ND*nano* Undergraduate Research Fellowship (NURF)
2011 Project Summary

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Project title: Solid polymer electrolytes for rechargeable batteries

Solid polymer electrolytes [SPEs] would enable the development of ultra-light and nontoxic Li-ion batteries; however, SPE conductivity is too low to power potable devices. The addition of spherical metal oxide nanoparticles [NPs] slightly improves SPE conductivity; despite this, nanorods [NRs] and other shapes have not been studied. Studies suggest that metal oxide fillers with high aspect ratio may favor ionic conductivity. [1] Thus, we chose to compare the effect of NPs and NRs on the conductivity and thermal properties of SPEs using impedance spectroscopy and differential scanning calorimetry [DSC].

We synthesized Fe_2O_3 NRs (16 x 105 nm) and TiO_2 NRs (17 x 76 nm) using hydrothermal procedure (Figure 2). [2],[3] We also purchased Fe_2O_3 and TiO_2 NPs with average diameter of 30 nm and 24 nm, respectively. We added 0.5 – 10 wt% nano-fillers into a polyethylene(oxide) [PEO]/$LiClO_4$ (10:1) electrolyte. DSC shows 1. nano-filler shape does not affect the average Tg or the Tg range, where Tg is the glass transition temperature, and 2. samples with NRs have higher heats of fusion [Hf] than samples with NPs (i.e., samples with NRs are more crystalline). Equivalent Tg values suggest that nano-filler shape does not affect SPE mobility. Interestingly, even though NR samples are more crystalline than NP samples, they produce higher conductivity at low concentrations (Figure 1). This result is compelling because it is well established that crystallization decreases conductivity. It is possible that Fe_2O_3 NRs are well dispersed at low concentrations and therefore provide more surface area and a straight pathway to aid Li+ mobility, and therefore ionic conductivity.

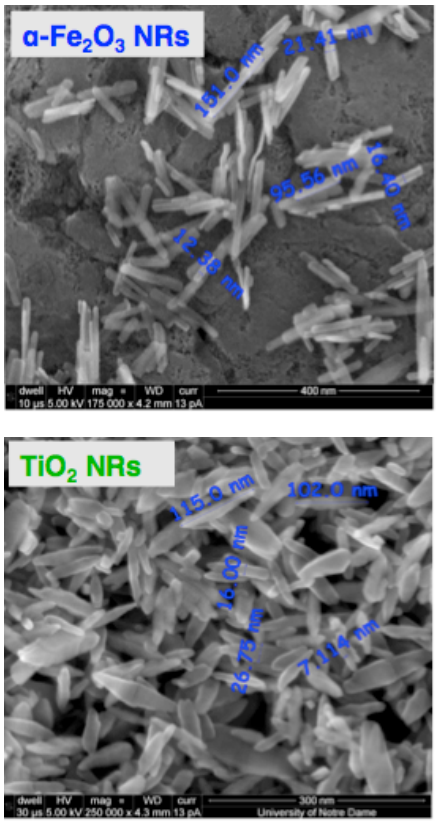

Figure 1: SEM images of Fe_2O_3 nanorods (top) and TiO_2 nanorods (bottom).

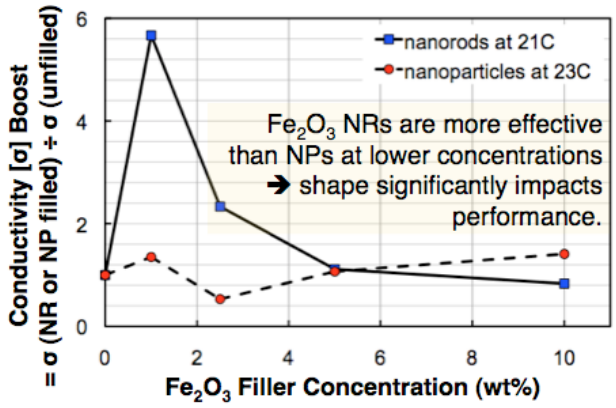

Figure 2: Conductivity boost of PEO:$LiClO_4$ (10:1) + X% Fe_2O_3 NR/NP

References

[1] Fullerton-Shirey, SK; Maranas, JK, "Structure and mobility of PEO/LiClO4 solid polymer electrolytes filled with Al2O3 nanoparticles" ***Journal of Physical Chemistry C*** 114, 9196 (2010).

[2] Tang *et al.,* "Facile route to alpha-FeOOH and alpha-Fe2O3 nanorods and magnetic property of alpha-Fe2O3 nanorods" **Inorganic Chemistry**, 2006, 45, 5196.

[3] Teng et al., "Hydrothermal Synthesis of Single-Crystalline Anatase TiO_2 Nanorods with Nanotubes as the Precursor" ***Journal of Physical Chemistry B***, 2006, 110, 4193-4198.

Work presented/submitted during 2011 NURF program:

Poster presentation at the 4th Annual Undergraduate Scholars Conference hosted by the Notre Dame Center for Undergraduate Scholarly Engagement (CUSE)