BAB V

KESIMPULAN DAN SARAN

5.1 Kesimpulan

Dari penelitian yang telah dilakukan, terdapat beberapa hal yang dapat disimpulkan. Adapun kesimpulan tersebut adalah sebagai berikut:

1. Pada proses *direct carbonization* %*yield* terbesar yaitu 35,21 % dan pada proses HTC + Pirolisis yaitu 15,77 %, dan seiring penambahan urea maka %*yield* akan menurun pada kedua proses menjadi 27,3 % dan 24,53 % pada proses *direct carbonization* dan 10,33 %, dan 7,14 % pada proses HTC + Pirolisis.
2. Pada hasil analisis SEM, proses HTC+Pirolisis tanpa penambahan urea menghasilkan *hard carbon* dengan struktur bulat, sedangkan dengan penambahan urea struktur yang dihasilkan menjadi acak dengan permukaan yang tidak merata, sedangkan pada proses *direct carbonization* baik tanpa dan dengan adanya penambahan urea struktur yang dihasilkan acak dengan permukaan yang tidak merata. Ukuran diameter partikel yang didapatkan dari *hard carbon* tanpa penambahan urea pada proses HTC + Pirolisis berkisar 1-7 µm.
3. Pada hasil SEM-EDX, penambahan urea menyebabkan terjadinya penurunan %C dan kenaikan %N. %N tertinggi dihasilkan pada metode *direct carbonization* sedangkan %C tertinggi dihasilkan pada metode HTC + Pirolisis.
4. Pada hasil analisis XRD, *hard carbon* yang dihasilkan memiliki struktur *amorphous* yang lebih dominan dari struktur kristalin dan memiliki jarak *interlayer* (d(002)) berkisar $\pm 0{,}39\ nm$ dan jarak *intercrystallite* (d(100)) berkisar $\pm 0{,}21\ nm$. Nilai d(002) terrbesar didapatkan dari proses *direct carbonization* tanpa penambahan urea.

5.2 Saran

Demi kepentingan pegembangan penelitian selanjutnya, penelitian ini memiliki saran yang dapat dipertimbangkan sebagai berikut:

1. Perlu untuk dilakukan analisis lebih lanjut untuk dapat menguji karakteristik elektrokimia sehingga dapat diketahui kecocokannya untuk penerapan *hard carbon* pada SIBs.

DAFTAR PUSTAKA

Aviara, N. et al., 2014. Energy and exergy analyses of native cassava starch drying in a tray dryer, Cross M*ark*, Volume 73, pp. 809-817.

Balagopalan, C. et al., 1988. Cyanogen Accumulation in Environment During Processing of Cassava for Starch and Sago, Water, air and Soil Pollution, Volume 102, pp. 407-413.

Correa, C. R. et al., 2019. Pyrolisis vs Hydrothermal Carbonization: Understanding The Effect of Biomass Structural Components and Inorganic Compounds on The Char Properties. Journal of Analytical and Applied Pyrolisis, Volume 1, pp. 137-147.

Demiral, H. et al., 2008. Adsorption textile dye into activated carbon prepared from industrial waste by $ZnCl_2$ activation, J. Int. Enviromental Application and Science, Volume 3, pp. 381-389.

Dou, X. et al., 2019. Hard carbons for sodium-ion batteries: Structure, analysis, sustainability, and electrochemistry. Materials Today.

Egerton, R.F., 2005. Physical Principles of Electron Microscopy.

Elaigwu & Greenway., 2016. Chemical, structural and energy properties of hydrochars from microwave-assisted hydrothermal carbonization of glucose, Int. J. Ind Chem, Volume 7, pp. 449-456.

Funke, A. & Ziegler, F., 2010. Hydrothermal carbonization of biomass: A summary and discussion of chemical mechanisms for process engineering. Biofuels, Bioproducts, & Biorefining, Volume 4, pp. 160-177.

G.Annison & D.L.Topping., 1994. Nutritional Role of Resistant Starch: Chemical Structure vs Physiological Function. Anual Reviews Further, Volume 14, pp. 297-320.

Hu et al., 2012. Engineering Carbon Materials from the Hydrothermal Carbonization Process of Biomass. Advanced Materials. Nanomaterials and Chemistry, Volume 22, pp. 813-828.

Irisarri, E. et al., 2018. Optimization of Large Scale Produced Hard Carbon Performance in Na-Ion Batteries: Effect of Precursor, Temperature and Processing Conditions. Journal of The Electrochem

Jacobs, H. & Delcour, J.A., 1998. Hydrothermal modifications of granular starch, with retention of the granular structure, *Journal of Agriculture and Food Chemistry*, Volume 46, pp. 2895-2905.

Kakunuri, M. & Sharma, C. S., 2017. Effect of Current Collector and Pyrolisis Temperature on the Electrochemical Performance of Photoresist Derived Carbon Films. *Journal of Solid State Science and Technology*, Volume 6, pp. 3001-3006

Kambo, H.S. & Dutta, A. 2015. A comparative review of biochar and hydrochar in terms of production, physico-chemical properties and applications. Renewable and Sustainable Energy Reviews, Volume 45, pp. 359-378

Kang et al., 2012. A graphene-based nanostructure with expanded ion transport channels for high rate Li-ion batteries. *Chemical Communications*, Volume 48, pp. 5904-5906.

Komaba, S. et al., 2011. Redox reaction of Sn-polyacrylate electrode sinaprotic Na cell. *Electrochemistry Communications*, Volume 21, pp. 65-68.

Kricheldorf, H., 1999. Ring-opening polycondensations. *Macromol Rapid Commun*, Volume 21, pp. 528-541.

Li, M., Li, W. & Liu, S., 2011. Hydrothermal synthesis, characterization, and KOH activation of carbon spheres from glucose. *Carbohydrate Research*, Volume 346, pp. 999-1004.

Liu, H. D. et al., 2019. Easy one-step hydrothermal synthesis of nitrogen doped reduced graphene oxide/iron oxide hybrid as efficient supercapacitor material. *J Solid State Electochem.*

Loeffler, N. et al., 2015. Secondary Lithium-ion Battery Anodes: From First Commercial Batteries to Recent Research Activities. *Johson Matthey Technology Review*.

Lv, Q. et al.,2018. Selectively nitrogen-doped carbon materials as superior metal-free catalysts for oxygen reduction. *Nature Communication*.

Mischnick, P. & Momcilovic, D., 2010. Chemical Structure Analysis of Starchand Cellulose Derivatives. *Advances in Carbohydrate Chemistry and Biochemistry*, Volume 64, pp. 117-210.

Misture, S.T., 2001. In Situ X-ray neutron diffraction study of $Ba_2IN_2O_5$. *Materials Science Forum*, Volume 378, pp. 336-339.

Morell, M.K., Samuel, M.S. & O'Shea, M.G., 1998. Analysis of starch structure using fluorophore-assisted carbohydrate electrophoresis. Electrophoresis, Issue 19, pp. 2603-2611.

Nunes, C., Mahendrasingam, A. & Suryanarayanan, R., 2005. Quantification of Crystallinity in Subtantially Amorphous Materials by Synchrotron X-ray Powder Diffractometry. Pharmaceutical Research, Volume 22, pp. 1942-1953.

Nwokocha et al., 2010. Effect of drying temperature on physiochemical properties of cassaca starch. International Agrophysics, Volume 3, pp. 219-225.

Ratchahat, S. et al., 2010. Synthesis of Carbon Microspheres from Starch by Hydrothermal Process. Science Journal Ubon Ratchathani University, Volume 1, pp. 40-45.

Schneider, B., 2014. Electron Microscopy Procedures Manual, s.l,: Florida State University.

Sevilla, M. & Fuertes, A.B., 2009. Chemical and Structural Properties of Carbonaceous Products Obtained by Hydrothermal Carbonization of Saccharides. *Chemistry A European Journal*, Volume 15, pp. 4195-4203 Stoddard, 1999.

Simone, V. et al., 2016. Hard Carbon derived from cellulosa as anode for sodium ion batteries: Dependence of electrochemical properties on structure. Journal of Energy Chemistry, Volume 25, pp. 761-768.

Sun, X. & Li, Y., 2004. Colloidal Carbon Spheres and Their Core / Shell Structures with Noble-Metal Nanoparticles. Angewandte Chemie, Volume 43, pp. 597-601.

Texas A & M, U., 2019. X-ray Diffraction Laboratory. [Online] Available at: http://xray.tamu.edu/pdf/lab%20manual.pdf

Titirici, M.-M., 2013. *Sustainable Carbon Materials from Hydrothermal Processes*.

Tjokroadikoesoemo, P.S., 1986. *High Fructose Syrup dan Industri Ubi Kayu Lainnya*, Penerbit PT. Gramedia Pustaka Utrama, Jakarta.

Vatanasuchart et al., 2010. Properties of Pullulanase Debranched Cassave Starch and Resistant Starch. *Kasetsart Journal (Natural Science),* Volume 44, pp. 131-141.

Wang, Q., Li, H., Chen, L. & Huang, X., 2009. Monodispersed hard carbon spherules Winarno, 1995 with uniform nanopores. Carbon, 14(39), pp. 2211- 2214.

Wang, W.-N. & Wurm, P., 2010. Standard Operating Procedure (SOP) Surface Area & Pore Size Distribution Analysis, s.l.: WUSTL.

Xing, Z. et al., 2016. One –pot hydrothermal synthesis of Nitrogen-doped graphene as high-performance anode materials for lithium ion batteries. *Scientific Reports,* Volume 6.

Zheng, H. et al., 2012. *Hard Carbon: a promising lithium-ion battery anode for high temperature applications with ionic electrolyte*. *RSC Advances*, Volume 2, pp. 4904-4912.

Zheng, M. et al., 2015. *An Easy Catalyst- Free Hydrothermal Method to Prepare Monodisperse Carbon Microspheres on a Large Scale*. *The Journal of Physical Chemistry C*, pp. 8455-8459