Abstract #493, 224th ECS Meeting, © 2013 The Electrochemical Society

An Alternative Configuration for Room Temperature Sodium ion-sulfur Battery

Dong-Ju Lee,[a] Ju-Won Park,[a] Ivana Hasa,[b] Yang-Kook Sun,[a,*] Bruno Scrosati[b] and Jusef Hassoun[b,*]

[a]*Department of WCU Energy Engineering, Hanyang University, 133-791, Seoul, Republic of Korea.*
[b]*Department of Chemistry, University of Rome Sapienza, Piazzale Aldo Moro, 5, 00185, Rome, Italy.*

Rechargeable electrochemical cells based on sodium, designed for energy accumulation, have attracted large interest in view of its abundance and low cost. A typical Na–S battery consists of sulfur at the positive electrode and sodium at the negative electrode separated by a solid beta alumina ceramic electrolyte, operating at elevated temperature (300 ^{o}C) in order to assure the molten state of the electrode and the high ionic conductivity of the solid electrolyte.[1] Many studies have been performed in order for the better understanding of the operating mechanism and the thermal characteristics of this kind of electrochemical cell,[2,3] however the high operating temperatures used so far have implied additional cost and safety issues.

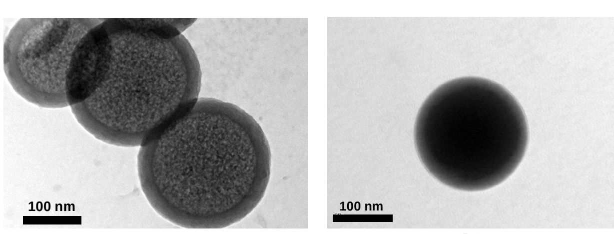
Recently, studies reporting low-temperature or room temperature[4,5] cells using sodium metal as the anode, sulfur as the cathode and electrolytes based on organic solvents have been reported.

In this work we have developed a new battery configuration exploiting a hollow carbon–sulfur composite HCS–S cathode and nanostructured tin–carbon Sn–C in a stable, TEGDME–sodium trifluoromethane-sulfonate, $NaCF_3SO_3$ electrolyte. The results reported here clearly demonstrate that the adopted advanced morphology allows the achievement of high electrode kinetics and of enhanced cycle life, this finally leading to the development of an advanced sodium ion–sulfur battery.

Fig. 1 a, b illustrate the TEM analysis of the carbon spheres before (a) and after (B) sulfur impregnation. The images evidence the ring-shell form of the pristine hollow carbon spheres, as well as the uniform distribution of the sulfur in their core.

Fig. 2 shows the TEM analysis of the Sn-C composite electrode material; the images evidence how the tin metal particles of nanometric size are evenly confined and distributed in an amorphous carbon matrix.[6]

Fig. 3 shows its conductivity Arrhenius plot indicating a value higher than 10^{-3} S cm^{-1} over the full temperature range here explored.



(a) (b)

Figure 1. Transmission Electron Microscopy (TEM), SEM, images of the precursor carbon spheres (a) and of the hollow carbon sphere–sulphur composite (b).

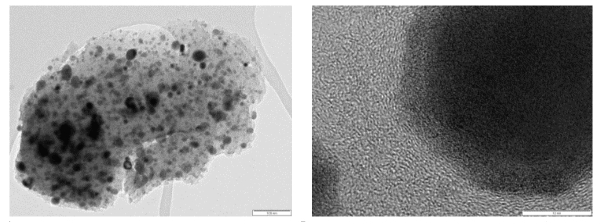


Figure 2. Transmission Electron Microscopy (TEM) images of the nanostructured Sn–C composite.

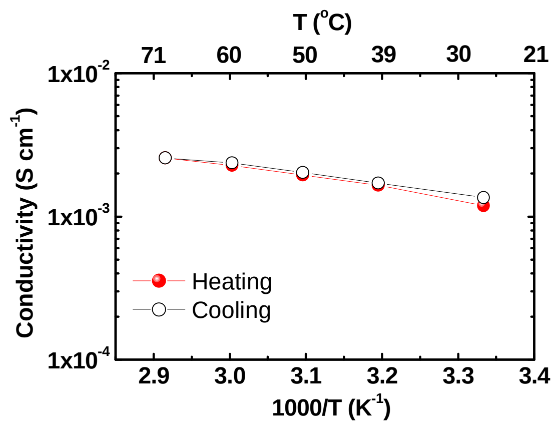


Figure 3. Arrhenius plots of conductivity of the $TEGDME_4NaCF_3SO_3$ electrolyte.

References

[1] T. Oshima and M. Kajita, *Int. J. Appl. Ceram. Technol.*, **1(3)**, 269–276 (2004).
[2] R. Knodler, *J. Appl. Electrochem.*, **14**, 39–46 (1984).
[3] W. Smith and J. Gillant, *J. Phys.: Condens. Matter*, **4**, 3215–3234 (1992).
[4] X. Lu, B. W. Kirby, W. Xu, G. Li, J. Y. Kim, J. P. Lemmon, V. L. Sprenkle and Z. Yang, *Energy Environ. Sci.*, **6**, 299–306 (2013).
[5] J. Wang, J. Yang, Y. Nuli and R. Holze, *Electrochem. Commun.*, **9**, 31–34 (2007).
[6] J. Hassoun, G. Derrien, S. Panero and B. Scrosati, Adv. Mater., **20**, 3169 (2008).