Highly Mesoporous Electrodes Derived from Polymer Blends of Polyacrylonitrile-Polystyrene and Polyacrylonitrile-Poly(Methyl-Methacrylate) Paired with a Cost-Effective Deep Eutectic Solvent for High Energy Density Supercapacitors

Shah, Ashay (School: Plano East Senior High School)
Shah, Ashna (School: Plano East Senior High School)

Supercapacitors (SC) have received attention due to quick charge times and higher power densities than lithium-ion batteries (LIB), which enable them to be implemented in electronic devices. However, they possess lower energy densities than LIB. Furthermore, commercial SC and LIB have narrow temperature windows, limiting their application. Our work aimed to replace LIB by creating a cost-effective SC with a high energy density and wide operating temperature window. We created a novel, low cost, and wide temperature range Deep Eutectic Solvent. We fabricated SC using three polymer blends: Polyacrylonitrile (control), Polyacrylonitrile (PAN)-Poly(methyl-methacrylate) (PMMA), and PAN-Polystyrene (PS), and each was tested at four different temperatures. We developed a methodology where immiscible polymer blends with different degradation temperatures were carbonized. PS and PMMA degraded to form pores due to their lower degradation temperature to increase the surface area. Channels were formed on the PAN-PS SC, which had never been obtained before. This allowed for a surface area of 3171 m2/g, leading to an energy density of 67.2 Wh/kg, which was 13.5 times greater than commercial SC. The PAN-PS SC retained its superb electrochemical properties throughout -50°C to 110°C, meaning that our SC can be expanded for use in extreme temperature applications and areas, unlike commercial SC and LIB. A cost analysis indicated that our SC was up to 3 times cheaper than commercial SC. Our SC charged fully in 20 seconds and a vehicle simulation using our SC demonstrated 36-47% higher fuel economies than Hybrid Electric Vehicles with LIB. Our SC will have a transformative impact on multiple fields, with applications in medical implants and automobile, mobile and oil industries.

Awards Won:

Air Force Research Laboratory on behalf of the United States Air Force: First Award of $750 in each Intel ISEF Category