Electrochemical reduction of nitrogen oxides

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Nitrogen oxides in aqueous solutions as nitrate and nitrite are in gas phase as NO_x (NO, NO_2, N_2O) are notorious as pollutants. Removal of nitrates and nitrites are necessary for water purification for drinking and NO_x removal is necessary, for example, to drive a car with a combustion engine. There are widely used removal technologies of nitrogen oxides with pros and cons. In the light of urged electrification and delocalisation of chemical processes, driving the conversion of nitrogen oxides to a desired harmless (N_2) or useful molecules by electricity is strongly awaited.

In this lecture, first the background on nitrogen oxides electrochemical reduction is described, highlighting the characteristics of and challenges faced by the conversion of the liquid phase or gas phase nitrogen oxides. A particular focus will be given to the state-of-the-art research works towards decontamination (N_2 production) as well as ammonia production as NH_3 is one of the most important chemicals to humans. The latter molecule is of great interest to achieve waste (pollutants)-to-value creation. Recent demonstrations of liquid-phase nitrate and gas-phase NO electrochemical reduction using polymer electrolyte membrane (PEM) electrolyzer technology are discussed in detail. The nitrate hydrogenation can be performed continuously in a PEM cell and high nitrate conversion can be achieved. A combination of photocatalytic process with the PEM electrolysis-based nitrate reduction will be shown as a mean to boost product selectivity [1]. Furthermore, nitrate (liquid) [2] and NO (gas) [3] conversions to NH_3 using a PEM cell, and the effect of reaction conditions and catalyst materials are explained. A recent study of selective surface poisoning by CO to improve the reaction selectivity is described [4].

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[4] M. Li, J. Verkuil, S. Bunea, R. Kortlever, A. Urakawa, **2023**, e202300949.