The 2nd JASTIP-WP2 Annual Workshop
Feb. 3, 2017(Pullman Bangkok Grande Sukhumvit Hotel)

Extension of Solvent Treatment Method Developed by SATREPS Program to ASEAN Region

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Members of our group (tentative)

Hideaki Ohgaki, Proferssor, Institute of Advanced Energy, Kyoto University
Ryuichi Ashida, Lecturer, Graduate School of Engineering, Kyoto University
Janewit Wannapeera, Researcher, Institute of Advanced Energy, Kyoto University
Katsuyasu Sugawara, Professor, Akita University
Nakorn Worasunarak, Assoc. Professor, JGSEE/KMUTT
Suneerat Fukuda, Assoc. Professor, JGSEE/KMUTT

Japan-Thailand SATREPS Project

Development of clean and efficient utilization of low rank coals and biomass by solvent treatment

Dec. 20, 2013 – Dec. 19, 2018

Kouichi Miura
Institute of Advanced Energy,
Kyoto University

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JGSEE/King Mongkut's University of Technology Thonburi

Purposes of the SATREPS Project

1. To establish a technology converting low rank coals and/or biomass wastes using a new method called "Degradative Solvent Extraction", which was developed by Kyoto University group, to raw material independent small molecular weight components called "Soluble" and Residue.
2. To develop technologies for utilizing Soluble and Residue effectively.
   eg. Preparation of value added materials such as carbon fiber, clean fuel, chemicals, etc. Effective methods to combust/gasify Residue
3. To assist the development of human resources and research capabilities in Thailand by conducting joint research.

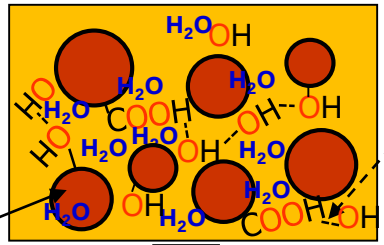
- The technologies developed under cooperative researches will contribute to reduce the emission of global warming gases as well as environmental pollutants.
- The technologies developed will be disseminated to ASEAN countries which need such technologies.

What is the

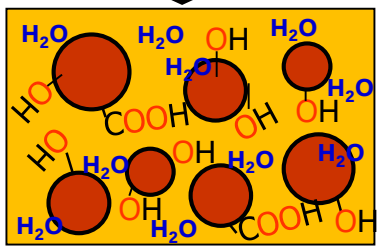
“Degradative Solvent Extraction”?

Proposed method

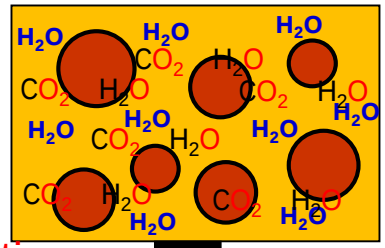
In non-polar solvent



Heated up to 150 °C



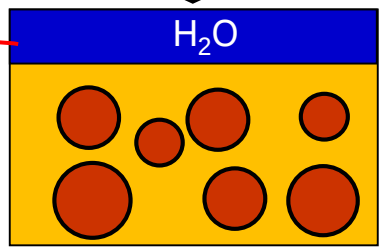
Heated up to 350 °C



Cooled

Non-evaporative dewatering

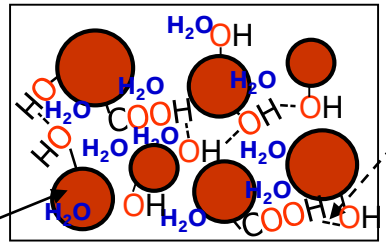
CO_2, H_2O



Upgrading without cross-linking reactions.

Conventional heat-treatment

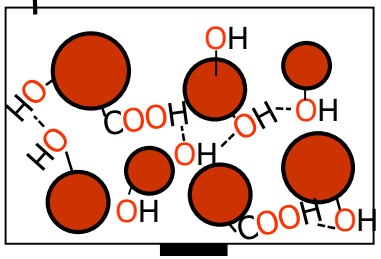
In inert gas



Heated up to 150 °C

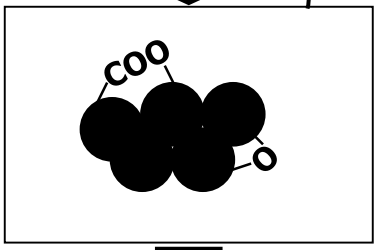
H_2O

Evaporative dewatering

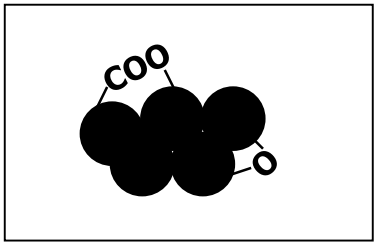


Heated up to 350 °C

CO_2, H_2O

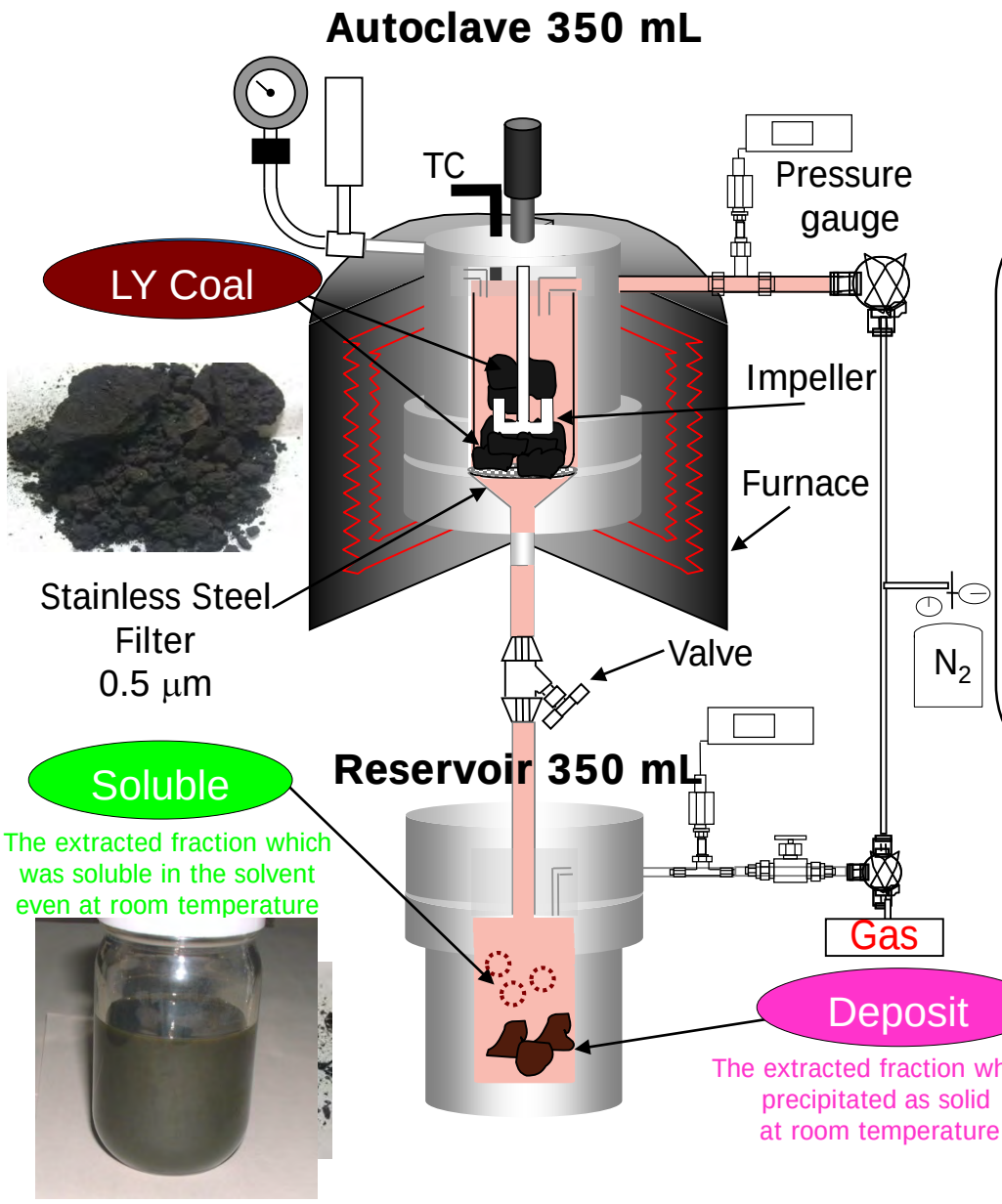


Cooled



Significant enlargement of the coal molecules.

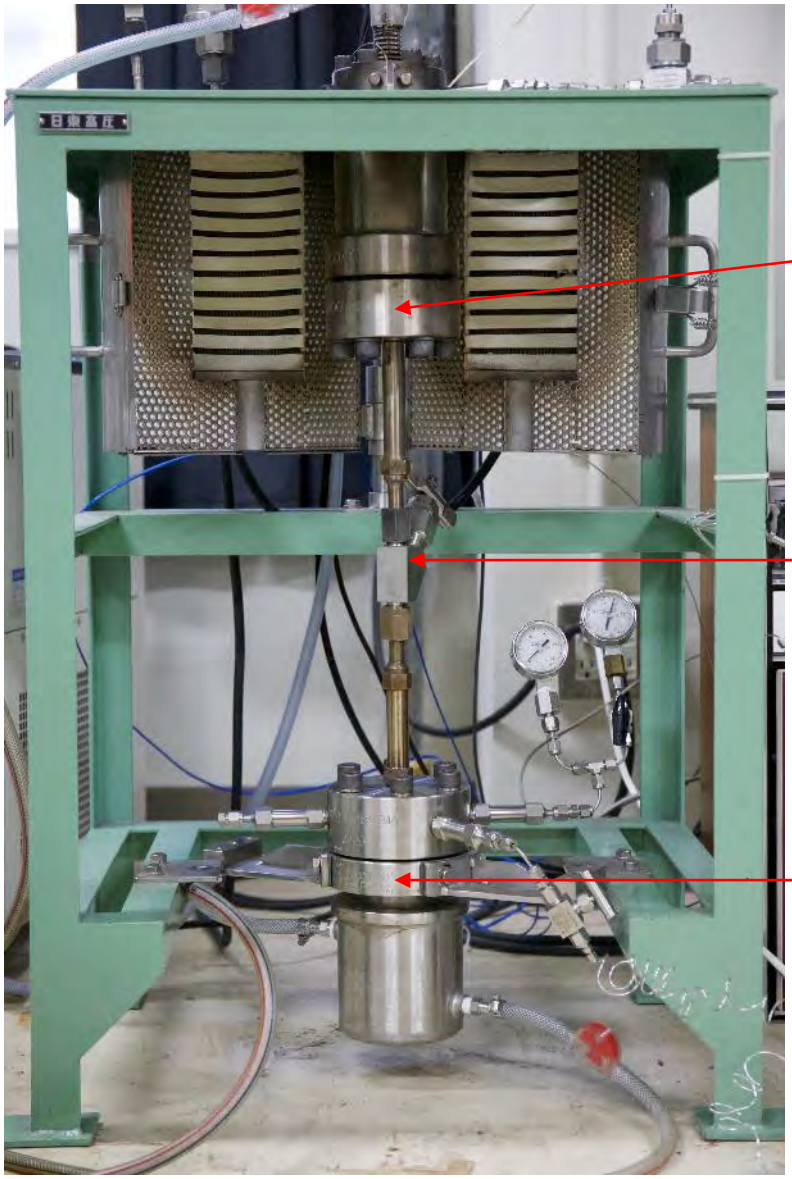
Apparatus and procedure



Experimental conditions

- Coal: 14 g-d.a.f.
  (Charged as received)
- 1-MN : 300 mL
- Temperature : 350°C
- Holding time : 0, 1, 2, 3 h
- Final pressure : 2.3, 6.8, 15.7 MPa

Apparatus used



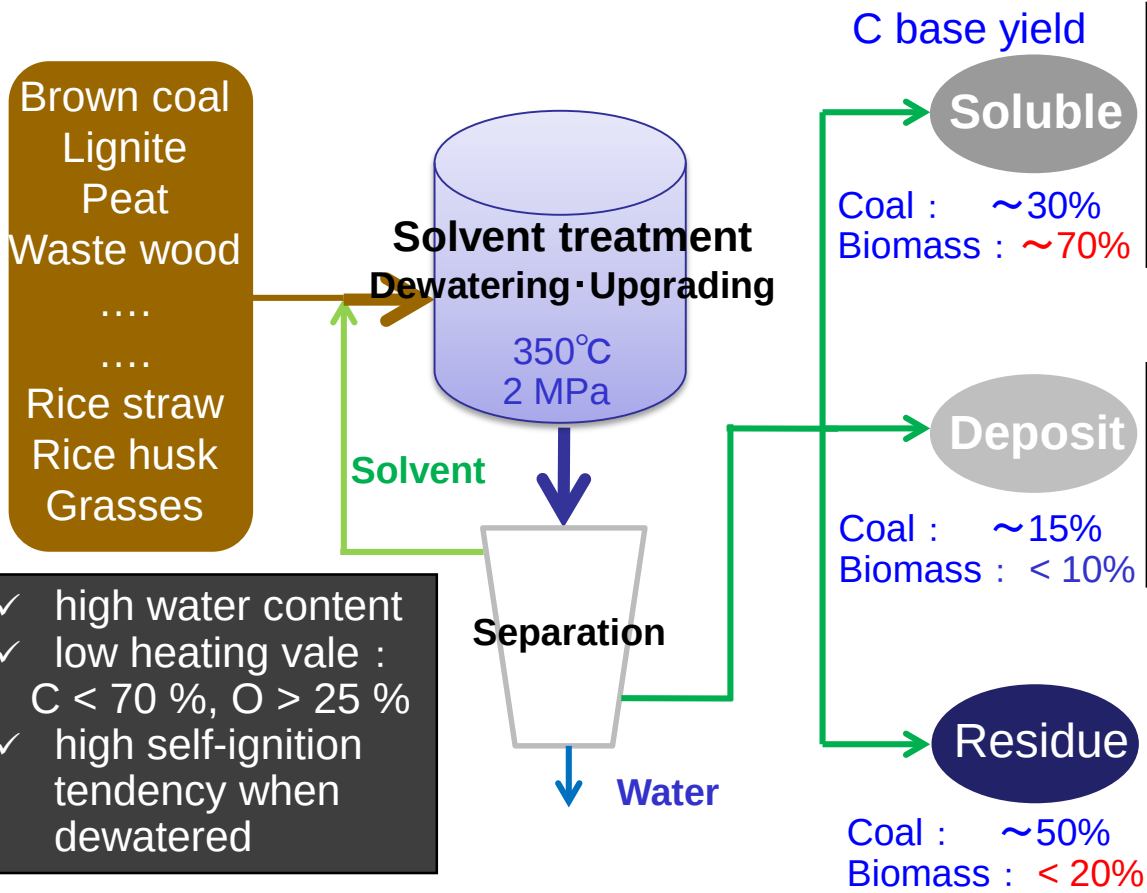
Raw materials used

Brown coal (Loy Yang)

Rice straw

Leucaena

Core technology is “Degradative Solvent Extraction”



Raw material independent property
high HHV：C≒82 %, H ≒9 %, O ≒9%
low MW: 100-500, peak at ca. 300
80 % are volatile components
melts below 100 °C
free from water and ash

Raw material independent property
C ≒76 %, H ≒5.5 %, O ≒15.5%
melts below 250 °C
free from water
low ash content：＜1.4 %

High reactivity to combustion
low water content
Concentrated mineral components

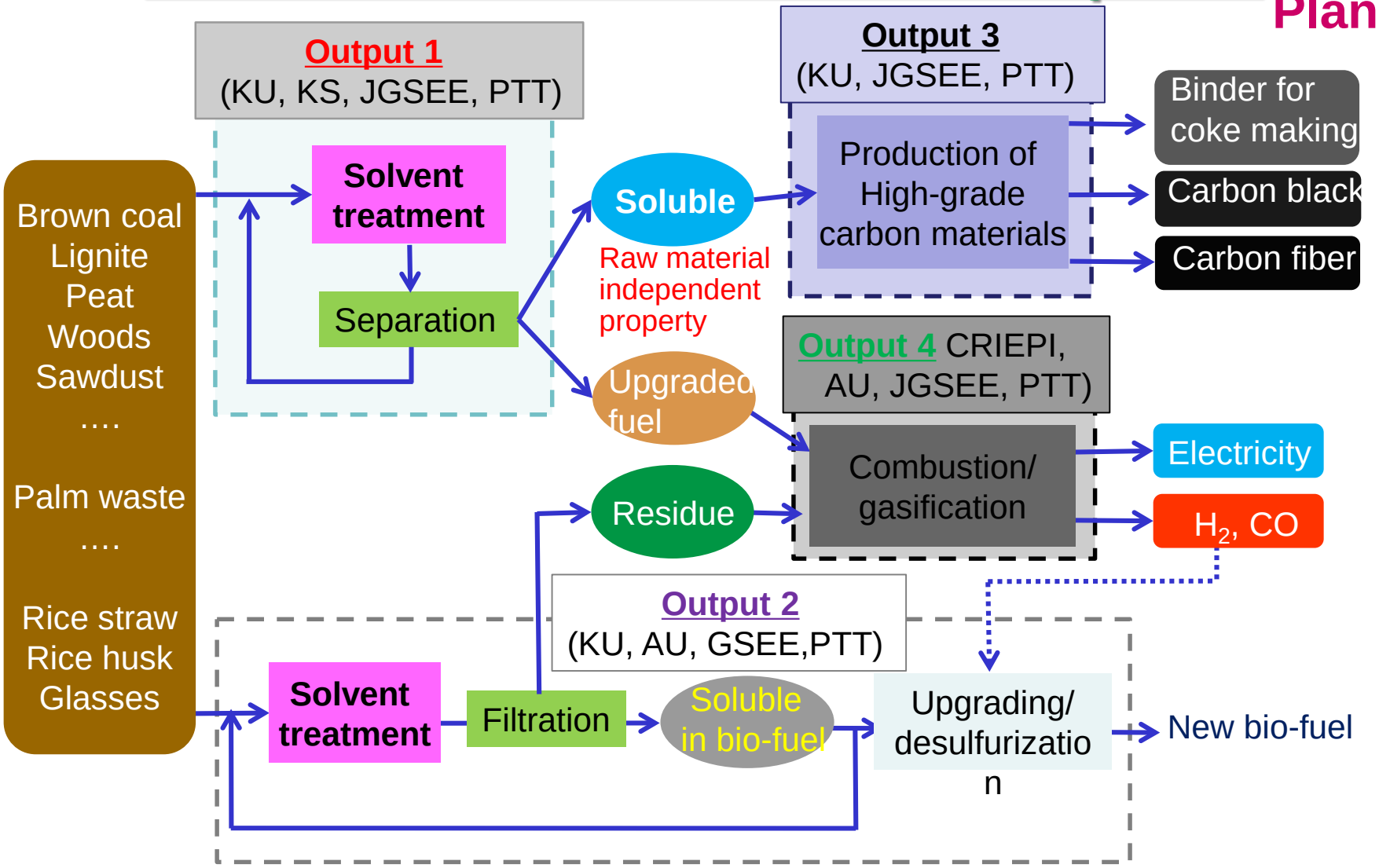
- ✓ high water content
- ✓ low heating vale：
  C < 70 %, O > 25 %
- ✓ high self-ignition tendency when dewatered

The method dewaters and upgrades various low grade carbonaceous resources, producing high quality extract in high yield under mild conditions.

- ➢ Almost no heating value loss through the treatment
- ➢ Soluble and Deposit have raw material independent properties

Structure of Research and Development

Planned



Output 1: Upgrading of low rank coals and biomass by solvent treatment
Output 2: Production of new bio-fuel from biomass wastes and effective upgrading
Output 3: Production of high-grade carbon materials from the Solubles
Output 4: Combustion/gasification of upgraded fuels/residues

Cooperative Structure of our project

Japan

Head Investigator: Kouichi Miura
Research fund: 178 million yen from JST

Kyoto University: Miura Gr.
Kouichi Miura, Specially App. Prof.
Hideaki Ohgaki, Prof
Ryuichi Ashida, Assist. Prof.
Motoaki Kawase, Prof.
Taro Sonobe, Research Administrator
Janewit Wannapeera, Dr.
Trairat Muangthong-on, PhD cand.

Akita University: Sugawara Gr.
Katsuyasu Sugawara, Prof.
Takahiro, Kato, Assis. Prof.
Kenji Murakami, Prof.

CRIEPI: Makino Gr.
Hisao Makino, Dr.
Kenji Tanno, Dr.
Satoshi Umemoto, Dr.
Atsushi Ikeda, Mr.
Shiro Kajitani, Dr.

Kobe Steel Co. Ltd: Okuyama Gr
Noriyuki Okuyama, Dr.
Takuya Yoshida, Dr.
Shigeru Kinoshia, Mr.
Koji Sakai, Mr.

Thailand

Head Investigator: Bundit Fungtammasan
Research fund: 300 million yen from ODA

JGSEE/KMUTT: Bundit Gr.
Assoc.Prof. Bundit Fungtammasan
Assoc.Prof. Sirintornthep Tawprayoon
Assoc.Prof. Nakorn Worasuwannarak
Assoc.Prof. Suneerat Fukuda
Dr. Supachita Krerkkaiwan
Ms. Sasithorn Buranatrevedhya
Mr. Supachai Jadsadajerm
Mr.Jaggapan Sanduang
Ms.Thitima Sornpitak
Mr.Kaweewong Wongaiyara

PTT-RTI, PTT Public Company Ltd: Arunratt Gr.
Arunratt Wuttimongkolchai, Ms.
Suttipong Tunyapisetsak, Mr.
Suchada Butnark, Dr.
Anurak Winitsorn, Dr.
Suriya Porntangjitlikit, Mr.
Kornthape Prasirtsiripham, Mr.

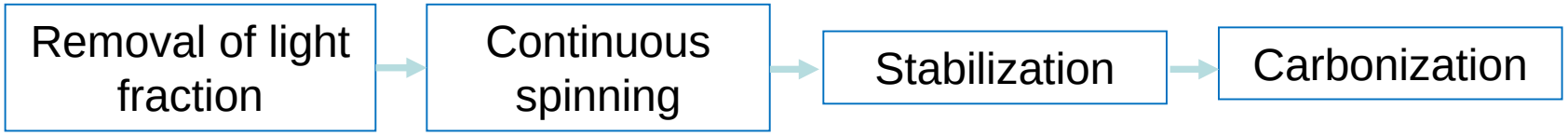
Four research groups from Japan and two research groups from Thailand are involved in this project.

More than 30 researchers from academy and industry contribute to this project

Planned Schedule of Research and Development

Activity	Schedule (from 2014 to 2018)																				Group in charge	
	2014				2015				2016				2017				2018				Japan	Thailand
	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q		
Task 1. Upgrading of low rank coals and biomass by solvent treatment																						
1.1 Production of Solubles from low rank coals and biomass using a batch autoclave																					KU	JGSEE
1.2 To optimize the production of Solubles from low rank coals and biomass																					KU	JGSEE
1.3 To characterize the properties of Solubles and Residues from low rank coals and biomass																					KU	JGSEE
1.4 To design and construct the semi-continuous extraction process (1 kg/h)																					KS	PTT
1.5 Production of Solubles from low rank coals and biomass using the semi-continuous extraction process																					KS	PTT
1.6 Conceptual process design for constructing a pilot plant of 10 ton/day																					KS	PTT
Task 2. Production of new liquid biofuels from solubles																						
2.1 Optimization of production of liquid biofuels using batch reactor (5 L)																					KU	JGSEE, PTT
2.2 Upgrading liquid products to liquid biofuels by hydroprocessing																					AU	PTT
2.3 Combustion test in gas turbine engine																					CRIEPI, KS	PTT
2.4 Cost estimation, feasibility study and scale-up plant (in case of technical soundness)																					KS	PTT
Task 3. Production of high-grade carbonaceous materials from Solubles																						
3.1 Characterization of Solubles as a raw material for high performance carbon materials																					KU	JGSEE
3.2 Design and construct a small apparatus producing carbon fiber/carbon black																					KU	JGSEE
3.3 Production of carbon fiber from Solubles																					KU	JGSEE
3.4 Design and construct a small continuous spinning apparatus (0.1 kg/h)																					KU	JGSEE
3.5 Production of carbon fiber using a small continuous spinning apparatus																					KU	JGSEE PTT
3.6 Conceptual process design for a pilot plant																					KU	JGSEE
Task 4: Combustion/gasification of upgraded fuels/residues																						
4-1 Fundamental Examination of combustion/gasification behaviors of upgraded fuels/residues in TG																					CRIEPI,AU	JGSEE,PTT
4-2 Examination of combustion/gasification behaviors of upgraded fuels/residues in Entrained bed reactor																					CRIEPI,AU	JGSEE,PTT
4-3 Examination of combustion behaviors of upgraded fuels/residues in Fluidized bed reactor																					CRIEPI	JGSEE

Preparation of carbon fiber from Soluble – Task 3 -



-20% of light fraction was removed by heat treatment

-20% of Soluble can be utilized as oil without treatment

Spinning using a mono-hole continuous spinner at -200℃

Oxidation treatment in air at -300℃

Heat treatment at -800℃

Continuous spinning of the modified Soluble

Modified Soluble is heated to 285 °C

Pitch fiber coming out from the mono-hole

Pitch fibers collected

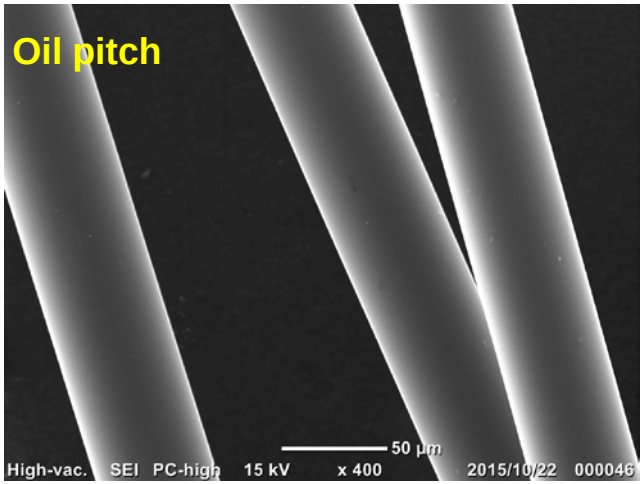
Rotating drum (16 cmϕ)
(rotating at 600 – 1000 rpm)

Fig. Mono-hole spinning machine

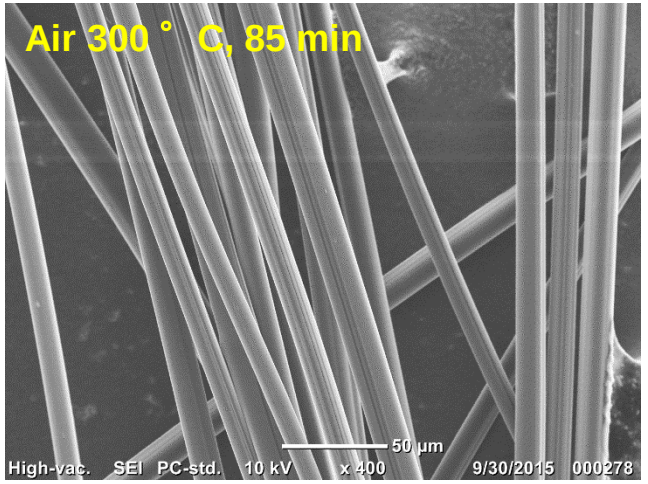
Carbon fibers: J-RS Soluble

- SEM images of carbon fibers (400x)

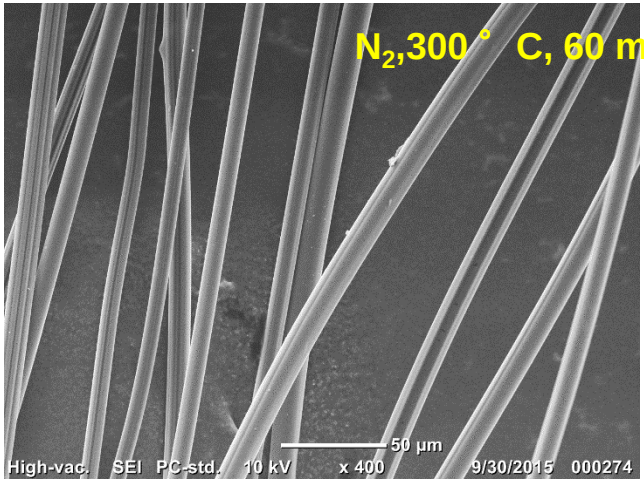
Fibers dia.
51.7-54.7 µm



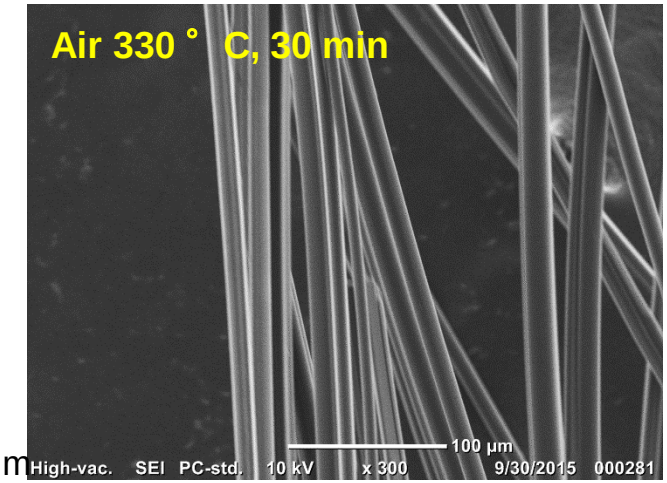
Fibers dia.
11.4-16.7 µm



Fibers dia.
6.6-13.8 µm

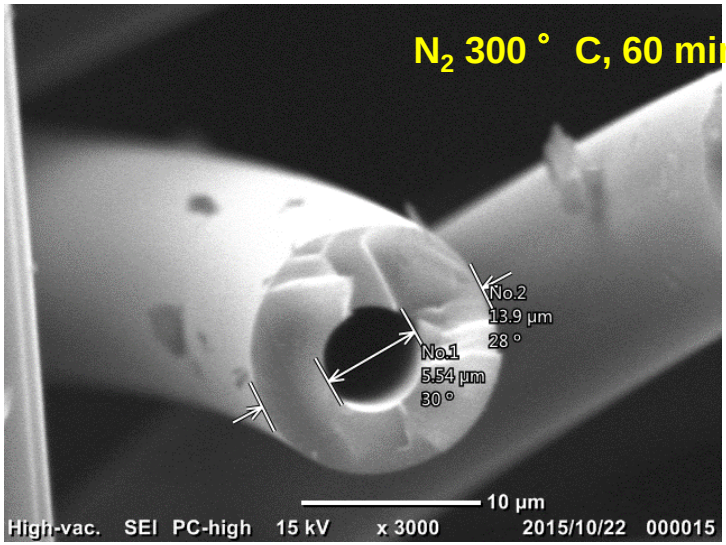


Fibers dia.
12.1-16.8 µm

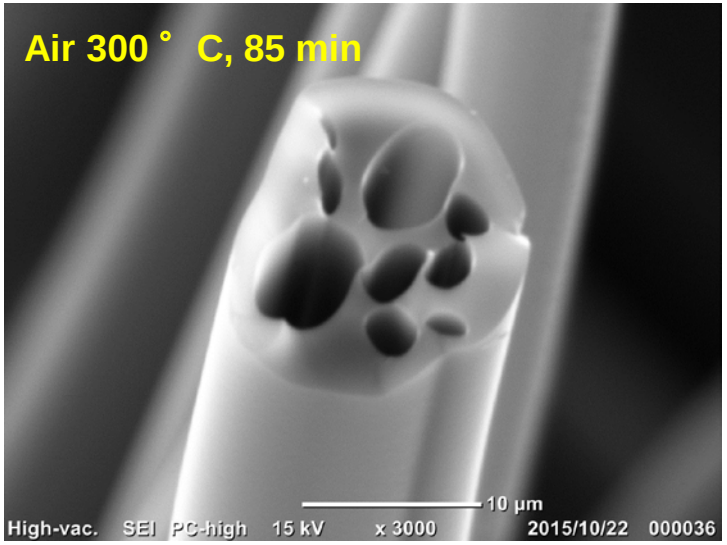


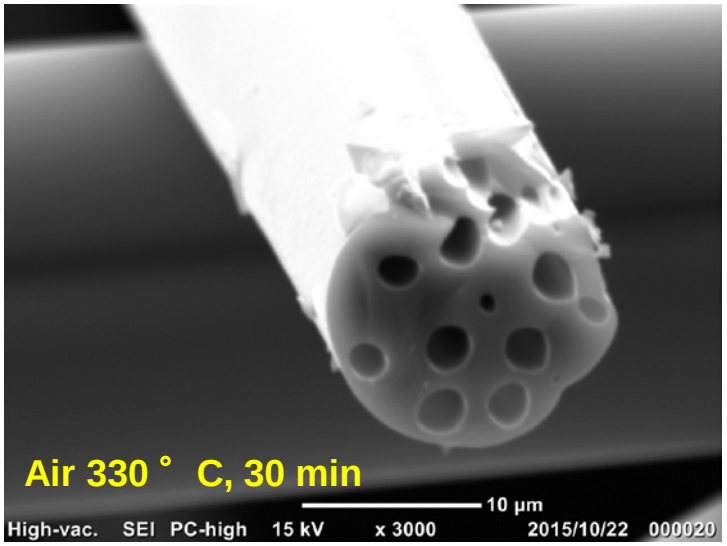
Carbon fibers: J-RS Soluble

- SEM cross-sectional images of carbon fibers (3000x)



  - Only one hollow was observed from the fibers prepared from Soluble treated by the N_2 purge.
  - Several hollows were observed from the fibers prepared from Soluble treated by the air oxidation.



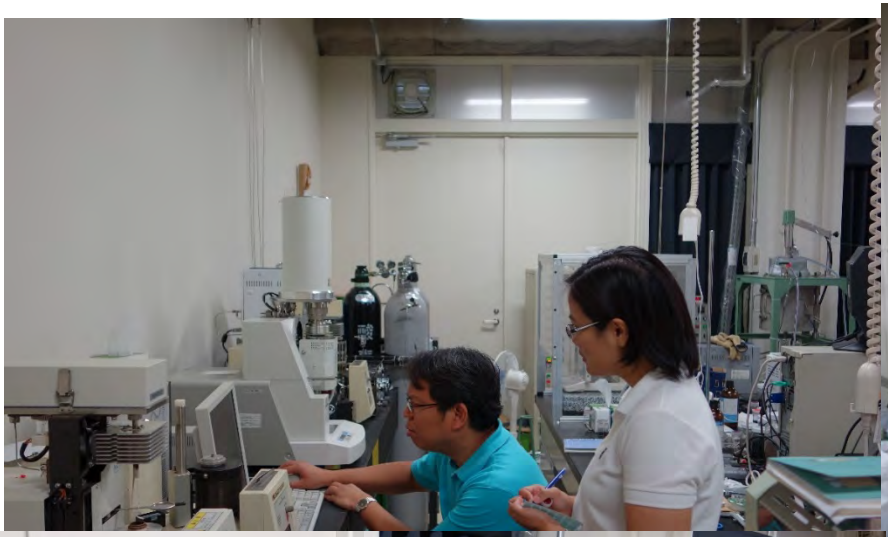


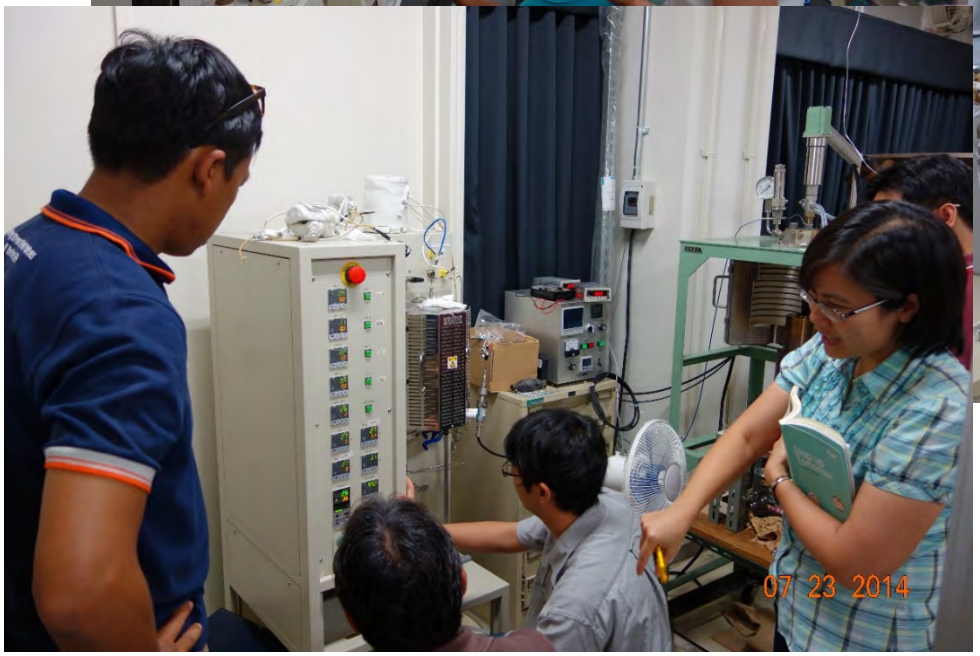
Dispatch of researchers
Acceptance of researchers

History of exchange

Year	Number of dispatch researchers	Number x Day (man-day)	Number of accepted researchers	Number x Day (man-day)
2013	11	55	1	60
2014	39	311	11	255
2015	27	249	9	123
2016	19	197	12	154
Total	**96**	**812**	**33**	**592**

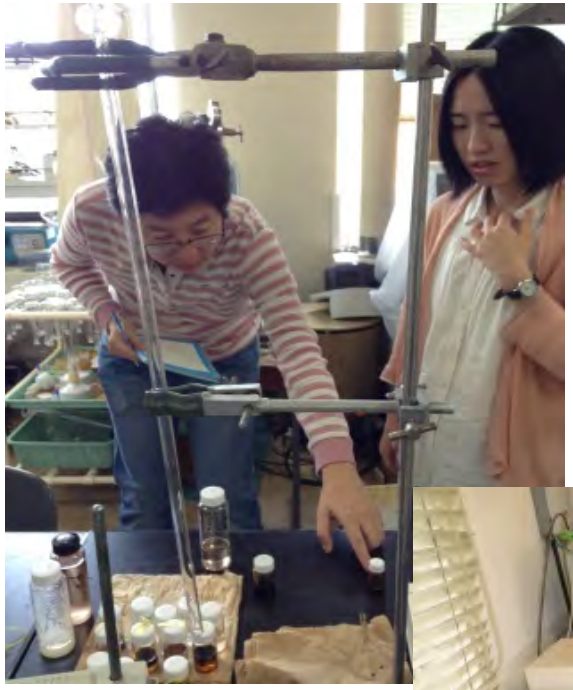
Visit Kyoto University (July. 17 – Aug. 3, 2014)





Training of solvent extraction and carbon fiber preparation

Akita University (June, July, 2014)



Training of solvent desulfurization experiments

Visit CRIEPI

(June. 15-17, 2015)

Training of DTF operation

(Feb. 1, 2015)

Plant tour at Kobe Steel (Aug. 4, 2014)

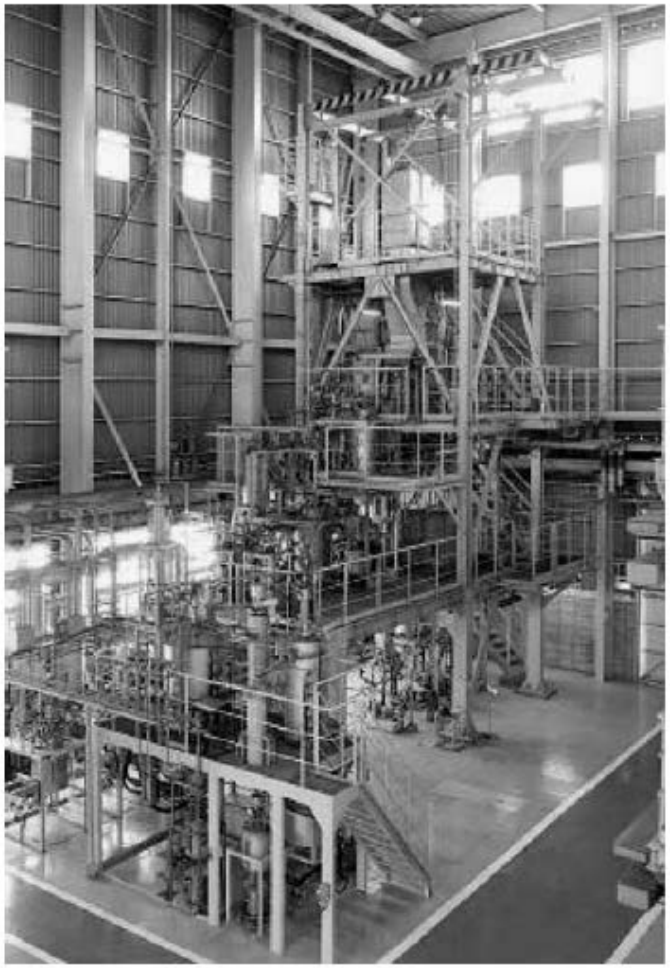


図 3 0.1t/d HPC 連続製造試験装置
Fig. 3 0.1t/d HPC Bench scale unit

The Thai members had a opportunity to see the continuous HPC production facility

Solvent Extraction Plant tour at Kobe Steel (April, 2015)

Activities extending the SATREPS project

Activity assimilating the SATREPS output to ASEAN countries

Japan - Thailand SATREPS Workshop 2016

"Development of Clean and Efficient Utilization of Low Rank Coals and Biomass by Solvent Treatment"

1 March 2016
Sattabongkot room,
Pilot Plant Development and Training Institute building,
KMUTT(Bangkhuntien campus)

Supported by a JST fund

Outline of the Workshop

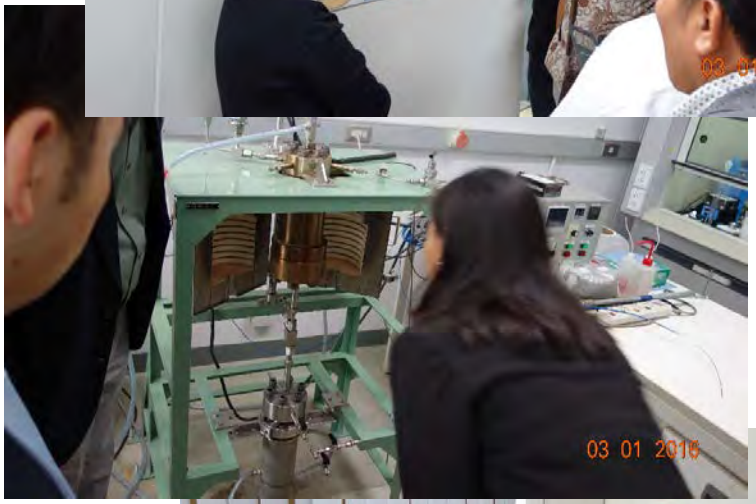
- Laboratory tour of JGSEE/KMUTT and poster presentations of the STREPS project
- Introduction of the SATREPS project
- Presentations of from 4 ASEAN countries

Participants from ASEAN countries

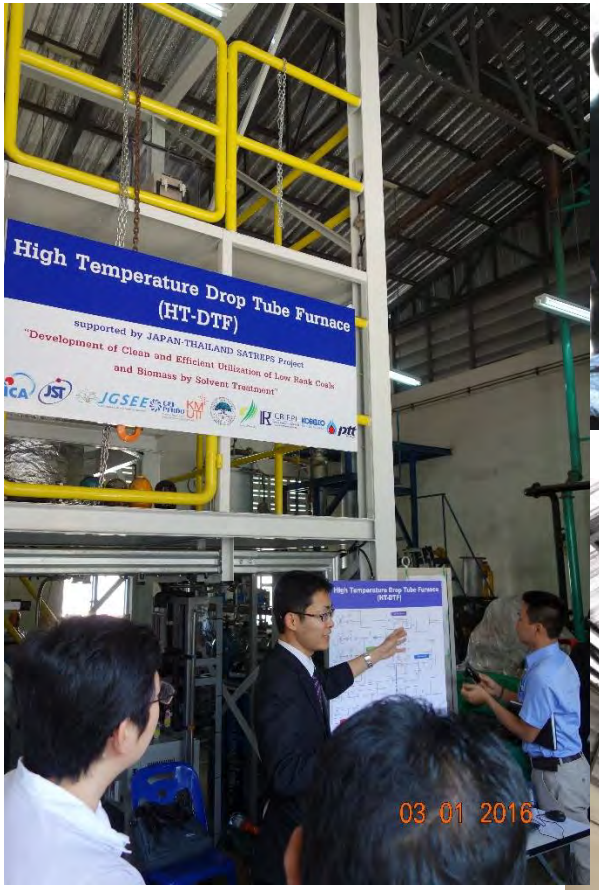
Name	University/Organization	Country
Dr. Lim Chee Ming	Universiti Brunei Darussalam	Brunei
Dr. Long Bun	Institute de Technologi Cambodia	Camobodia
Dr. V. K . Vijay	Indian Institute of Technology Dehli	India
Dr. Harwin Saptoadi	Universitas Gadjah Mada (UGM)	Indonesia
Iman K. Reksowardojo	Institut Teknologi Bandung, Indonesia	
Dr. Khamphone NANTHAVONG	Deputy head of NU Laos	Lao PDR
Mr. Boualy VONGVISITH	Renewable Energy and New Materials Institute, Ministry of Science and Technology, Laos	
Mr. Phonepasong Sithideth	Institute of Renewable Energy Promotion, Ministry of Energy and Mine, Laos	
Dr. Masjuki Hj. Hassan	Universiti Malaya (UM)	Malaysia
Dr. Hamdani Saidi	Universiti Teknologi Malaysia	
Dr. Nasrudin Abd Rahim	Universiti Malaya (UM)	
Dr. Hla Toe	Ascociate Professor	Myanmar
Dr. Rizalinda de Leon	University of the Philippines Diliman	Phillipines
Atty. Pete H. Maniego, Jr	National Renewable Energy Board	
Dr. Ereese Macabebe	Ateneo de Manila University	
Dr. Liu Dac Hai	Vietnam National University-Hanoi	Vietnam
Dr. Le Chi Hiep	Vietnam National University-Ho Chi Minh City (VNU - HCM)	
Dr. Van Dinh Son Tho	Vietnam Japan International Institute for Science of Technology	

Other participants: 1 from India, 20 from Thailand, and 18 from Japan

Tour of JGSEE/KMUTT



Tour of JGSEE/KMUTT



Presentation of ASEAN participants

Prof. Harwin Saptoadi (from Indonesia)

Dr. Van Dinh Son Tho (from Vietnam)

Prof. Hamdani Saidi (from Malaysia)

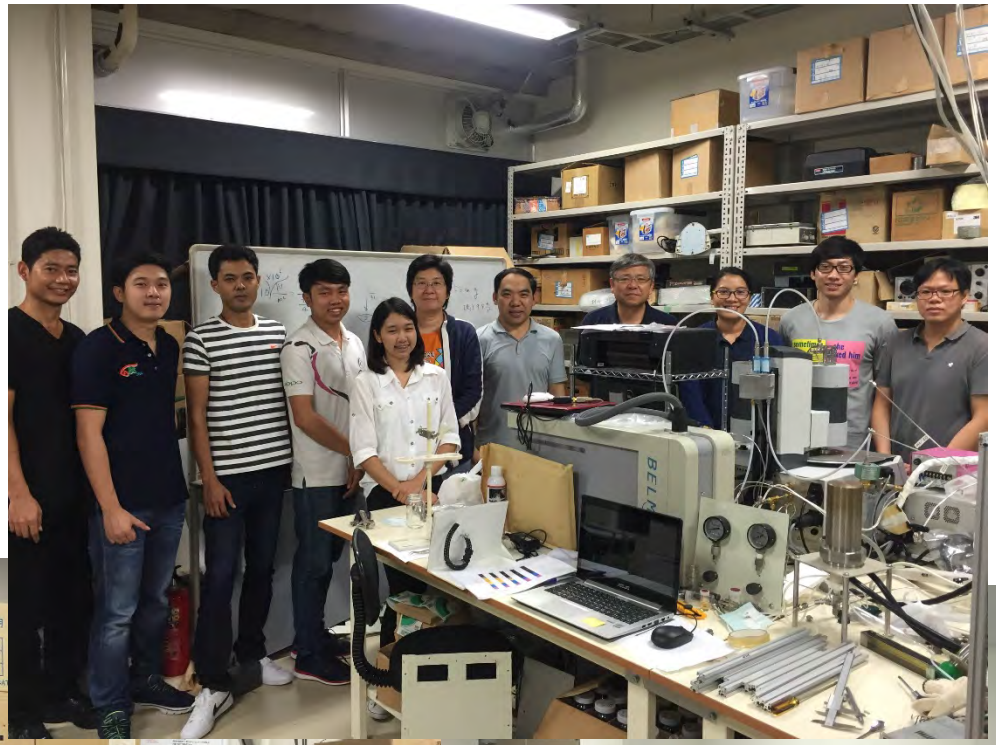
Dr. Atty. Pete H. Maniego (from the Philippines)

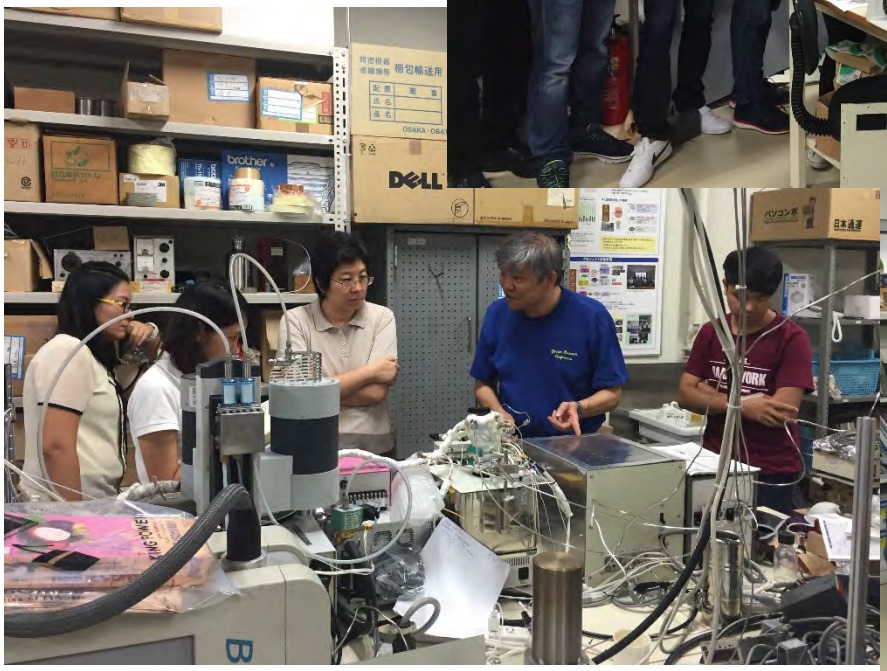
Workshop scenes

Pamphlet and video prepared for the Workshop

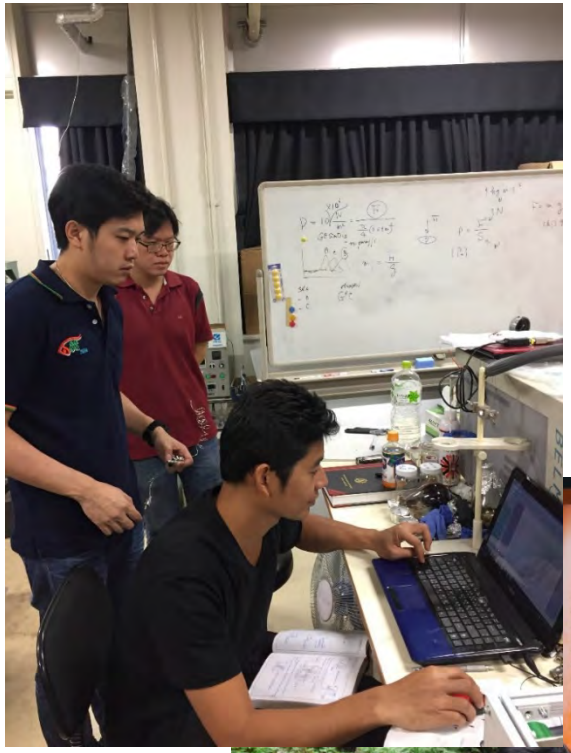
fang: rice straw, tan: charcoal

Training at Kyoto University Sep. – Oct., 2016





Training of 2 Thai students at Kyoto University
Sep. 9 – Oct. 18, 2016



supported by a KU fund

Training of 1 Laos researcher at Kyoto University
Jan. 9 – Feb. 7, 2017

Dr. Xayalak from Laos National University is using a set of thermoanalysis equipment

supported by a JICA fund

Expected Outcome/Future of our Project

- Implementation of a new technology for utilizing low rank coals and biomass wastes in Thailand
- Human building in both Japan and Thailand for effective utilization of biomass waste/low rank coal

- JGSESS/KMUTT and PTT-RTI help dissimilation of the technologies developed to ASEAN countries
- JGSESS/KMUTT works as a center of biomass conversion technology development and human resource building in ASEAEN countries

Japanese members will assist the activities through JASTIP (Japan ASEAN Science and Technology Innovation Platform) program .