Electrochemical properties of citric-gel synthesized Ge based compound as an anode material for Li ion batteries

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For lithium ion batteries, germanium and germanium compounds have showed the most promising properties as an anode material due to their high electrical and ionic conductivity. The germanium based electrodes has 4 times higher specific capacity than conventional graphite electrode. However, the capacity of germanium based electrodes is degraded after a few cycles due to the significant volume change of the electrode and the resultant pulverization of the electrode during charging and discharging. Many researches have focused on solving this crucial problem by making the germanium/germanium compound based electrodes either in thin film form or the composites with carbon. Currently, the Ge/GeO_2 compound based anode materials have been prepared by sputtering [1], CVD [2], and wet chemical routes [3]. However, expensive chemical or equipment has been used in these techniques. In this study, the Ge based compound was synthesized by cost-effective and simple citric-gel method. Ge based compound were prepared with different holding time of pre-heating temperatures and its effect on specific capacity were compared.

GeO_2 and citric acid were used as the precursors. Aqueous solution of GeO_2 and citric acid was poured into the beaker. The solution was pre-heated at 150°C for different holding times. The obtained solid foam was then heat treated at 250°C for 3 h. Final product was ground using agate mortar-pastel. To make electrode, the slurry was prepared using ground powder mixed with carbon black and binder, which was then applied on copper foil.

The XRD pattern was compared and matched with GeO_2 (PDF#43-1016; hexagonal); confirming the formation of single phase GeO_2 in the product. Figure 1 shows the SEM micrograph of as-synthesized Ge based compound. It can be clearly seen that the synthesized compound is consists of nano particles having the size ranging from 15 to 20nm. However, the nano-particles are generally agglomerated and can be easily de-agglomerated.

Synthesized GeO_2 based anodes were characterized for its electrochemical charge-discharge behavior. The maximum specific capacity of 760 mAh/g was observed for the sample pre-heated at 150 °C for 4 h. Nevertheless, no-reliable relationship between variation in the pre-heating holding-time and the performance of electrode was observed. In addition, the electrode exhibited good cyclability. The results demonstrate that the synthesized compound by citric-gel method can be successfully used as an active material for anode in lithium-ion batteries.

References

[1] J.K. Feng, M.O. Lai, L. Lu, Electrochimica Acta, 62 (2012) 103-108.
[2] R.A. DiLeo, M.J. Ganter, M.N. Thone, M.W. Forney, J.W. Staub, R.E. Rogers, B.J. Landi, Nano Energy, (2012).
[3] C. Jing, X. Zang, W. Bai, J. Chu, A. Liu, Nanotechnology, 20 (2009) 505607.

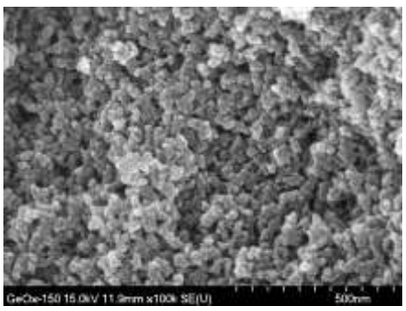

Figure 1. SEM micrograph of as-synthesized Ge based compound.