J Material Sci Eng 2017, 6:6(Suppl)
DOI: 10.4172/2169-0022-C1-077

Hybrid electrode materials built on vertically aligned carbon nanofibers arrays for high-performance electrical energy storage

Jun Li, Steven Klankowski, Gaind Pandey and **James Emery Brown**
Kansas State University, USA

Today's high-performance electrochemical energy storage (EES) devices are represented by the high energy capacity of lithium-ion batteries (LIBs) and the high power and long cycle life of supercapacitors. At present, they are not able to be integrated into one system due to the distinct electrochemical mechanisms. The performance of the conventional electrodes is limited by the low electrical conductivity and slow ion diffusion in the electrode materials. In recent studies, we have demonstrated an effective approach to overcome these two issues using a three-dimensional nanostructured core-shell architecture consisting of ~100 – 200 nm thick coaxially coated electroactive materials (such as Si, TiO_2, $LiCoO_2$, V_2O_5, and MnO_2) on a highly conductive nanostructured current collector, i.e. vertically aligned carbon nano fiber arrays. This hybrid electrode structure allows effectively mitigating the slow Li+ diffusion by shortening the diffusion length in solid electrode materials. With proper deposition techniques, the shell materials can form secondary mesoporous structures which further reduce the ion diffusion path length down to ~10 nanometers in solid electrode materials. In addition, it provides another benefit due to the significant pseudo capacitive contribution associated with fast faradaic reactions at or near the electrode surface. As a result, these electrodes present the features of a battery-super capacitor hybrid based on Li chemistry. The EES devices based on such hybrid materials offer high specific energy at very high power rates that are comparable to supercapacitors. These studies demonstrated the potential for multi-scale nanostructured EES electrodes to achieve stable long charge-discharge cycles in the super capacitor power regime (i.e. completing charging or discharging in less than 1 min.) while maintaining the battery-like high energy capacity. Such hybrid structure also significantly improves the mechanical stability of the electrode materials, particularly for future batteries involving larger ions such as Na^+ and Mg^{2+}.

junli@ksu.edu

New class of porous and metal-free electrocatalyst for oxygen reduction reaction by enhanced amide functionalization on graphene

Mohammad Shamsuddin Ahmed and Young-Bae Kim
Chonnam National University, Republic of Korea

In the meantime, considerable effort has been focused to search for sustainable and renewable sources of green and clean energy because of the increasing demands and environmental impact of traditional energy resources, such as fossil fuels. Fuel cells (FCs) obtain significant attention as next generation energy sources because of their superior energy conversion efficiency and potential to provide clean energy. Metal-free electrocatalysts for oxygen reduction reaction (ORR) in FCs are an interesting research topic due to low cost much stable and tolerance to crossover effect than that of expensive noble metals. However, a porous graphene catalyst has been prepared with 1,4-diaminobutane (DAB) through amide functionalization, and has been used as a metal-free electrocatalyst for ORR in alkaline fuel cells. DAB has been used as a junction among functionalized graphene layers to impart electrocatalytic activity for the ORR resultant from the interlayer charge transfer. The successful amidation in the process of catalyst preparation have been confirmed. A hierarchical porous structure has also been confirmed through surface morphological analysis. The BET specific surface area and thermal stability have increased after successful amide functionalization. The as-prepared catalyst has been proven an efficient metal-free electrocatalyst with better electrocatalytic activity, stability, and tolerance to crossover effect than commercially available Pt/C for ORR via a direct four-electron involved pathway. This report will encourage preparing many more carbon-based electrocatalysts for other electrochemical applications including catalysis and sensing.

suddin_bcsir@yahoo.com