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Quantification of urea electrolysis products in alkaline medium

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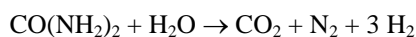
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The treatment of nitrogen compounds of sewage waters in wastewater treatment plants (WWTPs) is very costly in energy and has an impact on the environment with discharges of nitrates into rivers and N₂O (greenhouse gas) in the atmosphere. WWTPs operators are therefore looking for innovative treatment concepts that enhance the value of both mater and energy. Because nitrogen derives mainly from urea, which is contained in large quantities in urine (0.33 mol L⁻¹), an electrochemical remediation of urine can be foreseen to alleviate the problems of its treatment in WWTPs.

The objective of our works is the implementation of an electrochemical system allowing the degradation of urea (pollutant) at the anode and the production of hydrogen (green fuel) at the cathode, according to the overall process:



In recent years, many works have concerned the evaluation of the electrocatalytic properties for urea electro-oxidation by voltammetry using Ni-based catalysts, because of the Ni ability in this matter [1-2]. Two main axes have followed: (i) the nanostructuring of the electrode material to increase the active surface area in various forms (nanowires, nanosheets, nanoribbons, nanoparticles) or (ii) the addition of a co-element to nickel that mainly modifies the oxidation potential of urea. For our part, we have studied from an analytical point of view composites made of Ni-Rh nanoparticles embedded in carbon matrix that combines these two aspects [3].

Concerning the electrolysis process, the studies generally focus on the proportions of N₂ and O₂ produced in the gas phase at the anode and the percentage of H₂ formed at the cathode. However, to the best of our knowledge, none of these works report mass balances performed on the various soluble intermediates arising from secondary reactions that can be obtained, nor their faradic yields.

This led us to proceed with electrolysis to identify and quantify both gaseous and solution species produced. For this purpose, we carried out electrolysis on a simple nickel plate in alkaline solutions as well as in alkalized synthetic urine and quantified the reactions products by different analytical means (Gas chromatography, UV-Vis spectrometry, ionic chromatography).

Our results with simple urea solutions show that at the cathode, H₂ is collected with a yield of 100% (*i. e.* hydrogen is the only reaction). At the anode, nitrites are detected as a by-product with levels depending on the applied potential. This is the first time that this result is reported in the literature. The problem with the obtention of nitrites is that nitrogen is not removed from the solution (as a gaseous product like N₂).

We will also present results obtained with synthetic urine and report on the improvement of N₂ production rates through modification of the (Ni-based) electrode compositions.

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