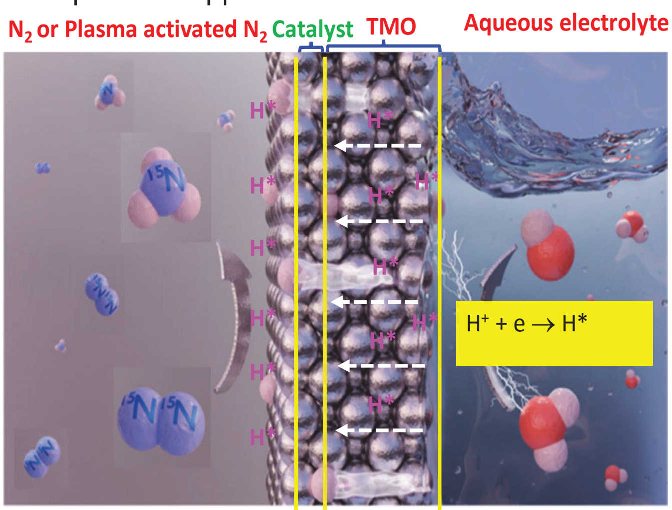
Huixin He Laboratory

Microwave Enabled Fast Fabrication of Transition Metal Oxide-based Hydrogen Selective Membranes The focus of this project is to develop **multifunctional transition metal oxide (TMO)-based hydrogen selective membranes.** These membranes will be used to develop novel electrocatalytic systems to efficiently produce ammonia (NH_3) from water (H_2O) and nitrogen (N_2) in air. The novelty the electrochemical systems lies in the **spatial separation** of the sites for electrochemically generate active hydrogen from water and the sites for N_2 activation, hydrogenation, and NH_3 generation. The key advantage is that the reactions in these two sites can be conducted in different environments, allowing for independent optimization. As a favorable outcome, it becomes possible to simultaneously enhance catalytic N_2 reduction and suppress the overwhelming side reaction, such as hydrogen evolution reaction. Significant improvement in the efficiency of ammonia synthesis toward practical applications.



A schematic drawing illustrates the novel electrocatalytic systems to efficiently produce ammonia (NH_3) from water (H_2O) and nitrogen (N_2). In this electrochemical system, a TMO membrane will be used to electrochemically generate active hydrogen atoms (H*) at the right side of the membrane. Due to its unique hydrogen transportation property of the TMO membrane, the generated hydrogen atoms are then selectively transported to the other side of the membrane (the left side), which N_2 or plasma activated N_2 will be hydrogenated and producing NH_3.

A novel microwave enabled fabrication approach will be developed to fabricate these TMO membranes. Our preliminary studies demonstrated using microwave enabled approach can shorten the fabrication time to 15 minutes, which is significantly shorter than the traditional hydrothermal fabrication method (24 hours). **The undergraduate student** will learn how to use microwave chemistry for fast and direct growth of transition metal oxide (TMO) nanomaterials on highly porous carbon cloth materials. The microwave chemistry will be optimized to grow TMO nanomaterials with controlled size, shape, and crystal structures. The resulting materials will be characterized with a suite of tools. Some of them will be directly used as stand-alone membrane electrodes for electrochemical nitrogen (N_2) reduction and plasma assisted N_2 fixation for ammonia synthesis.

An innovative "near peer" mentoring strategy will be employed to help/train them to develop important skills, which are imperative in their future career development. Through this project, they will learn and perform microwave synthesis and characterization of nanomaterials with various techniques, such as scanning electron microscope (SEM), powder x-ray diffraction (PXRD), UV-Vis spectroscopy, and electrochemical techniques for ammonia synthesis. If the project goes smoothly, the student will be welcomed to participate in the nitrogen plasma enhanced ammonia synthesis at Princeton Plasma Physics Laboratory. Special efforts will be made to develop their capability in logical thinking, effective literature research, and independent project planning. In addition, written and oral communication of their research accomplishments will be strongly emphasized. They will be encouraged to attend ACS national meetings to present their work.