

High Capacity Hard Carbon Synthesized from Phenolic Resin for Sodium Ion Battery

Azusa Kamiyama^a, Shun Fujimura^a, Kei Kubota^a, Soshi Shiraishi^b, Hidehiko Tsukada³, and Shinichi Komaba^a

^a Tokyo University of Science, 1-3 Kagurazaka, Shinjuku, Tokyo 162-8601, Japan

^b Gunma University, 1-5-1 Tenjim-cho, Kiryu, Gunma, 376-8515, Japan

^c AION Co., Ltd., 12, Kitatone, Koga, Ibaraki, 306-0213, Japan

E-mail: komaba@rs.kagu.tus.ac.jp

Non-graphitizable carbon, so-called hard carbon (HC), is a promising negative electrode material because of high capacity and good cyclability in sodium ion batteries.¹ The electrochemical properties are significantly affected by carbon sources and synthesis condition.² Recently, Hasegawa and our group reported that hard carbons prepared from different carbon sources deliver large reversible capacity beyond 300 mAh g⁻¹ in Na cells.^{3,4} However, origin of the large capacity and suitable structure of HC for Na insertion/extraction are still unclear. In this study, we investigate influence of preparation condition of phenolic resin based HC on the structure and electrochemical properties in order to clarify relation between the microstructure and electrochemical properties for high-energy Na ion batteries.

HC samples were prepared by pyrolytic carbonization of macroporous phenolic resin at 800 °C for 1 h in Ar, and then heating again at different temperatures of 1100, 1300, and 1500 °C for 1 h in Ar. X-ray diffraction patterns of prepared carbon samples show broad diffraction peaks at 22 – 23° in 2θ corresponding to 002 line of graphite. Heat-treatment temperature dependence of interlayer distance of the carbon layers (d_{002}) and crystallite size (L_c) along stacking axis are plotted in Fig. 1. With raising heat-treatment temperature, d_{002} decreases and L_c increases. In addition, specific surface area measured by nitrogen adsorption/desorption decreases in Fig. 1. SAXS data confirms no significant difference in size of micropores inside of the HCs of 1300 and 1500°C whereas smallest pore-size of HC prepared at 1100 °C. Initial charge/discharge curves of the HCs in Na cells filled with 1 mol dm⁻³ NaPF₆/EC: DEC (1: 1 v/v) are shown in Fig. 2. Reversible capacity increases as the heat-treatment temperature raises, which is corresponding to capacity growth in the voltage plateau region below 0.15 V. We further changed the synthesis condition of HCs and will present their structural characteristics and electrochemical properties.

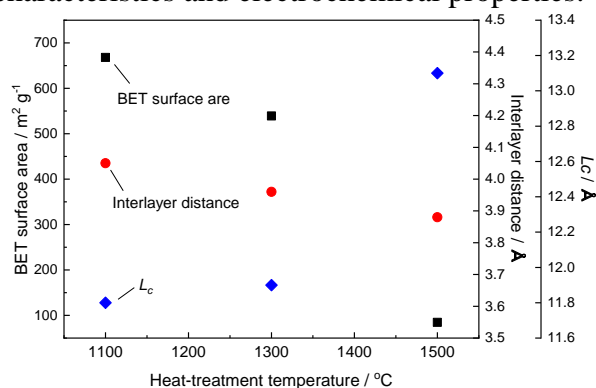


Fig. 1. Variation in BET surface area, interlayer distance, and L_c of carbon layers for HCs prepared at different temperatures.

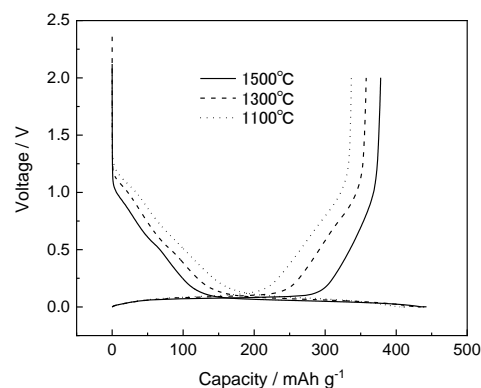


Fig. 2. Initial charge-discharge curves of HC prepared at different heat-treatment temperatures.

References:

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- [2] M. Dahbi, S. Komaba, *et al.*, *J. Mater. Chem. A.*, **5** (2017).