

Chau Tran

Title: Fabrication of Porous Carbon Nanofibers with Adjustable Pore Sizes as Electrodes for Supercapacitors

Advisor: Prof. Vibha Kalra

Date: Friday, May 30th, 1-3pm

Location: CBE conference room

Abstract: " Blends of polyacrylonitrile and sacrificial Nafion in DMF have been electrospun into non-woven nanofiber mats with diameters in the range of 200-300 nm. The TEM images of internal morphology of Nafion: PAN nanofibers show a co-continuous assembly. Electrospun nanofiber mats are subjected to carbonization to obtain porous carbon nanofibers (CNFs) as PAN converts to carbon and Nafion decomposes out to create intra-fiber pores. Porous CNFs exhibit specific surface area of up to $1600 \text{ m}^2 \text{ g}^{-1}$. They are applied as free-standing electrode materials for EDLCs without any additive. Electrochemical measurements show large specific capacitances of 210 F g^{-1} and 60 F cm^{-3} in $1 \text{ M H}_2\text{SO}_4$. We achieved an energy density of 4 Wh kg^{-1} at an extremely high power density of 20 kW kg^{-1} . We also try to improve the electrochemical properties of polyaniline for stability and high energy density at high power rate. By using a galvanostatical polymerization method, we achieved a uniform coating of polyaniline on porous CNFs. The combination of two different storage mechanisms resulted in very high capacitances of 365 F g^{-1} and 140 F cm^{-3} in 50/50 polyaniline/CNFs. In collaborating with Dr. Yossef Elabd's research group, the porous CNFs are utilized for studying ionic dynamics in EDLCs. The spectroelectrochemical results show that both EMIM cation and TFSI anion concentration decrease in the CNFs enriched with both nitrogen and oxygen upon charging. Contrastingly, the cation concentration increases and the anion concentration decreases in CNF electrodes enriched with only oxygen. This charge separation, in part, enhances charge storage and allows us to achieve an energy density of $\sim 75 \text{ Wh/kg}$. In addition, the effect of elongational flow on phase separating binary mixtures is studied with MD simulation. The result shows a formation of a perpendicular lamellae structure at intermediate elongational rate. Further increasing elongational rate leads to a disordered morphology. We see a difference in the domain growth, $R(t) \sim t^\alpha$, between a polymer blend and a simple fluid mixture. A growth exponent of $1/3$ for the polymer blend and 0.6 for the fluid molecular mixture was found under elongation rates from 0.005 to 0.1 ."