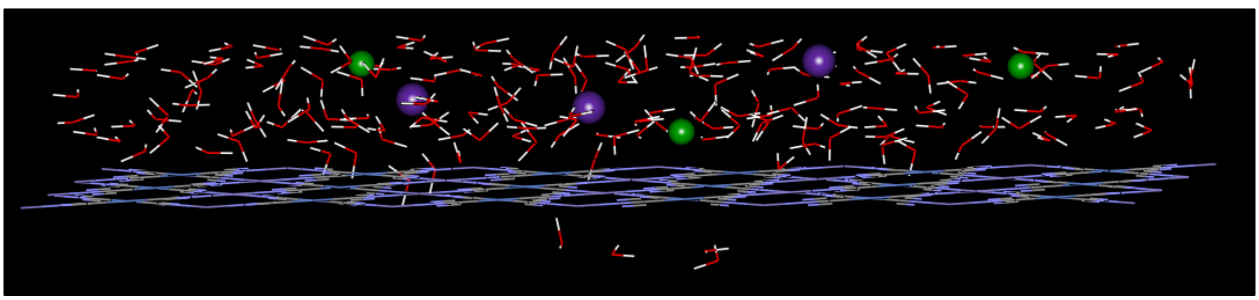
Tyler Nash

SBIR Proposal Abstract

Non-Fouling Water Reuse Technology

Army contingency operating bases (COBs) rely heavily on their supplies of both potable and non-potable water for daily operations and to ensure soldier health. The workhorse of the water supply system is the Reverse Osmosis Water Purification Unit (ROWPU). The ROWPU system provides the majority of both potable and non-potable water sources for COBs, especially in geographic locations where the local treated water supply quality is poor or non-existent. According to Science and Technology Challenge Area 4a, the need for water resupply at COBs must be reduced by 75%. ROWPUs could be utilized to recycle gray water generated at COBs to help meet this goal, but some significant problems associated with fouling of the membrane must be addressed with the current system. Membrane fouling results in costly unit replacement and a significant in labor associated with the ROWPU system. In response to these issues, we have proposed a replacement for the membrane component of the RO system, coupled with an integrated backwash cycle to significantly reduce fouling, labor requirements, and operating costs. Our membrane replacement material is a 2-D transition metal cyanide-bridged nanosheet material that is highly resistant to fouling and will allow operation at much lower pressures than traditional membranes. Molecular modeling has demonstrated the feasibility of this system as an RO membrane, and a method has been previously developed to exfoliate nanosheets of this material.



Molecular simulation capture of water molecules passing through the nanosheet pores. Water molecules can be seen orienting with the O-H bond perpendicular to the sheet in preparation for passing through the pores. Some water molecules have already permeated the nanosheet. The sodium and chloride ions are enlarged for contrast.

BIOGRAPHY

Tyler Nash obtained his B.S. and M.S. in Chemistry in 2011 at Texas State University San Marcos. He then began the Materials Science, Engineering, and Commercialization doctoral program in Spring 2012. During his stay at Texas State, Tyler has been involved in a multitude of research projects including synthesis of smectite clays, synthesis and testing of impact-resistant polymers, nanoparticle catalyst development, applications and preparation of 2-D nanoparticles, and molecular modeling of these systems. His current focus is on a family of 2-D transition-metal cyanide-bridged nanoparticles. His work involves tailoring these materials for different applications, the most notable being catalysis and nano-scale electronics. During the last three semesters, Tyler has performed duties including teaching Physics 1410 labs, scanning electron microscope (SEM) and energy dispersive X-ray spectroscopy (EDS) training, and doctoral instructional assistant for the materials characterization course (MSEC 7311). He has also participated in the completion of multiple SBIR projects while at Texas State. Upon his projected completion of the MSEC program in Fall 2013, Tyler will enter industry, where he will use the skills he has acquired at Texas State to achieve success. Tyler is also involved in an early-stage entrepreneurial endeavor with three other students in the MSEC program (Jeffrey Simpson, Sayantan Das, and Travis Cantu), which is built upon the commercialization of science-based consumer products.

Fields of Experience: Nanoparticle synthesis and characterization • Two-dimensional nanoparticle systems • Nanoparticle catalysis • Polymer nanocomposites • Molecular modeling of polymer and nanoparticle systems

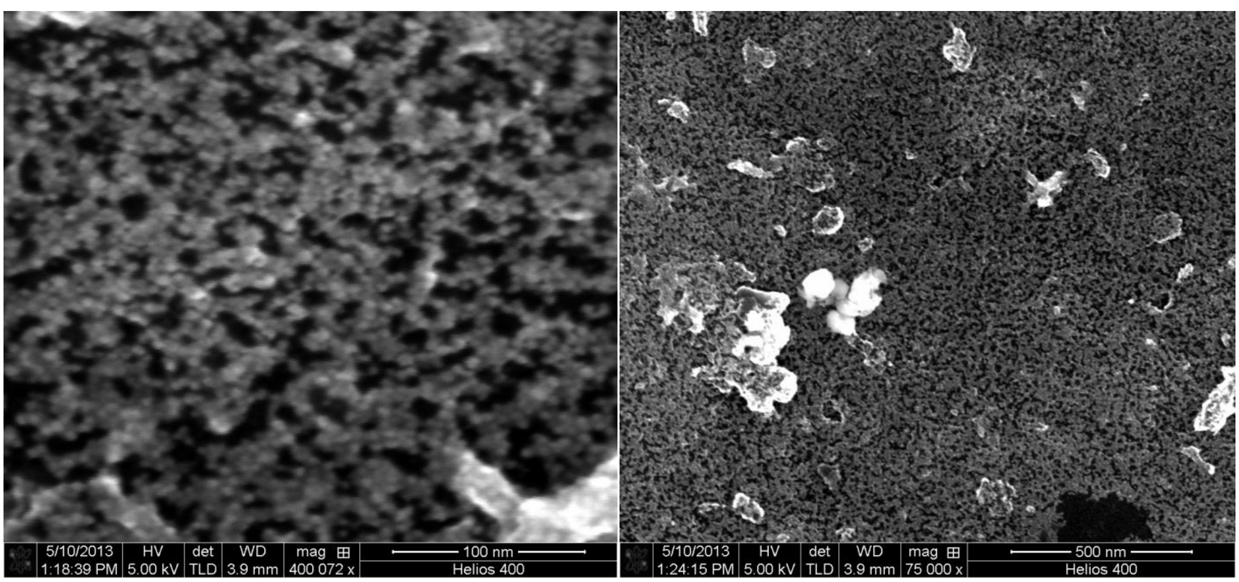
Education: B.S. in Chemistry from Texas State University-San Marcos (2011); M.S. in Chemistry from Texas State University-San Marcos (2011); Projected to complete Ph.D. in Materials Science, Engineering, and Commercialization from Texas State University-San Marcos in Fall, 2013.

Current Position: Ph.D. student in the Materials Science Engineering, and Commercialization Program at Texas State University-San Marcos.

Dissertation Proposal Abstract

2-D Transition Metal Cyanide Nanosheets as Precursor Material for an Ultra-low Platinum Group Metal Catalyst

Traditionally, platinum group metal (PGM) catalysts have utilized relatively high loadings of pure precious metals to achieve the activity required for catalysis. Only the metal exposed on the surface of these catalysts is active in catalysis. Therefore, traditional PGM catalysts are only able to use a small percentage of the total PGM in the catalyst, yielding very inefficient use of the metals. The high precious metal content renders this type of catalyst component very costly and sensitive to any price fluctuation in platinum group metals. Thus, there has been a substantial effort by researchers to find alternative catalysts that use either lower precious metal content or non-precious metal alternative to achieve the same activity. This proposal involves the synthesis and testing of a tunable, high activity catalyst material, using 2-D transition metal cyanide-bridged nanosheet precursors with the empirical formula $M(H_2O)2Ni(CN)_4{\cdot}4H_2O$, where M can refer to various transition metals in the +2 valence state. A significant portion of work has already been completed on the synthesis of the catalyst material, but optimal parameters for synthesis must be discovered. Three types of evaluations will be conducted to test efficiency in commercially important catalytic processes – the hydrogenation of styrene to ethylbenzene (important metric for industrial and chemical production catalytic processes), the oxygen reduction reaction (important for fuel cell cathode catalyst materials), and NO_x to N_2 emission conversion (important for diesel emission control). This proposal presents the details of the synthesis and characterization processes, the results of work already conducted, and remaining proposed work for the dissertation.



SEM images of the catalyst. The catalyst is comprised of 3-5 nm Pt-Ni nanospheres deposited on activated carbon.