

Preparation of SiO_x/C Composites with Na-Containing Polymer and Their Electrode Performance for Lithium-Ion Batteries

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1. Introduction

Silicon monoxide, SiO, is of interest for high-energy negative electrode materials for lithium-ion batteries since SiO has an advantage of better electrode performance due to suppressed volume expansion compared with Si during cycling. However, low initial coulombic efficiency is the challenge for commercial use. In a previous report, heat treatment higher than 1000°C and carbon coating of SiO improve the initial coulombic efficiency [1]. In addition, heat treatment of mixture of SiO and sodium salt promotes disproportionation reaction of SiO and improves the cycle performance because nanocrystalline Si was uniformly dispersed within a porous SiO matrix after removing water-soluble sodium silicate [2]. Our laboratory reported the one step process of carbon coating and disproportionation by adding Na containing polymer [3]. In this study, we prepare SiO_x/C composites by using sodium alginate (AlgNa) not only as a carbon source but also as sodium source for the reaction promotion.

2. Results and discussion

Figure 1(a) showed the X-ray diffraction patterns of SiO_x/C composites prepared by heat-treating SiO and AlgNa in different weight ratios (SiO:AlgNa = 1:y) followed by washing the resultant product by water to remove water-soluble sodium silicate(s). The intensity of peaks assigned to SiO₂ and Si increased with increasing the amount of AlgNa. This shows promotion of disproportionation reaction of pristine SiO. Although the disproportionation temperature is required to set higher than 1000°C in the previous work [2], addition of AlgNa successfully enables us to reduce the reaction temperature to 800°C. In case of adding large amount of AlgNa (y = 1), undesired silicon carbide was produced.

Cycle stability of the composites was shown in Figure 1(b). In case of y = 0.167, the composite showed the best cycle stability to deliver more than 1000 mAh g⁻¹ over 50 cycles. Furthermore, it is noteworthy that initial coulombic efficiency increased gently in y = 0 - 0.167, especially, the highest value of 70% is exhibited at y = 0.167, indicating the suitable carbon coating and formation of water-soluble sodium silicate(s) with AlgNa. On the other hand, adding larger amount of AlgNa, a remarkable decay of capacity was observed. It is likely due to inactive and insulating SiC and SiO₂ covering the particle surface, resulting in the deterioration of lithiation property. Based on these findings, we will further discuss the role of AlgNa as an advanced carbon source for preparation of the carbon composites.

3. References

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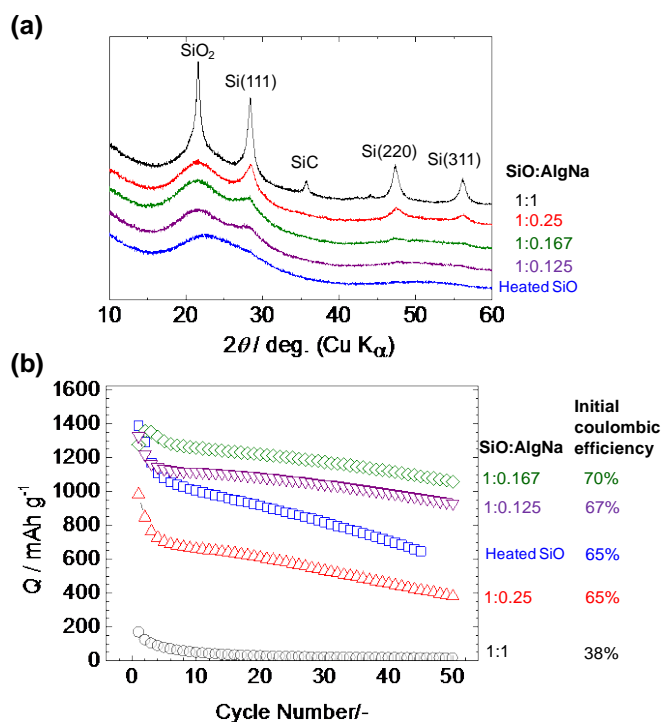


Fig. 1. (a) XRD patterns of SiO_x/C composites prepared with different amount of AlgNa as a carbon source. (b) Capacity retentions of SiO/C electrodes tested in Li cell with 1.0 M LiFF₆ EC:DEC at a rate of 100 mA g⁻¹ in the range of 2.0 - 0.0 V vs. Li / Li⁺.