



EILON MIARA SEMINAR

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Theory of Nutrients Recovery by Capacitive Deionization

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Nitrogen and phosphorus are valuable nutrients for agriculture, forming the main components of fertilizer. In many wastewaters, nitrogen is present as nitrate and ammonia cation, and phosphorus as phosphate anions. Nutrient recovery is a process in which we extract the nutrients from wastewater and re-utilize them for agriculture. The recovery process can be beneficial in two ways, for water purification by lowering the concentration of nutrients in wastewater, and on the other hand, the desalinated nutrients can be used to enrich water and increase the concentration of nutrients for various needs such as fertilizers. Regarding water purification in water bodies, high concentration of nitrogen and phosphorus can lead to phenomena such eutrophication and algal blooming that cause oxygen depletion in the water and release toxins harmful to aquatic organisms. Both ammonia and phosphate are weak acids or bases, meaning their species' electric charge depends on the local water pH. Therefore, recovery of these species can be challenging without adding chemicals to shift the water pH, which adds cost and complexity to the water purification process.

Capacitive deionization (CDI) is a fast-emerging membraneless technology used for water treatment. CDI cell typically consists of two or more porous electrodes and spacers with feed water flowing through the cell while supplying a constant voltage or current between the electrodes. The porous electrode structure includes larger macropores, used for ion transport, and smaller micropores, where ions are electrosorbed into overlapped electric double layers, resulting in decrease of the effluent concentration. During CDI charging, strong pH gradients are known to develop, and thus CDI can potentially remove pH-dependent species without chemically adjusting the feed pH. Although experimental research has been made, there was no theoretical model describing this process, which is a crucial step towards unlocking the potential of this technology. To that end, we previously developed a mathematical model simulating desalination of water with pH-dependent species using CDI cells. Here, we extended the theoretical framework to analyze the recovery of several groups of pH-dependent species, i.e., ammonia and phosphate, in the presence of functional groups in electrode micropores. Our model predicts that CDI can store effectively both N and P containing species, confirming the promise of CDI towards nutrient recovery from wastewaters. Moreover, we compared our theoretical model with experimental work which performed in our group and explored the influence of operation parameters such as feed pH, charging voltage and superficial flow to optimize the recovery process.

Note: the seminar will be given in English