EXPLORING POTENTIAL MATERIALS, SCIENCE, AND TECHNOLOGY FOR IMPROVEMENTS IN REUSING ENERGY AND WASTE

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Exploring the science and engineering of new approaches to energy and waste reuse is both a very important and very interesting issue. There have been great efforts made to find potential materials, science, and technology for improvements in the reuse of energy and waste, to ensure energy sustainability and to increase the effectiveness and efficiency of engineering processes to achieve optimum energy production. Most of the efforts have been devoted to materials for photovoltaics, hydrogen production, batteries, and green energy. The range of materials of interest is very wide, from polymers to quantum dots. However, the engineering and environmental issues still present limitations, such as high energy demands, catalyst costs, and insufficient reuse or regeneration of spent adsorbents and catalysts. These challenges have opened new exploration of, for example, cheaper precursors, regeneration of spent adsorbents or catalysts, extraction of useful elements from waste, and overall optimization of engineering processes.

More recently, multifunctional and advanced materials have started to show promise for future applications. Integration of economical precursors, high performance materials, efficient methods, easy-to-use designs, and cost-effective manufacturing are always required for competitive energy production, and one would therefore expect clean energy that could address global warming to remain a major issue for many years. Development of alternative uses and reuses of by-products (waste) has also been of interest, not only to reduce the production of carbon dioxide, but also to achieve zero-waste policies. Overall, efforts are being made toward achieving high efficiency, economical or low-cost, renewable, and eco-friendly energy production.

Adsorption processes utilizing agro-waste as a simple method for removing heavy metals, pollutants, and odor from wastewater, are another important thread for environmental and industrial applications. Exploring new alternative adsorption processes and low-cost, highly efficient, and abundant adsorbents from agro-waste are being pursued for the further development of environmental applications that could remove or reduce a diverse range of hazardous pollutants and facilitate minimization methods for the management of waste on large a scale.

To address the above issues, the 3rd International Tropical Renewable Energy Conference (i-TREC) 2018, with the main theme of "Sustainable Development of Tropical Renewable Energy," was held on September 6–8, 2018, at the Discovery Kartika Plaza, Bali, Indonesia. This conference was proudly organized by the Tropical Renewable Energy Center, Faculty of Engineering, Universitas Indonesia. The conference consisted of four symposia, including Smart Grids and Regulation, Bioenergy, Multifunctional and Advanced Materials, and Eco Tropical Built Environment.

The current edition consists of 21 peer-reviewed papers, out of 313 papers submitted to the 3rd International Tropical Renewable Energy Conference (i-TREC) 2018, which are divided based on the symposia topics. The 21 presented and selected papers come from various countries, including the USA, UK, Canada, Brunei Darussalam, Malaysia, and Indonesia. At the conference, the participants updated the current trends in new materials and approaches to reuse of energy and waste, providing a space for discussion focusing on the methodology, technology, and empirical work of tropical renewable energy. Publishing information on the conference via traditional printed media, however, takes time and, for several reasons, the discussion presented therein might remain unknown to a wider audience.

In this special issue of the International Journal of Technology, we would therefore like to present the discussions in the form of research papers, and thereby make it available to a wider readership and, with the inclusion of these published materials, enrich and extend the i-TREC conference reports.

The first paper, written by M. Shakouri, E.N. Krishnan, L. Dehabadi, A.H. Karoyo, C.J. Simonson, and L.D. Wilson, reported vapor adsorption transient tests for dehumidification and desorption. This work was aimed at addressing the feasibility of laboratory-scale studies using experimental modeling and data-simulation by means of the transient and cyclic testing of a heat exchanger within an energy wheel setup in a parallel-flow air stream configuration. This was a model system for industrial-scale energy wheels that require large-scale and advanced instrumentation to analyze large volumes of data. The authors designed a new transient test, which will enable tests in both counter-flow and parallel-flow configurations; are affordable for automated cyclic testing; and can enhance the accuracy and reduce the uncertainty of the relative humidity measurements.

The second paper, written by M. Mamat, M.A.A. Abdullah, M.A. Kadir, A.M. Jaafar, and E. Kusrini, focused on the preparation of layered double hydroxides (LDH) with different divalent metals for the adsorption of methyl orange (MO) dye from aqueous solutions. The LDHs were prepared with different divalent metal cations, including Ca, Mn, and Zn, and were utilized as adsorbents for the removal of MO from aqueous solutions. The authors found that the removal percentage of MO dye increased with the LDH dosage, and that CaAl, MnAl, and ZnAl LDHs were able to adsorb up to 96.6%, 97.9%, and 99.8% of MO dye, respectively.

The third paper, written by A. Usman, E. Kusrini, A.B. Widiantoro, E. Hardiya, N.A. Abdullah, and Y. Yulizar, investigated the fabrication of chitosan nanoparticles containing samarium ion, which are potentially applicable to fluorescence detection and energy transfer. Chitosan nanoparticles were fabricated in acidic solution in the presence of potassium persulfate, using a microwave technique. The authors found that the yield of chitosan nanoparticles increased non-linearly with the potassium persulfate concentration, and the size of chitosan nanoparticles was in the range of 3 nm to 5.5 mm, depending on the potassium persulfate concentration. The chitosan nanoparticles were also treated with samarium for fluorescence detection. The fluorescence intensity, at 590 nm of samarium-treated chitosan nanoparticles, increased by a factor of more than 20 when compared with the samarium ion itself and was significantly higher than that of the untreated chitosan nanoparticles. Chitosan nanoparticles appear to be not only useful for drug carriers, where the drug delivery can be traced by monitoring fluorescence emission, but, with their photoemissive properties, chitosan nanoparticles treated with samarium could also be applicable as an environmentally friendly photocatalyst for photodegradation of discharged pollutants, as well as an efficient photosensitizer and participant in energy transfer.

The fourth paper, written by N.S.A. Shukor, A.B. Alias, M.A.M. Ishak, R.R.R. Deris, A.H. Jawad, K.A. Radzun, and K. Ismail, reported adsorption of sulfur dioxide gas by mixed activated carbon (AC) from different biomasses, including coconut shells (CS), rubber seed pericarp (RSP), and their blends, which were successfully produced by using $ZnCl_2$ as the chemical activating agent. The authors reported that single RSP-AC and CS-AC samples produced breakthrough times for SO_2 adsorption of 23 min and 14 min, respectively. The longest SO_2 breakthrough time for the blended activated carbon (CSRSP-AC) was achieved at 15 min, with a ratio of 20:80 (CS:RSP), and was slightly longer than the individual CS-AC. The high amount of microporous RSP in the blend increased SO_2 adsorption capacity.

The fifth paper, written by E. Kusrini, D.D. Kinastiti, L.D. Wilson, A. Usman, and A. Rahman, focused on adsorption of lanthanide ions from an aqueous solution in multicomponent systems using activated carbon from banana peels (*Musa paradisiaca L.*). In this work, the adsorption performance of banana peels was evaluated with the removal of lanthanide ions from an aqueous solution in a multicomponent system, including Y^{3+}, La^{3+}, Ce^{3+}, Nd^{3+}, and Sm^{3+} ions. The selection of the best adsorbent was accomplished by the iodine number method, with activated carbon having the highest iodine absorbance at 572.2 mg/g. The optimum condition in the multicomponent lanthanide elements for the adsorption was determined to be a contact time of 2.5 h, a pH of 4, and an adsorbent dosage of 100 mg. The adsorption of Ln^{3+} ions from low-grade bauxite with adsorption efficiencies was 67.6%, 71.0%, 65.0%, 62.9%, and 56.6% for Y^{3+}, La^{3+}, Ce^{3+}, Nd^{3+}, and Sm^{3+}, respectively.

The sixth paper, written by M.H. Mohamed, C. Ajaero, D.W. McMartin, K.M. Peru, V. Friesen, M. Simair, J.V. Headley, and L.D. Wilson, investigated solubilized chitosan biopolymers for sequestration of organic acids in aquatic environments after phytodegradation. In this work, pristine chitosan was dissolved in two different respective aqueous acids—acetic acid (AcA) and hydrochloric acid (HCl). The respective solutions were used as media to associate with naphthenic acid fraction compounds (NAFC) from raw oil-sands process-water (R-OSPW) contaminants and treated wetland OSPW (TW-OSPW) samples. The results revealed selective removal of NAFCs and lyotropic effects due to variable counterion binding of chloride versus acetate with the ionized NAFCs (carboxylate species).

The seventh paper, written by R. Afriansyah, S. Nadhifa, and S. Bismo, reported performance tests and operating-condition optimization of parallel-plate plasma reactors for carbon dioxide decomposition. The authors developed a dielectric barrier discharge (DBD) plasma reactor for carbon dioxide (CO_2) decomposition to address the current phenomenon of CO_2 emissions exceeding 400 ppm in the atmosphere. In this research, a parallel-plate plasma reactor was designed by configuring the DBD reactor with two parallel electrodes. The casing of the reactor was modified using an acrylic plate that acted as a shell for optimal contact between the CO_2 gas and the electrodes. The DBD reactor used a 220 VAC line power (PLN) at 50−60 Hz frequency. The performance of the DBD reactor was tested and optimized by varying the regulator output (AC) voltage and the CO_2 feed flow rate to obtain the optimal operating conditions from the parallel-plate plasma reactor for decomposition of CO_2. The authors reported that the optimal process performance for the 7-gram (ozone production equivalent) plasma reactor was achieved at a discharge power of 82 Watts and a feed flow rate of 1.2 L.min^{-1}, with CO_2 conversion of 4.413% and energy efficiency of $2.093×10^{-3}$ mol.J^{-1}.

The eighth paper, written by A. Rahman, M. Nurjayadi, R. Wartilah, E. Kusrini, E.A. Prasetyanto, and V. Degermenci, dealt with enhanced activity of TiO_2/natural zeolite composite for

degradation of methyl orange under visible light irradiation. In this work, a series of TiO_2 nanoparticles, anchored on mordenite zeolite from an Indonesian natural deposit, were prepared by the sol-gel route. Mordenite was incorporated during the sol-gel process by dispersing mordenite powder into the TiO_2 sol-gel precursor. Subjecting the material to photodegradation in a reactor under ultraviolet and visible radiation demonstrated better dye degradation under visible light than ultraviolet irradiation, and the yield was proportional to the content of TiO_2 nanoparticles incorporated into the zeolite.

The ninth paper, written by Y. Muharam and A.D. Putri, reported on the simulation, with a mathematical model, of hydrotreating vegetable oil in a slurry bubble column reactor to produce green diesel using an $NiMo-P/Al_2O_3$ catalyst. A steady-state two-dimensional axisymmetric model of a slurry bubble column reactor—2.68 m in diameter and 7.14 m in height—was developed. The numerical simulation was performed using a model for the reactor operating at 34.5 bar and 598 K. Triglyceride of 5 wt.% in dodecane enters the reactor with a very low velocity so that it resembles a batch operation. Hydrogen of 188 mol hydrogen/triglyceride enters the reactor with a velocity of 0.02 m/s. The simulation results showed that the vegetable oil (triglyceride) conversion would be 97.73%, the product yield 83.34 wt.%, and the product purity 77.23 wt.%.

The tenth paper, written by X. Zhang and J.W. Fergus, presented the solid electrolyte used for lithium ion batteries. In this work, the authors synthesized cubic garnet-type ceramic electrolyte $Li_{6.75}La_3Zr_{1.75}Ta_{0.25}O_{12}$ (LLZTO) via the co-precipitation method, obtaining porosity of about 20%. The total conductivity at room temperature and the activation energies were estimated to be at 7.24×10^{-6} S/cm and 0.31-0.46 eV, respectively. The conductivity of the LLZTO-NASICON composite, 1.18×10^{-5} S/cm, was higher than that of LLZTO, and the activation energies were estimated to be 0.23–0.58 eV. The LLZTO-PEO(LiClO$_4$) composite had a similar room temperature total conductivity to LLZO, of 1.04×10^{-6} S/cm, but higher activation energies, of 0.59-0.85 eV. This work showed the preparation and conductivity of LLZTO-based composites of LLZTO-NASICON and LLZTO-PEO(LiClO$_4$), which advances the development of LLZO solid electrolytes for high-safety solid-state lithium batteries.

The eleventh paper, written by F.I. Saaid, T-Y. Tseng, and T. Winie, presented the preparation of polyvinylidene fluoride-co-hexafluoropropylene (PVdF-HFP) quasi-solid-state electrolyte for application in dye-sensitized solar cells (DSSC). In this article, the authors proposed the use of a quasi-solid-state electrolyte to overcome the shortcomings of liquid electrolytes and SPE. They found that the presence of PVdF-HFP in the liquid electrolyte gave the electrolyte mechanical stability, but adversely decreased electrolyte conductivity. The crystalline VdF of PVdF-HFP provided mechanical strength to the electrolyte; however, PVdF-HFP increased electrolyte viscosity and hence reduced the mobility of the ions. The DSSC assembled without PVdF-HFP showed higher efficiency than DSSCs assembled with PVdF-HFP. Although PVdF-HFP deteriorated the performance of DSSCs, it overcame drawbacks such as electrolyte leakage and volatilization. The low conductivity of electrolytes resulted in low efficiency DSSCs, and therefore the conductivity of the present quasi-solid-state electrolyte needs to be further improved for application in DSSCs.

The twelfth paper, written by N. Sofyan, A. Ridhova, A.H. Yuwono, and J. Wu., presented their work on the characteristics of nano-rosette TiO_2, hydrothermally grown on a glass substrate at different reaction times and acid concentrations. They found that, after three hours of hydrothermal reaction time, the nucleation process had just taken place; the formation of the 3D

hierarchical architecture of the nano-rosettes was complete after six hours. They noted that the acid environment was a dominant factor in determining the 3D architecture of nano-rosette TiO_2. In pure water, there was no tendency to form 3D structures, except for the anatase nanoparticle TiO_2. An acid environment, however, depending on the acid concentration, became a driving force for forming 3D structures. The formation of 3D architecture with *Mimosa pudica* petal–shaped rutile TiO_2 occurred at a water to HCl ratio of 1:1. The growth of TiO_2 was determined by the reaction environment; in the absence of acid, there was more OH^-, and the growth of TiO_2 occurred via an edge-sharing mechanism to form anatase crystal structures. In the presence of an acid environment, however, there is less OH^- and thus the growth occurred via a corner-sharing mechanism to form rutile crystal structures. This reaction pathway also determined the growth mechanism for forming the 3D hierarchical nano-rosette architecture.

The thirteenth paper, written by S.N. Surip and W.N.R.W. Jaafar, presented a comparison study of the bio-degradation properties of polylactic acid (PLA) green composites reinforced by kenaf fibers. They found that PLA-kenaf green composite degradation was faster in a landfill burial condition. This was determined by the calculated weight loss, which was approximately 2–4% of the total weight loss of PLA and its composites after six months' exposure to a natural weathering environment. In contrast, the landfill burial condition showed 4–17% weight loss after six months buried in a landfill. The addition of natural fiber assisted in the degradation of the composites. At the same time, the addition of natural fiber led to a 0.3–1.3% higher weight loss among composites compared to neat PLA in a natural weathering condition. Weight loss was 11–13% higher for composites exposed to the landfill burial condition than for neat PLA. The addition of natural fibers acted to attract microorganisms and increase water absorption, which assisted in the hydrolysis of polymer and enhanced the degradation rate of the composites.

The fourteenth paper, written by A.H. Yuwono, L. Suhaimi, N. Sofyan, D. Dhaneswara, G. Ramahdita, A. Sholehah, and C. Hudaya, investigated the nanostructural growth of ZnO nanorods derived from chemical bath deposition (CBD). The authors examined the effects of CBD synthesis parameters (i.e., seeding solution concentration and growing time) on the nanostructural characteristics of ZnO nanorods in consideration of their potential application as transparent heaters. They found that a seeding solution (0.05 M) prepared at 25°C could provide more homogeneous coverage of ZnO nanorods on the substrate surface, with a larger average nanorod diameter, than previous reactions at 0°C. This resulted from the ripening mechanism at the seeding stage, which allowed the nuclei to grow more in the subsequent CBD process. Varying the CBD growing time from 3 to 5 hours produced nanorods with average crystallite sizes and E_gs of 22.85 to 32.48 nm and 3.63 to 3.13 eV, respectively. Considering their nanostructure characteristics and optical properties, the resulting ZnO nanorod samples showed promise for transparent heater applications. However, further optimization is still necessary to achieve the desired combination of high transparency and electrical conductivity.

The fifteenth paper, written by A. Zulfia, Y.R. Margaretha, B. Priyono, and A. Subhan, demonstrated the synthesis of LTO nanorods with activated carbon (AC)/nanosilicon (nano-Si) composite as anode material for lithium ion batteries. The synthesis was performed by varying the mass of nano-Si. The addition of nano-Si was expected to enhance its capacity, while the addition of AC was expected to provide a large specific surface area to increase electrical conductivity. The authors found that the higher the nano-Si percentage in the composite, the higher the charge transfer resistance and the lower the conductivity of the composite. Further, the higher the nano-Si percentage in the composite, the higher the resistivity. They also found that LTO–AC/15% nano-Si had the highest specific capacity, at 140.7 mAh/h. The LTO potential

peak was around 1.55 V, which is the theoretical potential of LTO. Another result was that both LTO and LTO–AC/15% nano-Si could perform up to 20°C, and both had a high coulombic efficiency.

The sixteenth paper, written by N.A. Abdullah, J. Tila, I.I. Hakim, N. Putra, and R.A. Koestoer, investigated the influence of the temperature in the reaction zone on the liquid produced for a non-sweeping gas fixed-bed reactor that used camphor as the feedstock. This experiment showed that the lower product yield at a low heating rate and at uncontrolled surface temperature was influenced by the low vapor temperature in the reaction zone. The highest liquid yield, of 46 wt%, was obtained with a 1500-watt heating supply and a wall temperature of 200°C in the reaction zone. The PID controller was used in an electric heater to control and keep the reactor temperature constant at 500°C as an optimum decomposition temperature.

The seventeenth paper, written by S. Ruksathamcharoen, M.W. Ajiwibowo, T. Chuenyam, A. Surjosatyo, and K. Yoshikawa, tried to determine the viability of hydrochars for producing the HTT to substitute for, or co-combust with, coal, without significant modifications to the boiler. HTT offered lower ash content than Indonesian coal and lower chlorine content than raw EFB, which would promote less fouling of combustion boilers. This method required approximately ten times less work than with the parent biomass, and the particle distribution profile was significantly improved by employing HTT.

The eighteenth paper, written by N. Aisyah, M.I. Alhamid, and Nasruddin, presented the exergy and exergo-environmental analysis for the heat pump system using selected environmentally friendly refrigerants. Using a multi-objective genetic algorithm, the optimum operating condition—including evaporation temperature, condensing temperature, and mass flow refrigerant—was determined. The results indicated that the optimum operating condition was 20°C evaporation temperature, 42.57°C condensation temperature, and 0.02 kg/s mass flow rate, leading to exergy efficiency of 51.92% and an exergo-environmental value of 101.925 mPts/h. R1234ze displayed performance comparable to, or better than, R410A.

The nineteenth paper, written by I. Chairunnisa and D. Susanto, reported the potential for building façades created with concrete panels as media for growing plants selected based on the climatic conditions of tropical countries in Indonesia, to replace green areas that have declined. It also compared the performance of pre-vegetated and non-pre-vegetated concrete panels by investigating compressive strength through laboratory experiments. Of the three trial mixes chosen, the mixture of fly ash had the highest compressive strength in both pre-vegetated and non-pre-vegetated concrete panels.

The twentieth paper, written by E. Djubaedah, A. Rachmat, N. Aisyah, Nasruddin, and A. Kurniawan, analyzed the configuration of a two-bed solar adsorption chiller, simulated and optimized using MATLAB, to determine system performance from a thermodynamic and economic viewpoint. The results indicated that a zeolite-water working pair had a lower value of exergy destruction and annual cost than a working pair of water-silica gel.

The twenty-first paper, written by J. Andreas, E.A. Setiawan, S. Halim, M. Atar, and H.N. Shabrina, introduced a new method of nanogrids systems, described as *dual power,* with a new DC voltage level. By experimental research, they developed and tested a DC boost converter that was developed to step up 48 V_{DC} from energy storage to 235 V_{DC} in the main bus. DC boost converters are the core of nanogrids systems, and the performance tests showed that the voltage

deviation range was between +3% and -1.2% and the converter efficiency was stable at 93–98%. This indicated that the converter already had good efficiency for use in dual power nanogrids.

We hope that this special edition of IJTech provides useful information and knowledge, as well as conveying new insights into the methods with which we conduct our research. We are pleased to accept and respond to any comments or enquiries that you may have regarding the direction and content of IJTech, and we invite you to join us in this venture by sending your work for future consideration.

Warmest Regards,

Eny Kusrini, Ph.D	Dr. Eko Adhi Setiawan	Dr. Nofrijon Sofyan
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