

High Capacity Composite Anode Materials Derived from Graphite and MOF in Lithium Rechargeable Batteries

Joongpyo Shim^{a,*}, Yoonhwa Kim^b, Yongwon Kim^a, Ho-Jung Sun^b, Gyungse Park^c, Jung-Chul An^d

Department of ^aNano & Chemical Engineering, ^bMaterial Science & Engineering, and ^cChemistry, Kunsan National University, Gunsan, Jeonbuk, 54150, Korea

^dEnergy Storage Materials Research Center, Research Institute of Industrial Science & Technology, Pohang, Gyeongbuk 37673, Korea

E-mail: jpshim@kunsan.ac.kr

Lithium-ion batteries (LIBs) have attracted much attention in the scientific and industrial field as a main power source for portable electronic devices, electric vehicles, etc due to their large electromotive force and high energy density. In recent years, a good deal of attention has been devoted to improving the performance of LIBs by developing better components, including novel electrode materials. Graphite and LiCoO₂ are conventionally used for anode and cathode materials due to their stable cycle characteristics, wide potential difference and high theoretical capacity. However, development of higher storage capacity devices using graphite anode is limited by the formation of LiC₆. For this reason, graphite anodes have been tried to replace by certain metal alloys (Li_xM, M = Ge, Si, Sn...) which have greater theoretical capacity.

Metallic tin has been widely researched as a promising anode material for LIBs. An equilibrium phase diagram of Li-Sn shows a number of different intermetallic compositions. Li₂₂Sn₅ possesses specific charge capacity, ~994 mAh/g. However, metallic Sn electrodes are cracked and pulverized by the large volumetric variations that occur during the charge and discharge reactions. This mechanical/physical degradation leads to the loss of adhesion and electrical continuity between the electrode and the current collector. This problem has been the biggest stumbling block to the development of practical Sn-based anodes.

We already reported that metal nanoparticles were uniformly deposited on the graphite surface using reducing agent in aqueous solution. Thin carbon layer was coated on graphite by the carbonization of carbon precursor under inert atmosphere. The carbon layer enhanced the adhesion of metal nanoparticles to the graphite matrix. Metal nanoparticles deposited on carbon-coated graphite showed very stable cyclability, and its capacity reached to ~90% of the theoretical capacity at a rate of 0.2C.

In this study, we report the synthesis of carbon nanotube-graphite (CNT-G) composite materials derived from the coating of MOF (metal organic framework) on the surface of graphite through carbonization. This process will increase the surface area of graphite materials. Metal nanoparticles are simply deposited on the surface of CNT-G to increase capacity and cyclability of anode in lithium rechargeable batteries. Metal nanoparticles will give higher capacity which is close to theoretical capacity without any fracture or detachment from substrate because CNT plays a role as anchor.

References:

- [1] I.-T. Kim, J. Lee, J.-C. An, E. Jung, H.-K. Lee, M. Morita, J. Shim, *Int. J. Electrochem. Sci.*, 11 (2016) 5207.
- [2] M.-J. Denga, D.-C. Tsai, W.-H. Ho, C.-F. Li and F.-S. Shieu, *Appl. Surf. Sci.*, 285 (2013) 180.
- [3] C. Nabais, R. Schneider, P. Willmann and D. Billaud, *Energy Conv. Manag.*, 56 (2012) 32.
- [4] J. Li, Q. Ru, S. Hu, D. Sun, B. Zhang and X. Hou, *Electrochim. Acta*, 113 (2013) 505.