Effect of temperature on the physical, electro-chemical and adsorption properties of carbon micro-spheres using hydrothermal carbonization process

Zaira Zaman Chowdhury [a], Bagavathi Krishnan [b], Suresh Sagadevan [cd], Rahman Faizur Rafique [e], Nor Aliya Binti Hamizi [a], Yasmin Abdul Wahab[a], Ali Akbar Khan[a], Rafie Bin Johan [a], Y. Al-douri [afg], Salim Newaz Kazi [h] ID and Syed Tawab Shah[a]

[a] Nanotechnology and Catalysis Research Center (NANOCAT), University of Malaya, Kuala Lumpur 50603, Malaysia; aliyahamizi@um.edu.my (N.A.B.H.); yasminaw@um.edu.my (Y.A.W.); aakhan.um.plasma@gmail.com (A.A.K.); mrafiej@um.edu.my (R.B.J.); yarub@um.edu.my (Y.A.-d.); tawab_shah2003@yahoo.com (S.T.S.)

[b] Department of Chemical Engineering, University Malaysia Pahang, Pekan Pahang 26600, Malaysia; beggyk@gmail.com

[c] Centre for Nanotechnology, AMET University, Chennai 603112, India

[d] Centre for Foundation Studies, Department of Physics, National Defense University Malaysia, Kem Sg. Besi, 57000 Kuala Lumpur, Malaysia

[e] Rutgers Cooperative Extension Water Resources Program, Rutgers, The State University of New Jersey; New Brunswick, NJ 08901, USA; rahman.rafique@rutgers.edu

[f] Physics Department, Faculty of Science, University of Sidi-Bel-Abbes, Sidi-Bel-Abbes 22000, Algeria

[g] Department of Mechatronics Engineering, Faculty of Engineering and Natural Sciences, Bahcesehir University, Besiktas, Istanbul 34349, Turkey

[h] Department of Mechanical Engineering, University of Malaya, Kuala Lumpur 50603, Malaysia; salimnewaz@um.edu.my

* Correspondence: dr.zaira.chowdhury@um.edu.my or zaira.chowdhury76@gmail.com (Z.Z.C.), sureshsagadevan@gmail.com (S.S.); Tel.: +60-102675621 (Z.Z.C.)

ABSTRACT

This research deals with the effect of the temperature on the physical, thermal, electrochemical, and adsorption properties of the carbon micro-spheres using hydrothermal carbonization (HTC). Until recently, limited research has been conducted regarding the effects of delignification during the HTC process of biomass residues especially *Dimocarpus longan*. In this regard, lignin was first extracted from the lingo-cellulosic waste of Longan fruit peel (*Dimocarpus longan*). The holocellulose (HC) separated from lignin and raw biomass substrates (Longan fruit exocarp/peel powder, LFP) were carbonized at different temperatures using water as the green catalyst. Hydrothermal carbonization (HTC) was performed for both of the samples (LFP and HC) at 200 °C, 250 °C, and 300 °C for 24 h each. The surface morphological structures, the porosity, and the Brunauer-Emmett-Teller (BET) surface area of the prepared micro-spherical carbon were determined. The BET surface areas obtained for HC-based carbon samples were lower than that of the raw LFP based carbon samples. The carbon obtained was characterized using ultimate and proximate analyses. The surface morphological features and phase transformation of the synthesized micro-spherical carbon was characterized by a field-emission scanning electron microscopy (FE-SEM) and X-ray diffraction (XRD) analysis. The results demonstrated that the extraction of lignin could significantly alter the end properties of

the synthesized carbon sample. The carbon spheres derived from LFP showed a higher carbon content than the HC-based carbon. The absence of lignin in the holo-cellulose (HC) made it easy to disintegrate in comparison to the raw, LFP-based carbon samples during the HTC process. The carbonaceous samples (LFP-300 and HC-300) prepared at 300 °C were selected and their adsorption performance for Pb (II) cations was observed using Langmuir, Freundlich, and Temkin linear isotherm models. At 30 °C, the equilibrium data followed the Langmuir isotherm model more than the Freundlich and Temkin model for both the LFP-300 sample and the HC-300 sample. The potential of the synthesized carbon microspheres were further analyzed by thermodynamic characterizations of the adsorption equilibrium system

KEYWORDS:
Catalyst; lignin; holo-cellulose (HC); isotherms; thermodynamics; hydrothermal carbonization (HTC)