Motivation

The global demand for fresh water for drinking, personal care, and irrigation is strongly increasing while simultaneously it is becoming more difficult to produce. For instance in coastal regions groundwater is becoming increasingly brackish. Existing technologies have many disadvantages, related to a high energy consumption, required large scale, high investment costs, high maintenance costs and/or low production rates.

In close cooperation with Voltea B.V. (Leiden, the Netherlands) we develop a novel technology that has the potential to be energy-efficient and cheap, applicable also on small scale and not requiring much maintenance.

Technological challenge

The CDI unit cell consists of two porous carbon electrodes, two ion-exchange membranes and a spacer. Technological challenges are manifold. First of all, the electrodes must combine high permeabilities for ions with extremely large accessible surface areas, leading to the demand for structures with nano-sized dimensions. The ion-exchange membranes must be highly permeable for counterions (ions of opposite charge as the membrane) while simultaneously be highly blocking for the co-ions. The spacer must have a low resistance to fluid flow but simultaneously lead to sufficient mixing.

To understand the CDI system and to guide the quest for process improvements, theoretical process modeling is of crucial importance. However, successful comprehensive models for CDI are not yet available and must combine momentum transport, reactor engineering and ion-transport modeling (Poisson-Nernst-Planck theory), as well as include chemical ion adsorption and Faradaic charge transfer effects.

Future developments are the use of the CDI unit not only to deionize water but also for upconcentration of industrial waste streams. Other directions are the use of CDI for selective ion removal processes (separation) making use of different chemical and electrostatic properties of the various (organic) ions. Finally, because of the large electric fields applied, CDI has a large potential to be of use as a disinfection technology, simultaneously with desalination.