Sulfurized Alcohol Composite Cathode for All-Solid-State Battery

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Lithium-sulfur batteries have been gathered attentions because sulfur has a high capacity of 1672 $mAhg^{-1}$, is abandon, cheap and benign to environment. Although sulfur itself dissolved into non-aqueous electrolyte and degrade cathode performance during charge/discharge, a material prepared through heat-treated polyacrylonitrile and sulfur composite (SPAN) showed good capacity and cyclability [1]. We also found that sulfurized alcohol (SA) made of alcohols and sulfur, showed good capacity of about 660 mAh/g and relatively good cycle stability as Li-S battery cathode [2]. On the other hand, new solid electrolytes have been developed such as Li_6PS_5Cl [3] which have comparable conductivity to conventional liquid electrolyte. Trevey et al. reported that SPAN could be utilized as cathode in all-solid-state batteries [4]. Although they use pressed powder cathode mixture, it is necessary from industrial point of view to investigate a slurry coating cathode [5]. In addition, utilization of metallic lithium anode in all solid state battery is advantageous for realizing high energy density. In the present work, we investigated new cells composed of sheet-type SA cathode, Li_6PS_5Cl electrolyte and lithium anode.

SA was synthesized through refluxing 1-Nonanol and sulfur at 723 K under N_2 flow. Solid electrolyte (SE) of Li_6PS_5Cl was prepared through mixing Li_2S, P_2S_5 and LiCl using ball mill for 15h, then heat-treatment at 823 K for 2 h [3]. A SA-polyimide slurry was made of SA, acetylene black (AB) and a polyimide binder with 80:5:15 weight ratio, and coated on Al foil then heat-treated to yield SA-polyimide electrode (SAPI). Cells of SA-AB-SE mixed powder (SASE) or SAPI cathode/SE/In-Li alloy or Li foil were constructed and were discharged/charged from 1.0 to 3.0V at 0.05 mA. The SE powder was pressed into a SE disc. The SASE or SAPI was pressed to one side of the disc, and the other side of the disc was contacted to In-Li ally or Li foil.

The SASE/SE/In-Li alloy SASE/SE/Li cells showed 2nd discharge capacities of 697 and 646 mAh/g, respectively. Not only SA but also lithium anode can be used as large capacity electrode for also all-solid-state battery. It is interesting that the SAPI contained no SE but only contact to SE, however showed a capacity of 442 mAh/g. It is because the SAPI layer was so thin that active material particle could contact SE. It is demonstrated that ordinary method utilized in the current LIB cathode manufacturing using polyimide can be used to construct SA-based all-solid-state battery.

References:

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