Electrochemical treatment of phenol in water in the presence of active chlorine

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Active chlorine is generally generated during Electrochemical Advanced Oxidation Processes (EAOPs) used for the treatment of wastewater which contains a large amount of chlorides [1]. In the presence of polluting organics, the production of chlorinated by-products occurs and this could represent one of the worst drawbacks of these processes. In this study, we have evaluated for the first time the development of an EAOP method in a microfluidic electrochemical reactor in the presence of chlorides.
Indeed, a comparative study was carried out to evaluate the performances of a conventional cell in comparison with a microfluidic reactor (using a very small inter-electrode distance of 145 μm), both equipped with a BDD anode and a Ni cathode, for the abatement of phenol 2 mM in the presence of NaCl 0.5 M. The oxidation of phenol was considered and the overall organics concentration was monitored by TOC analyses. Even the potential production of chloroacetic acids, chlorophenols, carboxylic acids, chlorate and perchlorate was carefully evaluated. Particular attention was devoted to monitoring the presence of perchlorate, produced by oxidation of chlorate, highly soluble in water and quite stable, very difficult to be removed [2].
Moreover, the treatment of phenol in the presence of chloride was extended to the chemical oxidation process by addition of sodium hypochlorite solution 10-13% in a batch stirred reactor for a more comprehensive study on the action of the active chlorine, both via chemical and electrochemical oxidation, where, in the latter case, it is generated in situ.
As expected, it was demonstrated that the electrogenerated active-chlorine promoted a more quickly oxidation of phenol and by-products with respect to the chemical process. In addition, it was shown that the use of the microfluidic device, operating under a continuous mode, let to achieve higher current efficiencies and a lower generation of some important by-products such as chlorate and perchlorate. For sake of completeness, the effect of various parameters (namely, flow rate, current density and nature of cathode) was also investigated in the case of electrochemical oxidation [3].

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[1] Feng et al., 2023. Generation, toxicity and reduction of chlorinated byproducts: Overcome bottlenecks of electrochemical advanced oxidation technology to treat high chloride wastewater. Water Research 230, 119531-119542.
[2] Long et al., 2021. Interpretation of high perchlorate generated during electrochemical disinfection in presence of chloride at BDD anodes. Chemosphere 284, 131418-131426.
[3] Randazzo et al., 2024. Oxidation of organics in water by active chlorine performed in microfluidic electrochemical reactors. Chemosphere, under revision.