Graduate Program for Mechanical Systems Innovation

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Capacitive deionization of water: Resonant desalination and selective nitrate extraction

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Venue：31A, 3F Faculty of Engineering Bldg. 2

Abstract:

Presented will be analytical models and experimental studies of capacitive deionization (CDI) for desalination and toxin removal. Well-designed CDI cells are a promising alternative to existing desalination technologies, including reverse osmosis. This is particularly true for the desalting of water with low to moderate levels of salinity (brackish water), where CDI is most efficient. CDI cell capacity scales approximately linearly with material requirements and capital costs, and these systems require negligible supporting infrastructure. A CDI cell uses one or more pairs of oppositely charged porous electrodes (typically carbon) within a housing fitted with a single inlet for feed water and a single outlet. A maximum of about 1.2 V potentials are applied between electrodes, driving ionic species in solution toward electrode surfaces, where they are capacitively and reversibly retained.

In the area of desalination, we developed a theory around and experimentally demonstrate new operation modes for CDI including sinusoidal electrical forcing. We use a dynamic system analysis approach and quantify the frequency response of CDI effluent concentration. We explore the coupling between electric charge, ionic charge, and mass transport and demonstrate that sinusoidal voltage forcing functions can achieve resonance-type operation for CDI. Operation at resonance results in an optimal balance between absolute amount of salt removed (in moles) and avoidance of dilution of the feed and brine streams.

In the area of toxin removal, we developed specialized CDI cells for selective toxin removal from water. We functionalize active carbon electrodes with ion-selective functional groups. We developed an experimentally validated model that combines a Donnan treatment for electric double layers (EDL) and electrosorption Langmuir-type equilibria. We built and demonstrated a CDI cell for nitrate removal and used ion chromatography to quantify performance. Functionalization of activated carbon electrodes provides a selective ion capture system with that can be regenerated with applied voltage. We demonstrated a nitrate-specific functionalization with up to 6.5-fold cycle selectivity.

主催：　東京大学大学院工学系研究科専攻間横断型教育プログラム 機械システム・イノベーション（GMSI）
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