Synthesis and application of graphite oxide by utilizing PEDOT:PSS as high performance binder for sodium-ion battery

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Based on the wide availability and low cost of sodium, ambient temperature sodium-based batteries have the potential for meeting large scale grid energy storage needs. In addition, since sodium is so abundant, sodium-based batteries could provide an alternative chemistry to lithium batteries. Graphite, the common negative electrode in Li-ion batteries, cannot be used as an insertion electrode in Na-ion batteries as Na atoms do not intercalate between the carbon sheets.

It is well known that graphite oxide (GO) is a typical pseudo-two-dimensional solid in bulk form, with strong covalent bonding within the layers. Some functional groups, such as hydroxyl, carboxyl, and other groups, bound to carbon sheets in GO lamellae make GO hydrophilic, and also enable GO to exhibit rich intercalation chemistry. Because GO has an expanded interlayer distance and thus an enhanced pore volume compared to its precursor graphite, GO is expected to show increased capacity. However, It has been shown that the expanded interlayer distance collapses at high temperatures (e.g., above 100 °C) that are typically encountered in the processes of making electrodes. It has also been reported that some polymers, such as poly(ethylene oxide) (PEO) and poly(sodium 4-styrensulfonate) (PSS) can be intercalated into GO to mitigate the shrinkage in interlayer distance. Another critical issue is that the surface of GO tends to be poorly conductive, and this could restricted its application as active material.

Conducting polymer poly(3,4-ethylene-dioxythiophene) (PEDOT) doped with poly(styrenesulfonate) (PSS) is commercially available in aqueous dispersion, which can easily be casted into film electrode at low temperatures (<100 ^{o}C). It has been widely used as an antistatic coating material, and as a hole-transport electrode for rechargeable polymer batteries or optoelectronic devices. PEDOT:PSS possesses high electric conductivity (ca. 550 S cm^{-1}) and excellent thermal stability, and therefore it can be used as an multifunctional binder that is simultaneously electrochemical active.

In this study, we report a brightening prospect to fabricate GO electrode at 50 ^{o}C by using PEDOT;PSS as a multifunctional binder. PEDOT:PSS further increases the surface conductivity of GO by synergistic effect. The low processing temperature ensures to retain expanded basal-plane spacing and surface functional groups at the GO surfaces, leading to good interfacial compatibility between GO surface and the polymer. The highest discharge capacity of 250 mAh g^{-1} was obtained. This excellent composite electrodes lead to remarkable high-rate (up to 10 C-rate) charge/discharge capability and cycling stability along with high specific capacity. It retains 60% capacity after 100 cycles at 1 C-rate charge/discharge density.

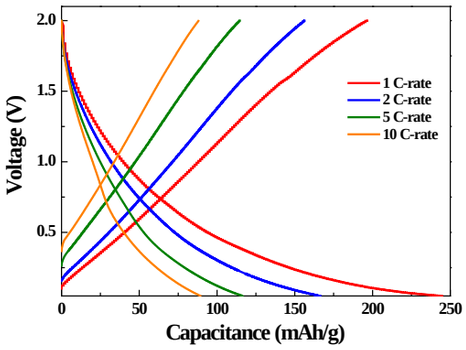

Figure 1. The charge/discharge curve of GO/PEDOT:PSS nanocomposite estimated at various current densities.