

I am providing the research project synopsis for the work I am interested in being a mentor for and engaging the early career scholar. The area that is highlighted is in the water, energy and environment area consistent with the AAP priority in this area. The early career scholar would be involved in all these aspects of the research proposed below and during the project period, I would be writing the research results with the early career scholar for targeted publications. We would also plan to submit future proposals to NSF and other funding agencies.

The proposed work aims at increasing cost-efficiency of thermal desalination systems through the development of new low-cost alloys with superior resistance to corrosion and higher working temperatures (up to 150°C). The proposed low-cost alloys include TiMn-Zr alloys with high strength and high entropy alloys (HEAs), based on the FeNiCrMnSi system, with good cold workability. We will rely on common elements such as manganese (Mn), nickel (Ni), iron (Fe), and silicon (Si) as raw materials in the alloy design. The ease of processing; i.e. using cold working for the beta-type Ti alloys and face centered cubic (FCC) HEAs will also help reduce costs. Each of the alloys to be studied will have higher strength than the commonly used commercially-pure Ti, which should give lower tube thicknesses and lower the costs further. A thorough understanding of composition-processing-microstructure-properties relationships will be obtained in order to optimize the processing parameters for high corrosion resistance and mechanical properties. Thereafter, the new alloys will be processed into sheets and tubes to evaluate the desalination efficiency and, specifically, measure the evaporation rates. The results of the study will be expressed in terms of the flux of the desalinated water and the cost of desalination per unit volume of the water produced over the longer timescale typical for corrosion processes. To evaluate how robust the new alloys are when challenged by real feed waters, we will explore individual and combined effects of corrosion, colloidal fouling and precipitative fouling of alloys on the process efficiency. An in-depth characterization of the alloy surface (charge, interfacial free energy, morphology) will inform the design and optimization of novel alloy materials with improved resistance to corrosion and fouling. Our working hypothesis is that the thermal conductivity of the CP Ti, Ti-alloys and HEAs will be similar while the resistance to corrosion and fouling will be significantly higher for new materials. The project team has the requisite expertise and a substantial research record in key areas of knowledge that underpin the proposed work: advanced materials synthesis and their characterization; mechanical behavior of alloys, electrochemistry, as well as desalination. Potential benefits of inexpensive, corrosion-resistant materials extend beyond thermally-driven separations and can have significant broader impact on other desalination technologies. We believe that the research program outlined in this proposal is a value-added project that can strengthen the economic sustainability of the water industry in both USA and Egypt by providing superior protection to key components of seawater desalination infrastructure.