Growth of carbon nano-tubes on carbon fibers textile for lithium-air battery cathode

Young Bok Kim, Il To Kim, Myeong Jun Song and Moo Whan Shin*
School of Integrated Technology,
Yonsei University
162-1, Songdo-dong, Yeonsu-gu, Incheon,
406-840, Korea

Rechargeable Lithium-air battery has been focused for recent years due to its high theoretical energy density such as 10^4Whkg^{-1} without oxygen weight [1-2]. Many lithium-air battery researchers have researched to realize high practical capacity of lithium-air battery close to theoretical capacity. In recently, much higher practical capacity (over 3000mAhg^{-1}) than the practical capacity of lithium-ion battery (~360mAhg^{-1}) has been reported with diverse methods of optimizing cathode structures [3-5]. However, the agglomeration of well-optimized cathode materials cannot be prevented in the process of preparing air-cathode that carbon materials are painted on nickel foam or gas diffusion layer (GDL). The agglomeration leads to adverse effect on properties of optimized carbon material as using air-cathode because it reduces the amount of surface area and it generates mechanical stress in air- cathode [6].

In addition, the binder to combine carbon materials as PVDF brings about decreasing battery performance due to the generation of new interfaces between cathode materials and binder, binder and gas diffusion layer. Those interfaces lead to increase inner impedance of lithium-air battery.

In this work, we synthesize multi-wall carbon nano-tubes (MWCNTs) on carbon nano-fibers (CNFs) textile and characterize its morphology and electrochemical characteristics. The carbon fiber textile is synthesized by electro-spinning process using polyacrylonitrile (PAN) and N, N dimethylformamide (DMF). After that, MWCNTs are grown on CNFs textile using chemical vapor deposition (CVD) system. We observed its morphologies using field-emission electron microscope (FE-SEM) [JEOL-JSM7100F] and transmission electron microscope (TEM) [JEOL, JEM-ARM200F]. And we demonstrate the increase of surface area after growing MWCNTs on CNFs by nitrogen adsorption/desorption isotherm measurement. The electrochemical performances are characterized by measuring of charge-discharge capacity and analysis of impedance [Prinston, Versastat-4].

The observation using FE-SEM and TEM confirms that MWCNTs on CNFs textile have been synthesized well. The textile structure has enough mechanical strength to use air-cathode without any supporting layer such as nickel foam or GDL. Therefore, it does not need to use any binder and it generates no more new interfaces. The comparison of impedance painted MWCNTs between grown MWCNTs on CNFs textiles demonstrates that the binder-free air-cathode brings about reducing energy loss during energy delivery in lithium-air battery. In addition, direct growth of CNTs on CNFs textiles prevents agglomeration and it makes high capacity of lithium-air battery.

Acknowledgment

This research was supported by MKE(The Ministry of Knowledge Economy), Korea, under the “IT Consilience Creative Program” support program supervised by the NIPA(National IT Industry Promotion Agency)(NIPA-2013-H0203-13-1002)

[1] K. M. Abraham and Z. Jiang, J. Electrochem. Soc. 143 (1996)1.
[2] H. Cheng and K. Scott, J. Power Sources 195 (2010) 1370.
[3] G. Girishkumar, B. Mc. Closkey, A. C. Lunts, S. Swanson and W. Wilcke, J. Phys. Chem. Lett. 1 (2010) 2193.
[4] S. D. Beattie, D. M. Manolescu and S. L. Blair, J. Electrochem. Soc. 156 (2009) A44.
[5] J. Read, J. Electrochem. Soc. 149 (2002) A1190.
[6] P. Agnihotri, S. Basu and K. K. Kar, Carbon 49 (2011) 3098