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| **Excellence in Research: A Novel High Throughput Forward Osmosis Membrane for Produced Water Treatment** |
| Sponsor | National Science Foundation |
| Investigators | Raghava Kommalapati with Sheena Reeves and Shafer (UH) |
| Project Dates | 08/19-07/25 |
| Amount Awarded | $500,000  |
| Project Description: |
| The goal of the proposed research is to develop an innovative method for treating shale gas and oil produced water (PW) that employs a novel high throughput forward osmosis (FO) membrane with significantly improved antifouling and reverse draw solute repelling properties. The proposed high throughput FO membrane consists of a nanofibrous support layer, a thin coating layer at the bottom of the support layer, and an ultrathin active layer. A graphene oxide (GO)-embedded polyetherimide nanofibrous substrate will be fabricated and used as the support layer, and the bottom of the support layer will be modified with the zwitterionic polymer, 2-methacryloyloxyethyl phosphorylcholine (MPC). The ultrathin active layer will be synthesized at low temperature with phase conversion, and its top will be coated with zwitterionic sulfobetaine methacrylate (SBMA). To obtain clean product water, a conventional reverse osmosis (RO) process will be integrated with FO filtration to form a hybrid FO-RO process. After fabrication and characterization, the novel membrane will be tested in the FO filtration system. A mixed ammonia-carbon dioxide draw solute will be used in the FO filtration process to take advantage of the availability of recycling options by using low-grade waste heat or thermal energy collected with a solar heater. The water produced from the final RO process will be tested for comparison with environmental disposal standards. The repelling and antifouling mechanisms will be elucidated through molecular dynamics simulations. The economic and environmental impacts of the hybrid FO-RO process for shale gas and oil PW treatment will be evaluated using a life cycle assessment approach. ***Intellectual merit*:** Current membrane processes for treating shale gas and oil PW are limited by their low flux and high energy costs for solute regeneration. The proposed research will explore a novel FO approach that could make high flux, energy efficient FO treatment of PW practical. This work will be the first to explore the FO treatment of PW using a membrane with zwitterionic coating on both sides. The central hypothesis of this research is that dual-side modification of the membrane with zwitterionic polymers will prevent organic fouling and repel reverse solute flux during the FO process through two mechanisms. The development of a static negatively charged surface on the active layer will enhance membrane antifouling properties. The zwitterionic coating on the support layer will develop a positively charged surface which will repel ammonium ion present in the mixed ammonia-carbon dioxide draw solution. This will minimize reverse draw solute flux during the FO filtration process. The decline in water flux for the dual-coated membrane is expected to be modest compared to an uncoated FO membrane. This is achieved by synthesizing the ultrathin active layer at low temperature, and a nanofibrous support layer. Molecular dynamics simulations of the FO membrane filtration will be conducted to elucidate the fundamental mechanisms underlying the antifouling and repelling behavior. A life cycle assessment study will be conducted to evaluate the economic and environmental impacts of shale gas and oil PW treatment with the proposed novel system and compared to the impacts of other treatment processes. ***Broader impacts:*** This collaborative, multi-disciplinary effort will increase the research productivity of the PIs and enhance their expertise in membrane engineering and wastewater treatment areas. This will enhance the research infrastructure at PVAMU and will contribute to the education and training of students from underrepresented groups. This project will help to increase the participation of students from African-American and Hispanic groups in engineering. Students and faculty will gain experience in team research, networking, dissemination, and professional development that will help them become fully engaged members of the STEM community. Successful completion of this project will provide the basis for pilot-scale testing for PW treatment and open the avenues for large-scale application of FO membrane systems. Development of an effective method for treating PW from hydrofracking operations will address an important environmental challenge, and provide industry with a safe and affordable alternative to injection of PW into aquifers. |