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# GREEN AND SMART MATERIALS PROPERTIES DESIGN AND PRODUCTION FOR SUSTAINABLE FUTURE

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In order to promote sustainability and the added value of products it is essential to explore and promote the development and application of green chemistry and engineering principles in the academic, industrial, and government sectors (Kusrini et al., 2015). This can specially be achieved by addressing how these green chemistry and engineering principles can bring value to the chemistry and engineering products and at the same time to the sustainability of the environment. In many ways, innovations in the chemical design and development of new material products such as renewable energy, composting, anaerobic digestion, pyrolysis and gasification, materials recycling, and modeling in processes leading to sustainable practices, are essential to achieving a safe and clean environment. On the other hand, engineered materials will play an important role in enabling technological designs that will strengthen, improve and transform engineering practice.

Any effort to develop and apply green chemistry and engineering principles will always revolve around the issue of sustainable development. In this context, especially in today's globalized era wherein human beings always try to increase their quality of life through harmony with nature, a process of choosing the optimal conditions, design requirements, parameters, measured procedures, and justified methods is essential in obtaining efficient, safe, and sustainable end results. Accordingly, in this special edition of the *International Journal of Technology*, we are pleased to publish selected peer-reviewed papers from the 14$^{th}$ International Conference on Quality in Research (QiR), which was held on August 10-13, 2015 in Lombok, Indonesia. These papers, which focus in metallurgical and materials engineering and related areas and have been peer-reviewed by experts in their field in order to meet professional and scientific standards, may provide the answer to all the aforementioned challenges.

Twenty papers have been selected and brought forward to the readers highlighting research and development in metals production, materials synthesis, materials mechanic, magnetic materials, and degradation of materials. It covers all aspects of modern materials engineering, including preparation and processing, relationships between structure (nano/micro) and properties, as well as performance and technological applications. In line with the highlight, this edition is divided into the following sections: (i) metals production, (ii) materials synthesis, (iii) mechanics of materials, (iv) magnetic materials and (v) materials degradation/ corrosion.

In the first paper written by S. Oediyani, K. Willyandhika, and Suharto, the readers will find the production of sponge iron from Lampung, Indonesia. In the process, iron ores were mixed with coconut shell charcoal used as reductor agent and was direct reduced by using rotary kiln furnace. By adding the carbon based reductor of up to 20% at temperature 1100$^{o}$C for 3 hours, the metallization achieved was up to 99%. The process described here may promote an added value of domestic iron ore products in Indonesia.

In the second paper, the readers will be introduced to the production of thin wall ductile iron (TWDI). In this paper, R.D. Sulamet-Ariobimo and J.W. Soedarsono discussed a process to eliminate the formation of skin effect or interdendritic graphite layer below the surface of materials. Various casting design, such as a mold product with different thickness was examined to investigate the skin effect formation phenomena. The results showed that the skin effect may be eliminated by using homogenous thickness mold. The skin effect thickness was also influenced by cooling rate and mold-molten metals interaction area.

The third paper is about metal matrix composites based on $Al_2O_3$ nanoparticles reinforced aluminum

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alloys used for high-voltage overhead transmission lines. In their work, A. Zulfia, F. Robby, Kirman, and A. Sukarto reinforced Al-0.12%Zr-0.15%Ce-5%Mg with volume fraction variation of 0.5-1.5% of $Al_2O_3$ nanoparticles by means of stir casting method. Up to 1.2% volume fraction of $Al_2O_3$, the mechanical properties and microstructures showed tensile strength increase with finest grain size structure. Addition by more than 1.2% volume fraction decreases tensile strength due to clustering and pore formation. Electrical conductivity of Al-0.12%Zr-0.15%Ce-5%Mg reinforced with 1.5 % volume fraction is 44% IACS which is still lower than unreinforced one.

In the next paper, A.Z. Syahrial, B. Priyono, A.H. Yuwono, E. Kartini, H. Jodi, and Johansyah, presented their investigation results on lithium ion battery (LIB). The focus of the work was on the anode material using lithium titanate ($Li_4Ti_5O_{12}$. LTO) synthesized by solid state using $TiO_2$ xerogel derived from sol-gel method and lithium carbonate ($Li_2CO_3$). For this purpose, three variations of $Li_2CO_3$ content addition in mol% or $Li_2CO_3$ molar excess of 0, 50, and 100% were made. The results showed that high-energy ball milling process upon solid state reaction has promoted formation of $Li_4Ti_5O_{12}$ and prevented the significant loss of Li+ source, resulting in higher conductivity up to 9.92×10-7 S/cm in comparison to the standard sample. The obtained results are promising in order to produce high-performance lithium ion battery anode material.

The fifth paper presented by H. Aripin, S. Mitsudo, I.N. Sudiana, E. Priatna, H. Kikuchi, and S. Sabchevski, discusses the fabrication of $SnO_2$-glass composites by mixing $SnO_2$ and amorphous silica xerogel extracted from sago waste ash. In this work, the authors investigated the effects of $SnO_2$ and sintering temperature on the densification characteristic of the nanosized $SiO_2/SnO_2$ composite. The results showed that an appreciable effect on the bulk density at temperatures from 1000−1500$^o$C was obtained with an incorporation of 5 mol% $SnO_2$ into silica xerogel. The resulting composite has a density 14% higher than that of silica xerogel glass composite sintered without $SnO_2$ making nanosized $SiO_2/SnO_2$ composite more favorable for optical design and construction applications.

The sixth paper written by D.S. Winatapura, S.H. Dewi, and W.A. Adi was dedicated on the synthesis and characterization of Fe3O4@ZnO nanocomposite and its application for photocatalysts. Magnetic $Fe_3O_4$@ZnO nanocomposite (NC) was synthesized by wet milling method using high energy milling machine. The results showed that the saturation magnetization (Ms) of $Fe_3O_4$ NP obtained a value of 66.26 emu.g-1 but then declined to 34.79 emu.g-1 after being encapsulated with ZnO shell. The result also revealed that the photodegradation efficiency of $Fe_3O_4$@ZnO NC was favorable at pH neutral of 7, which reaching 100%. With such properties, the resulting magnetic $Fe_3O_4$@ZnO NC could be extended to other various potential applications, including purification processes, separation, and photodegradation.

In this seventh paper, D. Nanto and S-C. Yu reported detail properties of manganite perovskite of $La_{0.7}Ca_{0.3}Mn_{1-x}Cu_xO_3$ doped with Cu with ($0.0 \leq x \leq 0.03$) showing magneto caloric effect. The samples were synthesized by conventional solid state reaction with variation of small amount of Cu doping 1 to 3% in Mn site in order to maintain the first-order magnetic transition without leading into second-order magnetic transition. The results showed that by decreasing Cu-doping, the maximum magnetic entropy change increased, while the relative cooling power was obtained in the range of 39−47 J/kg. The small amount of doping Cu in $La_{0.7}Ca_{0.3}MnO_3$ keeps the rate of relative cooling power in a wider temperature span. The obtained result demonstrated that $La_{0.7}Ca_{0.3}Mn_{1-x}Cu_xO_3$ is potential for the cooling technology based on magnetism and magnetic material.

The next paper presented by A.H. Yuwono, D. Kurniawan, N. Sofyan, G. Ramahdita, and A. Sholehah, reports investigation on zinc oxide (ZnO) as one of important semiconductor materials for the application in dye-sensitized solar cells. For this purpose, ZnO nanoparticles have been synthesized through precipitation method, followed by a sequence of thermal treatments including drying, calcination, and post-hydrothermal treatment (PHT). For increasing the crystallinity of ZnO nanoparticles, PHT was carried out with a pressure variation of 1 and 3 bar. The study showed that increasing the PHT pressure caused an adverse effect on the crystallinity, while the band gap energy (Eg) was found to increase slightly. Considering the obtained properties, ZnO nanoparticles in this study has the potential to be used as the semiconductor oxide layer in the dye-sensitized solar cells.

The ninth paper carried out by M.G. Darmayanti, C.L. Radiman, and I.M. Sudarma reports the extraction of kappa-type arrageenan from Eucheuma cottonii seaweed using demineralized water and ethanol precipitation. The resulting material is aimed at improving enhanced oil recovery (EOR) process as an essential technique to increase sweep efficiency to extract over a half of a reservoir's original oil content and maintain the production stability of oil fields. The measurements indicated that kappa-carrageenan showed relatively high resistance to temperature, shear rate, and salinity compared to polyacrylamide-based commercial enhanced oil recovery polymers. However, higher concentration of carrageenan is still needed to reach the same viscosity as the commercial polymers.

The next paper written by Sugiman and Sulardjaka elucidated water absorption and desorption behavior on mechanical properties of FM73M film adhesive. Immersion technique and gravimetric method were applied to examine the water effect in the samples. Tensile strength of the samples was measured and modeled by using FEM. It was found that the water desorption behavior follows the Fick's second law. Simulation prediction of residual tensile strength by using combination of continuum damage approach and environmental degradation was in good agreement with the experimental results.

In the eleventh paper, Kirman, A. Zulfia, and B. Suharno reported the feasibility of new metal matrix composite of AlZrCe-Mg alloy reinforced with Al2O3 nanoparticles to substitute aluminum conductor steel reinforced (ACSR). 2-5 wt% of magnesium were added to master alloy of Al-0.12%Zr-0.15%Ce reinforced with 1.2 % volume fraction Al2O3 nanoparticles by using stirr casting technique at 750oC and 500 rpm. The results showed that mechanical properties, i.e. tensile strength and hardness increase up to 92% and 127%, respectively due to finer grain size of Al alloys matrix. However, electrical conductivity decrease 2.74% IACS per 1 wt % Mg addition.

In the twelfth paper, Husaini and Zuhaimi reported a study of mode I and mixed mode fracture behavior of aluminum alloys (A6061 T6) using compact tension shears samples was conducted. Quasi static loading was applied to investigate the crack propagation behavior. Crack propagation was studied by using three holes in front of the crack tip with position of zigzag and inline. The first condition (zigzag holes) gave crack propagation in opening type fracture. On the other hand, the second condition (inline holes) showed crack initiation followed by shear type fracture.

The next paper is about prevention of die soldering formation in tool steel by surface hardening reported by M. Ariati, D.M. Nurjaya, and D. Rooscote. In this work, two kind of surface hardening treatments, i.e. double shot peening with nitriding and single shot peening were applied on the surface of H13 tool steel. Experimental simulation of high pressure die casting was conducted by dipping the surface hardened samples into molten aluminum alloys at different holding time of 0.5–30 minutes. The results of this study showed that surface hardening treatment using double shot peening with nitriding may prevent the formation of die soldering on H13 surface.

The fourteenth paper is a research on high performance of permanent magnet, i.e. Nd2Fe14B alloy. In general, the Nd-Fe-B as-cast ingot is homogenized for long time before hydrogenation, disproportionation, desorption, and recombination (HDDR) process for refining the grain and inducing anisotropic magnet properties in $Nd_2Fe_{14}B$ alloy; however, the process is quite expensive. Hence, in this work, S.B. Pratomo, Y. Kim, and D.H. Prajitno studied the possibility of replacing the homogenization process before HDDR process by water quenching. The results showed that the material produced from this method has magnetic properties almost similar to the material homogenized prior to HDDR process and thus there would be a hope that this process can be used as an alternative way in avoiding high production cost.

Recent research has suggested that an effect called magnetoresistance appears in graphite with interaction usually involving elements such as Fe, Ni, and Co. The use of graphite is only limited by the tendency to facilitate the interaction between magnetic ions. In the fifteenth paper, Yunasfi and W.A. Adi reported synthesis of nanocomposite of nickel-graphite. The results showed that the hysteresis loop of the sample consists of intrinsic saturation Ms, remanence Mr, and coercivity Hc are 1.40 emu/gr, 0.28 emu/gr, and 128 Oe, respectively. The value of magnetoresistance is about 28% at 7.5 kOe. These results are promising in terms of magnetoresistance behavior and the phenomena of sensorial characteristics.

Many efforts have been spent to enhance the magnetic properties of materials that can be used for magnetic recording media. Conventional magnetic fields and magnetic recording materials, however, have not been able to satisfy the needs for high Curie temperature, large magnetic anisotropy, good magnetization, and excellent chemical stability. In the sixteenth paper, Novizal, A. Manaf, and M.C. Fajrah analyzed the magnetic properties of nanoscale ferromagnetic material of barium strontium hexaferrite (BSH). The material was prepared by ball mill method, followed by reducing the particles size of material reach in nanometers with high pressure ultrasonic. The results showed an increase in the magnetic properties of BSH material of around 7%.

Conventional refrigeration technology is based on gas compression method with high electricity consumption. One of the solutions to this issue is magnetic refrigeration technology. In the seventeenth paper, D. Nanto, W-Z. Nan, S-K. Oh, and S-C. Yu presented the magnetocaloric effect of Sn-doped $La_{0.7}Ca_{0.3}MnO_3$ synthesized through solid state reaction technique. The results showed that $La_{0.7}Ca_{0.3}Mn_{1-x}Sn_xO_3$ has a significant decrease on Curie temperature of more than 80 K compared to that of pristine $La_{0.7}Ca_{0.3}MnO_3$. The large gap in the decreasing magnetic temperature phase transition might be useful as an option of metal/transition metal doped for tuning Curie temperature of magnetic refrigerant material.

The eighteenth paper written by A.A. Korda, R. Hidayat, and S. Suriana reported strain aging behavior of API 5L X65 and API 5L B steels which utilized for long term operation by using kinetic approach. The results suggested that API 5L X65 was more susceptible to strain aging than API 5L X65 steel. This evaluation is consistent with other mechanical properties which were also measured.

In the nineteenth paper, R. Riastuti, M.H.A.A. Notonegoro, and A.H.Y. Saputro investigated crevice corrosion resistance of 3207 Hyperduplex Stainless Steel in FeCl3 6% solution at temperature range of 65–90$^{o}$C. By using several corrosion examination methods such as weight loss, polarization and electrochemical Impedance spectroscopy, the results suggest that the critical temperature of crevice corrosion formation is at 70$^{o}$C. It is recommended that the usage of 3207 hyperduplex stainless steel in FeCl3 6% is below 70$^{o}$C to prevent crevice corrosion formation.

In the twentieth paper, K. Gibran and A. Rustandi reported an improved understanding of environmental effect to the cahodic protection design of bottom tank steel was studied. Site evaluation of environmental parameters was measured. The results indicated that cathodic protection design should be modified by setting 10 additional anodes and the minimum current and voltage at 154 A and 32 V, respectively.

We hope that this special edition may broaden our knowledge and perspective of various studies focusing in metallurgical and materials engineering field. The readers are further invited to submit their studies and further discussion in related areas of this journal.

With warmest regards from editorial board members,

Prof. Dr. Akhmad Herman Yuwono

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