Chlorination of Phenol Solutions by Chemical and Electrochemical Processes

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More than a century after the introduction of water disinfection process for public health, the toxicity of various disinfection by-products (DBPs) produced during this process continues to be a relevant problem [1]. Indeed, when waters are contaminated by recalcitrant organics, active chlorine species largely used for disinfection purposes, can lead to their removal, but also to the generation of several toxic by-products such as chlorophenols, chloroacetic and carboxylic acids, chlorate and perchlorate.
In this frame, electrochemical water treatments can potentially give an important contribution. Indeed, the removal of organics by electrogenerated active chlorine was reported to be higher with respect to that achieved by addition of hypochlorite [2]. However, the use of powerful electrochemical oxidation methods can lead to a further increase of the concentrations of the generated by-products [2].
Hence, it could be important to compare the performances of chemical and electrochemical chlorination for the treatment of waters polluted by organics from the points of view of their removal and the minimization of chlorinated by-products.
In this work, both the processes were studied and compared in order to assess the more effective operative conditions among those considered.
Specifically, chemical chlorination was performed by testing different concentrations of NaClO from 0.2 to 30 mM. On the other hand, electrochemical chlorination was tested on the abatement of phenol 2 mM, used as a model recalcitrant organic compound, in presence of NaCl 0.5 M. Different electrodes were tested in this case, with specific attention on the role of the cathode which can help in the conversion of some generated toxic by-products. In detail, electrolyses were performed by using BDD or IrO_2/Ta_2O_5 anodes and Ni, Ag, Cu, Sn and carbon felt as cathodes. Even the possibility of using H_2O_2 as scavenger was tested, as it can lead to a decrease of chlorate and perchlorate production [3].
The experiments were monitored by considering the abatement of phenol, the removal of TOC and the concentrations of the generated by-product, i.e. chlorophenols, chloroacetic and carboxylic acids, chlorate, perchlorate and ClO_2. Even the produced active chlorine was monitored during the elctrolyses.
It was highlighted that the electrochemical treatment, if performed under suitable operative conditions, can give both a higher removal of TOC and phenol and a lower production of toxic by-products with respect to chemical chlorination [4]. For example, among the studied electrodes, coupling the IrO_2 based anode with Ag or Cu can lead to achieve quite good TOC removal efficiencies and a lower generation of some important by-products such as chlorate and perchlorate, for the anode, and the chloroacetic acids, for the cathode. Eventually, lower concentrations of chlorate and perchlorate were observed by adding H_2O_2 without strongly affecting the TOC removal.

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