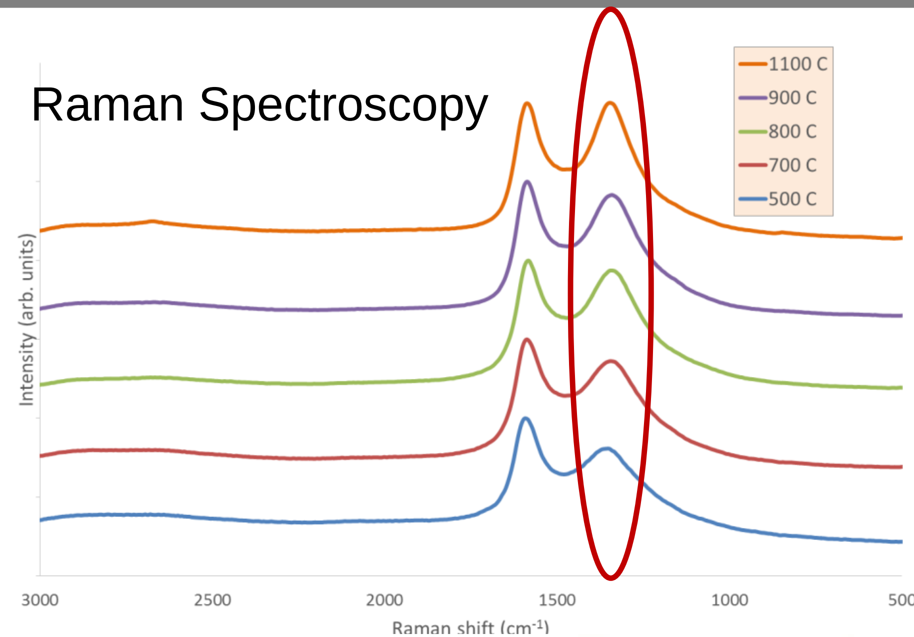
Shredder

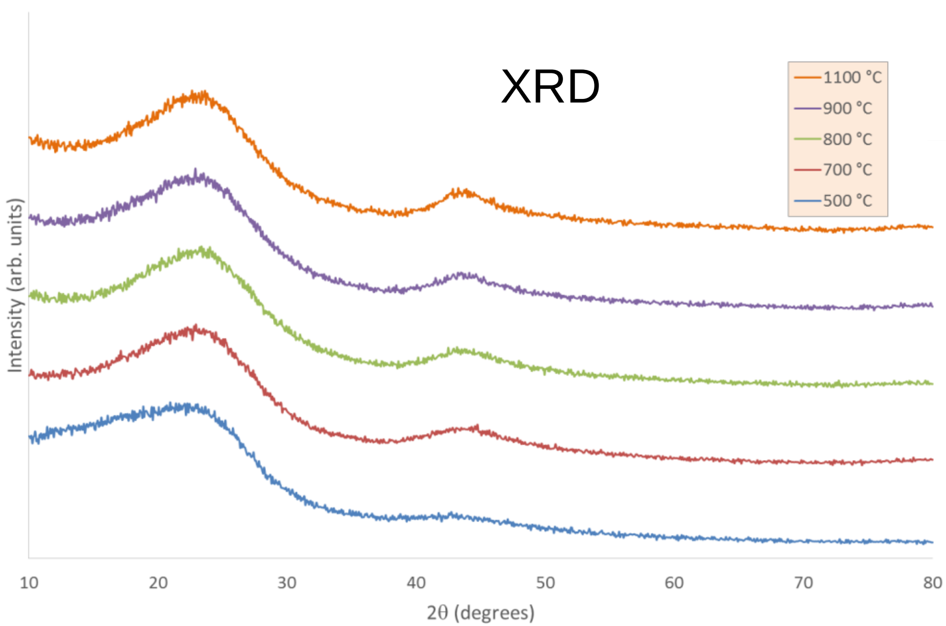
Rotor mill



Carbon from Coconut Shell

Coconut shell
Smaller than 75 μm
under N_2





Time schedule

Year	Plan

2016* (1st)	• Carbonisation of Thai biomasses
	  • 1 selected biomass
	    • Parameters of interest: type of inert gas, temperature, gas flow rate, heating rate
	  • Up to 10 types of biomasses
	    • 1 selected condition to compared among biomasses

2017 (2nd)	• Carbonisation of Thai biomasses (cont.) • Carbonisation of pretreated PEFB**
2018 (3rd)	• Hydrothermal carbonisation of biomasses found in Thailand • Hydrothermal carbonisation of pretreated PEFB
2019 (4th)	• Chemical activation of chars from carbonisation • Chemical activation of hydrochars from hydrothermal carbonisation
2020 (5th)	• Chemical activation of pretreated PEFB chars • Chemical activation of pretreated PEFB hydrochars

*less than 12 months
**Palm empty fruit bunch

MTEC
a member of NSTDA

สวทช NSTDA

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- JASTIP


Thank You