Powerless Desalination: The Development of a Novel PEGylated Membrane to Exploit Ambient Thermal Energy Gradients of the Ocean

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Forward Osmosis (FO) is an alternative method of desalination that uses a hypertonic “draw" solution to leach water molecules from a hypotonic "feed" solution such as seawater across a semipermeable membrane. Although FO is a promising technology for low energy desalination, the separation of draw solute from the profited water is a costly complication. No draw solution constituents have yet been discovered that facilitate FO at a lower net expense than traditional Reverse Osmosis and Multistage Flash Distillation. In this study, a modified FO membrane was found to create positive water flux from a seawater feed solution in absence of any free draw solute. Polyoxyethylene, a polymer that was found to create high osmotic pressures, was conjugated, or “PEGylated” to the interior “draw side” polysulfone surface of an FO membrane. The engineered asymmetric membrane demonstrated high enough osmotic pressure to overcome the negative osmotic pressure of the seawater feed solution while lacking any untethered draw solute. Molecular Dynamics computer simulations were used to investigate the apparent contradiction to the laws of thermodynamics. It was discovered that the energy responsible for sequestering water molecules from salt ions originated from an ambient temperature gradient. This bizarre discovery was used in the development of a novel, self-powered desalination cell to purify water with zero moving parts, deriving power from the thermal energy gradient of the ocean. This study is the first to demonstrate the generation of osmotic pressure using a tethered solute. The novel method of desalination has shown potential to universally liberate oceans to the human water supply.

Awards Won:
Fourth Award of $500