



Electrodeionization Using Microseparated Bipolar Membranes

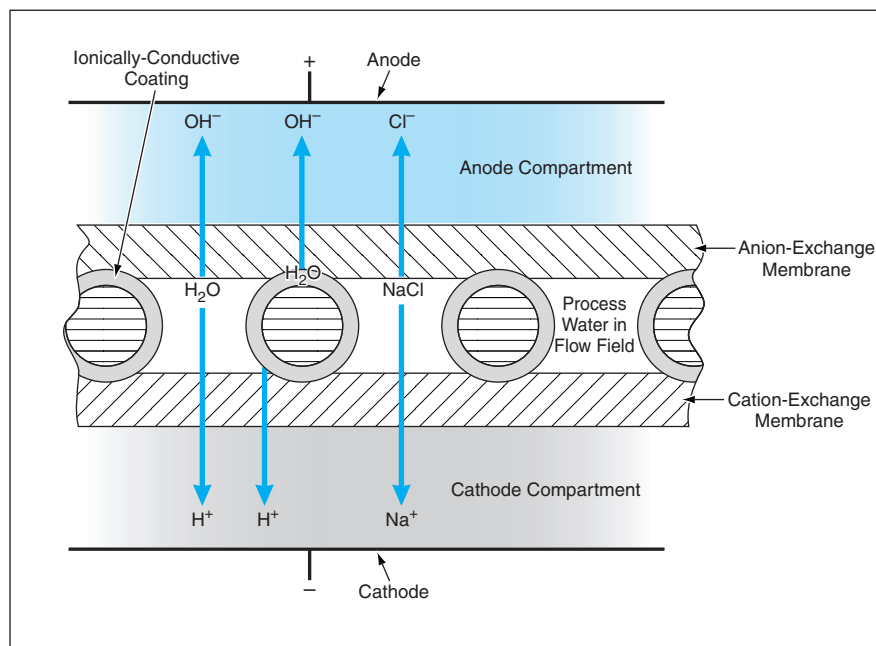
Low concentrations of ions do not inhibit further removal of ions.

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An electrochemical technique for deionizing water, now under development, is intended to overcome a major limitation of prior electrically-based water-purification techniques. The limitation in question is caused by the desired decrease in the concentration of ions during purification: As the concentration of ions decreases, the electrical resistivity of the water increases, posing an electrical barrier to the removal of the remaining ions. In the present technique, this limitation is overcome by use of electrodes, a flow-field structure, and solid electrolytes configured to provide conductive paths for the removal of ions from the water to be deionized, even when the water has already been purified to a high degree.

The technique involves the use of a bipolar membrane unit (BMU), which includes a cation-exchange membrane and an anion-exchange membrane separated by a nonconductive mesh that has been coated by an ionically conductive material (see figure). The mesh ensures the desired microseparation between the ion-exchange membranes: The interstices bounded by the inner surfaces of the membranes and the outer surfaces of the coated mesh constitute a flow-field structure that allows the water that one seeks to deionize (hereafter called "process water" for short) to flow through the BMU with a low pressure drop. The flow-field structure is such that the distance between any point in the flow field and an ionically conductive material is small; thus, the flow-field structure facilitates the diffusion of molecules and ions to and from the ion-exchange membranes.

The BMU is placed between an anode and a cathode, but not in direct contact with these electrodes. Instead, the space between the anionexchange membrane and the anode is denoted the anode compartment and is filled with an ionic solution. Similarly, the space between the cation-exchange membrane and the cathode is denoted the cathode compartment and is filled with a different



A **Bipolar Membrane Unit** contains a flow-field structure and solid electrolytes configured to provide conductive paths for the removal of ions from process water.

ionic solution. The electrodes are made of titanium coated with platinum.

The process water is introduced into the BMU, and a dc potential is applied between the electrodes. The ion-exchange membranes contain networks of molecular-size pores with electric charges fixed to their matrices. An ion-exchange membrane is nominally electronically nonconductive but is conductive to counterions; that is, to ions of charge opposite that of the ions immobilized in it. Because of the semipermeability of the membranes and the direction of the electric field between the electrodes, negatively charged ions migrate from the process water towards the anode and positively charged ions migrate from the process water towards the cathode. The ions thus removed from the process water become concentrated in the water in the anode and cathode compartments.

The removal of ions from the process water includes salt-splitting reactions (e.g., the separation of Na^+ and Cl^- ions). In addition, some water molecules dissociate into H^+ and OH^- ions. The

combination of this water splitting reaction and the highly efficient transfer of the H^+ and OH^- ions by the respective membranes ensures high transmembrane ionic conductivity, even when the concentrations of other ions in the process water are low. The ion-conducting circuit of the electrochemical cell is completed by the anode and cathode compartments.

This work was done by Donald Lyons, George Jackson, Craig C. Andrews, Charles L. K. Tennakoon, Waheguru Singh, G. Duncan Hitchens, Harry Jabs, James F. Chepin, Shivaun Archer, Anukia Gonzalez-Martinez, and Alan J. Cisar of Lynntech, Inc., for Johnson Space Center.

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

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