Fixed bed reactors with three dimensional electrodes for electrochemical treatment of waters for disinfection

M. Mascia*, A. Vacca, S. Palmas
Dipartimento di Ingegneria Meccanica, Chimica e dei Materiali, Università degli Studi di Cagliari, Piazza D'Armi, 09123 Cagliari, Italy

HIGHLIGHTS

- We tested a fixed bed electrochemical cell as reactor for water treatment.
- The reactor was experimentally characterised for hydrodynamics and mass transfer.
- We carried out galvanostatic electrolyses of water with low chloride content.
- Experimental profiles of concentrations along the reactor axis were obtained.
- Flow and concentration profiles within the reactor were modelled.

ABSTRACT

A fixed bed electrochemical cell was tested as reactor for treatment of waters by direct electrolysis. The aim was the development of a reactor configuration for effective and controllable primary and secondary disinfection. Stacks of titanium grids coated with Ru/Ir oxides or platinum were used as anodes and cathodes, respectively. The electrode packings were arranged in series, the system worked in continuous mode.

The reactor was characterised for mass transfer (by the limiting current densities technique) and flow behaviour (by pulse-response curves with an inert tracer). Electrolyses were carried out with 100 mg dm$^{-3}$ of chloride ions, and current density ranging from 2.5 to 7.5 mA cm$^{-2}$.

Active chlorine concentrations from 0.3 to 1.2 mmol dm$^{-3}$ were obtained in the reactor outlet, depending on the conditions. The higher value was measured with $i = 7.5$ mA cm$^{-2}$ and flow conditions corresponding to a Reynolds number of 5: under these conditions, about 1 mg dm$^{-3}$ of chlorates were detected, otherwise the selectivity of the process towards active chlorine was about unit.

A mathematical model at steady state was implemented, and pseudo first order kinetics was used to describe chemical and electrochemical reactions. The model allowed obtaining the concentration profiles of chloride and chloride oxidation by-products which were compared with experimental data, with good agreement in a wide range of flow rates. The configuration allowed a well-defined concentration profile: the active chlorine in the outlet was always 50% less than the value inside the reactor, allowing to exploit the process for primary and secondary disinfection.

ARTICLE INFO

Article history:
Received 15 June 2012
Received in revised form 24 September 2012
Accepted 25 September 2012
Available online 2 October 2012

Keywords:
Electrochemical reactors
Active chlorine
Hydrodynamics
Three dimensional electrodes
DSA anodes
Disinfection

1. Introduction

Among the water treatment processes, those addressed to microorganism removal are of great importance: almost all the water users, such as drinking water suppliers, swimming pools or desalination plants, require treatments with disinfection steps [1,2]. An effective disinfection process should ensure removal of harmful microorganism, avoiding generation of organic and inorganic by-products. In a supply water system, for drinking water or reuse of treated wastewater, it is also necessary to provides longer-lasting water treatment as the water moves through pipes to consumers. Two processes are then often requested: the primary disinfection, which kills or inactivates bacteria, viruses, and other potentially harmful organisms, and the secondary or residual disinfection.

For primary disinfection purposes a high concentration of disinfectants is often needed to ensure that the water is free of pathogens. On the other hand in the secondary disinfection low concentration of disinfectants is allowed, particularly for drinking waters, to ensure the quality of the water in the distribution system [2].