Performance of S cathode composed of microporous activated carbon with high S loading and porous 3-D current collector

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Summary

A sulfur (S) cathode has a high theoretical capacity (1,672 mAh g^{-1}). However, a major problem is the behavior of Li polysulfide (Li_2S_n) intermediates, which may dissolve into an electrolyte. If dissolution of Li_2S_n occurs, this should lead to a rapid capacity decay. We have investigated microporous activated carbon as matrix stabilizing S and realized stable cycling performance.[1-2] However, the S content (ca.30wt%) and S loading were reatively low, which remains to be improved. To enhance them, in this study we applied alkaline-activated carbon with a large pore volume and also a porous 3-D Al current collector. Using these materials together with our fluorinated electrolyte, we have successfully realized stable and high capacity of the S-based cathode.

Methods

Activated carbon (AACR) used in this study was an alkaline-activated type. AACR-S composite (AACR-1) was prepared by mixing AACR and S at a weight ratio of AC:S = 47:53, and then applying heat treatment: 155°C for 5 h, then 300°C for 2 h. The AACR-1 composite cathode was prepared by mixing the AACR-1 composite, acetylene black, and alginate binder at a respective weight ratio of 90:5:5 and loading the resulting slurry into a 3-D Al current collector, "celmet (Sumitomo Electric Industries)". The electrolyte was 1.0 mol dm^{-3} LiTFSI/FEC:HFE(1:1)+VC [9+1] (by vol.). All the cell components were installed into a pouch cell with a Li anode. A typical charge-discharge cycling test was carried out at 167.2 mA g^{-1} (0.1 C) with cutoff voltages of 3.0 and 1.0 V at 25°C.

Major results and conclusion

Fig. 1 shows the thermogravimetric analysis of elemental S and the AACR-1. The weight loss of AACR-1 indicated the S content: 53wt%. Fig. 2 shows the discharge capacities of AACR-1 and also SAC-2 (for comparison: steam-activated, 34wt%) cathodes during cycling. Their respective S mass loading into the 3-D collector was 6.9 and 5.4 mg cm^{-2}. The AACR-1 system showed higher S weight-basis capacity in spite of its higher S content and mass loading. Furthermore, the present fluorinated electrolyte contributed to stable capacity retention: 946 mAh $(g\text{-}S)^{-1}$ at the 100th cycle due to the resulting stable SEI at the cathode. This work was supported by "Advanced Low Carbon Technology Research and Development Program, Specially Promoted Research for Innovative Next Generation Batteries (ALCA-SPRING)" from JST.

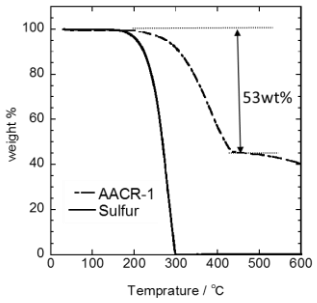

Fig. 1 TGA curves of sulfur and AACR-1

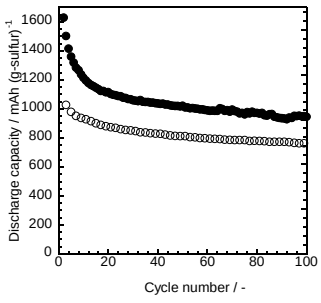

Fig. 2. Discharge capacity of AACR-1(●) and SAC-2(○) cathode in 1.0 mol dm^{-3} LiTFSI/FEC:HFE+VC

Reference

[1] T. Takahashi et al., Prog. Nat. Sci., 25 (2015) 612.
[2] S. Okabe et al., Electrochemistry, 85 (2017) 671.