Advanced Membranes for Selective Ion/Molecular Separation and Bio-electrochemical CO_2 Conversion

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The U.S. Department of Energy's National Energy Technology Laboratory (NETL) has long recognized the critical link between sustainable water and energy. In this presentation, recent progress at NETL on the development of new membrane materials for energy-efficient gas and liquid separations, bio-electrochemical conversion, and low-cost and energy-efficient desalination will be addressed. This will enable the recovery of valuable resources and the reduction of wastewater for treatment, thus mitigating the environmental impact.

Membrane and membrane-based processes have been considered as promising technologies for a variety of key energy-intensive separation applications due to numerous advantages. These include lower energy consumption, smaller environmental footprint, and the potential to be installed as a true bolt-on technology. Polymeric membranes are currently considered the most promising candidate for industrial applications due to additional benefits of being inexpensive and easy to manufacture. However, the performance of polymer membranes is limited by a trade-off between permeability and selectivity. To overcome the limitations of polymer membranes, a rational design of unique two-dimensional membrane materials has been utilized at NETL for such applications in collaboration with NETL's strategic partners. In this work, we will demonstrate that a two-dimensional material-based hollow fiber membrane is a very promising platform to provide high-performance and highly scalable membranes for practical applications in many challenging separation processes. Future activities may include the application of artificial intelligence and machine learning to design and synthesize high-performance membrane materials critical to water-energy challenges.
Keywords: Membrane Separation; Hollow Fiber Membrane; Two-Dimensional Materials; Bio-electrochemical CO_2 Conversion