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Prof. Natalie Arnett

"Synthesis of Phosphonated Hybrid Monomers for use as Additives in Proton Exchange Membrane Polymers for Fuel Cell Applications"

Fisk University
Assistant Professor – Department of Chemistry

Host: Judy Riffle

Abstract: Polymer electrolyte membrane fuel cells (PEMFC) are electrochemical devices, equipped with a proton exchange membrane (PEM), which converts chemical energy of fuel to electrical energy through an oxidation potential. PEMs exhibit the potential to produce clean energy in an efficient manner. However, inadequacies in membrane performance and properties at high temperatures (>180 ^{o}C), low relative humidity (RH), and high sulfonation levels have limited the widespread commercialization of these membranes. Polyfunctional acid materials have garnered much interest in recent years for addressing this challenge in the fabrication of solid electrolytes exhibiting proton conductivity in the solid state that allow proton conduction at high temperature and low relative humidity.

The current study describes the synthesis and characterization of 2,4,6- triphoshphonic acid-1,3,5-triazine (TPAT) for use as an additive in poly(arylene ether sulfone) copolymers for applications in PEMFCs. TPAT was synthesized by the reaction of cyanuric chloride (CC) and Triethyl phosphite (TEP) followed by acid hydrolysis. ^{1}H, ^{13}C and ^{31}P NMR confirmed the production of the TPAT monomer by the appearance of chemical shifts at 11.15 ppm in the ^{1}H NMR, 151.1 ppm in the ^{13}C NMR and 2.2 ppm in the ^{31}P NMR, respectively. Following its successful synthesis, TPAT was added to acidified BPSH-35 copolymer membranes with varying concentrations of TPAT (0%, 1%, 3%, 5%). Proton conductivity studies were then conducted on these membranes in the wet state. An increase in proton conductivity from 5.4 x 10^{-3} S/cm to 1.06 x 10^{-2} S/cm was observed as TPAT concentration was increased from 0% to 5%. Relative humidity results for the TPAT/BPSH-35 composite membranes above 70% showed an increase in the proton conductivity compared to BPSH-35 membrane without any TPAT additive.

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Bio: Dr. Natalie Arnett is an Associate Professor of Chemistry at Fisk University in Nashville, TN. Dr. Arnett's overall research program, which includes undergraduate and graduate trainees, has the overall objective to synthesize and characterize various synthetic and biopolymers for applications in fuel cells, reverse osmosis, and drug delivery. In January 2015, Dr. Arnett received a NSF Faculty Early Career Development (CAREER) Program award to support her research on developing novel membrane materials for fuel cell applications and integration of this polymer based research into general chemistry lecture and lab courses.

Dr. Arnett's teaching efforts include General Chemistry I and II, Organic Chemistry Lab (undergrad), and upper level graduate/introductory graduate courses in Polymer Chemistry as well as guiding the Chemistry Colloquium. Dr. Arnett serves as the Discipline Coordinator in Chemistry at Fisk University and has an Adjunct Appointment in the Department of Chemistry at Vanderbilt University as part of her participation in the Fisk-Vanderbilt Master's to PhD Program.

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