Bioresources and Energy Technology Lab - Integration of engineering technologies into bioresources utilization

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1. Background

(a) Status of energy and environment in Taiwan

- High dependence on energy import: The dependence on imported energy is on the increasing trend from 95.84% in 1990 to 99.34% in 2008. On the other hand, the energy supply and energy consumption totaled 142.5 and 117.7 million kiloliters of oil equivalent (KLOE) in 2008, respectively, in contrast to 58.7 and 51.9 million KLOE in 1990, respectively.
- Increase in the total of carbon dioxide (CO2) emissions: The CO2 emission in 2008 was 256.97 million metric tons in contrast to 110.50 million metric tons in 1990. On average, annual growth rate was 4.80% from 1990 to 2008, which could be divided into two growth stages: 6.85% from 1990 to 2001, and 2.30% from 2001 to 2008.
- According to the Renewable Energy Development Act passed by the Taiwan's Cabinet (Executive Yuan) in June 2009, the biomass energy is defined below: the energy is generated from the direct utilization of agricultural & forestry plants, biogas and domestic organic wastes, or it is obtained by the treatment/processing of these bioresources. The green energy provides the multi-benefits, including energy security (low-carbon fuels), sustainable agriculture (biomass utilization), environmental protection (global change), and economic development (green industry).

(b) Status of agricultural residues (biomass) in Taiwan

- Agricultural enterprises generate general industrial wastes. The main examples of this type of orgaic wastes include food processing wastes, waste paper, organic sludges, scrap wood, sugar milling wastes, and so on. On the other hand, there are many common crops and fruits in Taiwan, including rice, corn (or maize), and coconut. Inevitably, large quantities of crop/fruit residues are those left in the field after harvest to provide fertilizing benefits for the next cropping cycle, or produced from the crop grain processing facilities (e.g., rice husk from rice-milling works). According to the national statistical data surveyed by the Environmental Protection Administration (EPA) and the Council of Agriculture (COA), the annual production of agricultural wastes/residues and organic industrial wastes was estimated to be over 5 million metric tons.
- Only small fraction of the crop residues (i.e., rich straw, rice husk, corn cob) generated in Taiwan were used for poultry feed, or reused as fuel for household cooking and made as paving materials in the animal husbandry. It should be noted that sugar milling wastes (i.e., sugar bagasse) were almost reused as auxiliary fuel in the boiler to generate the power (steam and/or electricity). However, most of crop/fruit residues were arbitrarily incorporated into the soil and burned in the open field. These waste management approaches have received much attention in recent years mainly due to the local air quality deterioration, the risk of road accidents caused by drifting smoke and the dissipation of bioenergy potential.

It is well known that agricultural crop residues contain high amounts of lignocellulosic materials (i.e., cellulose, hemicellulose and lignin) and possess high heating value on a dry weight basis. Therefore, they could be recognized as potential sources of biofuels and biopower based on multiple benefits of energy recovery, agricultural waste management and greenhouse gases (GHGs) emission reduction. Based on the background described above, the National Pingtung University of Science and Technology (NPUST) established the Graduate Institute of Bioresources (GIB; Ph. D. program) in 2004 under the College of Agriculture. One of the main development goals in the GIB is to utilize the biomass residues. Under the funding support by the Ministry of Education, the College of Agriculture further set up the Asian Pacific Research Center for Tropical Agriculture (APRCTA) in 2008. One of the core laboratories is the Bioresources and Energy Technology Lab, which aims at creating added-values and industrial sustainability from the utilization/recycling/reuse of bioresources and biomass residues as biomass energy and green materials.

2. Goals

- Combining the resources of the APRCTA to develop the key technologies of ecological (bio-based) materials and bimass energy.
- Integrating the campus resources regarding agricultural and engineering technologies to promote the research & development on the utilization of agricultural residues, organic scraps, or by-products and other bioresources.
- Connecting the nearby official research organizations and industrial enterprises to establish the collaborative platform for human power training, examination & analysis, and technology development.

3.Research & development Features

Orientations	Main planning contents	Topics, Supports and Goals
Technology development	Developing bioresources & ecological materials	Carbon materials, biochar, energy crops, biosludge, shell residues
	Developing thermal conversion technologies	Biodiesel, pyrolysis, carbonization, liquefaction,
	Developing examination analysis technologies	Analytical techniques of biofuels and carbon materials

Orientations	Main planning contents	Topics, Supports and Goals
Teaching & eduation	Supporting professional course program	Biomass energy program (Dept. of Biomechatronics Eng.)
	Supporting professional courses (Graduate)	Grad. Inst. of Bioresources
	Supporting professional courses (Undergraduate)	Dept. of Wood Sci. & Design, Center for General Education
Academia–industry performance	Publishing research and applied papers	3–5 SCI papers per year
	Establishing platform for industrial technologies	1–2 academia–industry project per year
	Establishing platform for examination & analysis	Examination & analysis for biodiesel, carbon materials, biomass characterization

4. Lab space

(a) General & analytical lab (Room No.： BT 310； Area： 140 m2，including general lab 90 m2 and analytical lab 50 m2)

(b) Thermal conversion lab (Room No.：BT 305；Area：40 m2)

5. Research facilities

Pycnometer
(Model No: AccuPyc 1330: Micromeritics Co., USA)

Planetary ball mill
(Model No: PM 100; Retsch Co., Germany)

Surface area & porosity analyzer
(Model No: ASAP 2020; Micromeritics Co., USA)

Viscometer
(Model No: TV 2000-AKV; Tamson Co., Netherland)

6. Selected research papers

About 50 research papers (including in-press papers) have been published since 2005. Some important and relevant papers were listed below:

Tsai, W.T.*, Chang, J.H., Hsien, K.J., Chang, Y.M. (2009), Production of pyrolytic liquids from industrial sewage sludges in an induction-heating reactor. Bioresource Technology, 100, 406-412. (SCI; Impact factor = 4.453)

Tsai, W.T.*, Lee, M.K., Chang, J.H., Su, T.Y., Chang, Y.M. (2009), Characterization of bio-oil from induction-heating pyrolysis of food-processing sewage sludges using chromatographic analysis. Bioresource Technology, 100, 2650-2654. (SCI; Impact factor = 4.453)

Tsai, W.T.*, Lin, C.I. (2009), Overview analysis of bioenergy from livestock manure management in Taiwan. Renewable & Sustainable Energy Reviews, 13, 2682-2688. (SCI; Impact factor = 4.075)

Tsai, W.T.* , Hsien, K.J., Hsu, H.C., Su, T. Y., Lin, K.Y., Lin, C.M. (2008), Utilization of ground eggshell waste as an adsorbent for the removal of dyes from aqueous solution. Bioresource Technology, 99, 1623-1629. (SCI; Impact factor = 4.453)

Tsai, W.T.* , Mi, H.H, Chang, J.H., Chang, Y.M. (2009), Levels of polycyclic aromatic hydrocarbons in the bio-oils from induction-heating pyrolysis of food-processing sewage sludges. Journal of Analytical and Applied Pyrolysis, 86 (2), 364-368 (SCI; Impact factor = 1.911)

Tsai, W.T.*, Yang, J.M., Hsu, H.C., Lin K. Y., Chiu, C.S., Chiu, C.H. (2008), Development and characterization of mesoporosity in eggshell ground by planetary ball milling. Microporous & Mesoporous Materials, 111, 379-386 (SCI; Impact Factor = 2.555)

Tsai, W.T.*, Lan, H.F., Lin, D.T.(2008), An analysis of bioethanol utilized as renewable energy in the transportation sector in Taiwan. Renewable & Sustainable Energy Reviews, 12, 1364-1382 (SCI; Impact factor = 4.075)

Tsai, W.T.* , Mi, H.H, Chang, Y.M., Yang, S.Y., Chang, J.H. (2007), Polycyclic aromatic hydrocarbons (PAHs) in bio-crudes from induction-heating pyrolysis of biomass wastes. Bioresource Technology, 98, 1133-1137. (SCI; Impact factor = 4.453)

Tsai, W.T.*, M. K. Lee, Y. M. Chang (2007), Fast pyrolysis of rice husk: product yields and compositions. Bioresource Technology, 98, 22-28. (SCI; Impact factor = 4.453)