SOME ASPECTS REGARDING THE SEPARATION OF ORGANIC AND SUSPENDED MATTERS FROM WATERS BY ELECTROFLOTOCOAGULATION

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Abstract

Electroflotocoagulation is an electrochemical technique, in which a variety of organic and suspended matter can be effectively removed from an aqueous solution by electrolysis. The present paper presents the results obtained by investigation of the electroflotocoagulation technique on simulated water containing different concentrations of humic acids using alumminum anode and steel cathode. At various concentrations of humic acid, different current densities and different pH values of water, the removal efficiency of humic acid is high. Therefore, it was studied the influence of the anions presence: Cl^- and SO_4^{2-}. The good results obtained at low current densities involve low specific energy consumption, this technique being appropriate to a practical application.

Introduction

Electrocoagulation and electroflotocoagulation are important techniques for investigation and application of the electrochemical treatment of natural and wastewaters . The main advantages of electoflotocoagulation versus coagulation are simple equipment and easy operation, no chemicals added and a decreased amount of precipitate and sludge.The use of aluminium as anodes in electrocoagulation (EC) and electroflotocoagulation (EFC) cells requires preliminary studies of aluminium electrode behaviour in the presence of pollutants to be removed. These studies correlate the peculiar behaviour of aluminium [in aqueous solutions to specifics of water treatment in cells with soluble anodes (1-11).

Naturally-occuring organic compounds (humic compounds) are found, having significant concentration in waters. In many cases they act as the major buffering system, which has serious implications for acidification of lakes and rivers. Humic acids are responsible for the yelow-brown coloration of many lakes and water bodies. The halogens can interact with humic substances in drinking water treatment to produce halogenated carninogens such as chloroform and bromoform, which then directly introduced into the public drinking water with obvious health consequences.

This study presents some results obtained for removal of humic acids from simulated waters, by electrocoagulation, accompanied by electroflocculation and electroflotation.

Methods

To realise the experimental determinations, simulated waters containing humic acid (100 mg/L) were used. It was used humic acid sodium salt (technical grade product) made by ACROS ORGANICS New Jersey, USA. The removal of pollutants by electrocoagulation and separation was carried out in

the cell type, schematised in Fig.1, at galvanostatic condition. For experimental set-up a cell with horizontal electrode was used.

The quantitative determination of humic acids was made by using a Jasco V530 spectrophotometer, PC controlled, at wavelength λ=280 nm (8).

Figure 1. Schematic diagram of horizontal electrode cell 1 - anode, aluminium; 2 cathode, a grid of stainless steel wires, Φ 3 mm; 3 - enclosure; A - ampermeter; V - voltmeter; S - power source. Electrode gap: 5 mm. Batches of 500 mL solution were run into the cell.
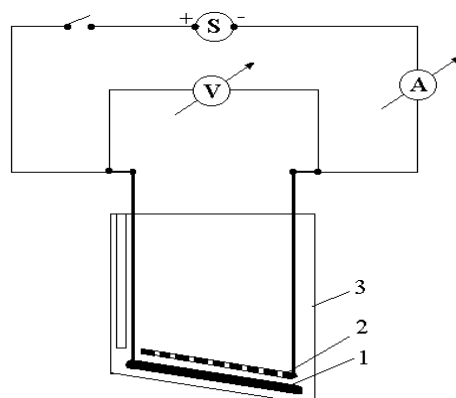
Results

Table 1 presents working condition and the assessment of process control parameters(humic acids removal, electrical energy consumption). The used quantity of electricity (used charge) is expressed as Ah/L for batches of 500 mL. The efficiencies of pollutant removal presented in Table 1 ranged between 91.6-95.9%.

Table 1. Evolution of the treatment in EFC cell ; humic acid 102.4 mg/L, NaCl 2mM, pH_i 7, i 100 A/m^2, T 22°C

Q/V (Ah/L)	U (V)	pH_f	C_f (humic acid) (mg/L)	Removal Efficiency (%)	W_{sp} (kWh/m^3)
0.05	8	7.5	8.5	91.6	0.4
0.1	8	7.7	4.5	95.6	0.8
0.15	8.2	7.7	6.5	93.6	1.23
0.2	8.2	8	4.2	95.9	1.64
0.25	8.2	8.3	4.9	95.2	2.05

Q - quantity of electricity; U - cell voltage; i - current density; W_{sp} - Specific Electric Energy Consumption; C_f – final concentration of humic acid after treatment; V - volume

The quantitative assessment of humic acid removal and electric energy consumption for some experimental conditions are presented in figures 2- 5.

The effects of Cl^-, SO_4^{2-} anions addition on the removal efficiencies and electrical energy consumption are presented in figure 2. Figures 3 and 4 give the results of experiments performed at initial pH=5, in the presence of Cl^- and Cl^-, SO_4^{2-} for the various current densities. The next results refer to the influence of initial pH values on the treatment process (figure 5).

Figure 2. Evolution of process control parameters versus electricity quantity at the anions addition-initial pH=5, i=100 A/m^2; humic acid concentration = 104.5 mg/L
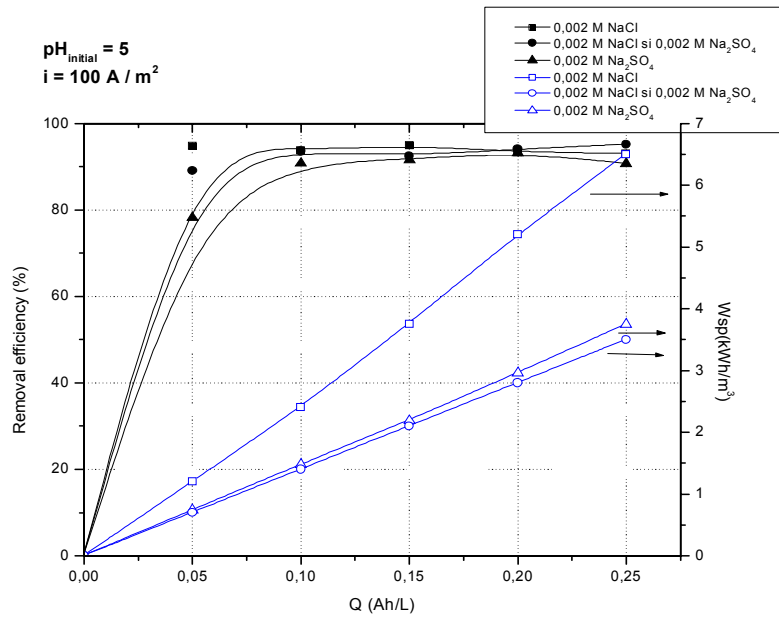

Figure 3. Influence of the current densities on the treatment process in the presence of Cl$^-$ anion - initial pH=5; humic acid concentration = 104.5 mg/L; 0.002 M NaCl
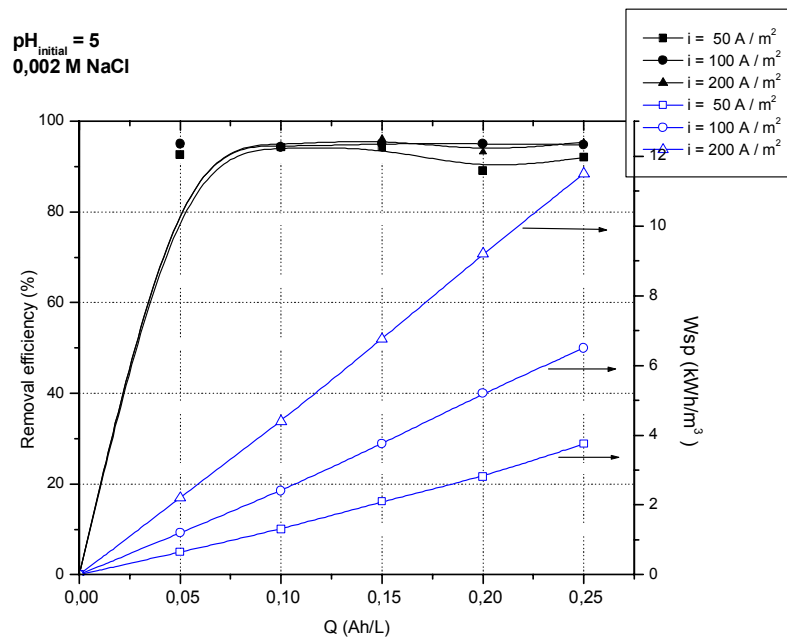
Figure 4. Influence of the current densities on the treatment process in the presence of Cl^- and SO_4^{2-} anions -initial pH=5; humic acid concentration = 104.5 mg/L; 0.002 M NaCl; 0.002 M SO_4^{2-}
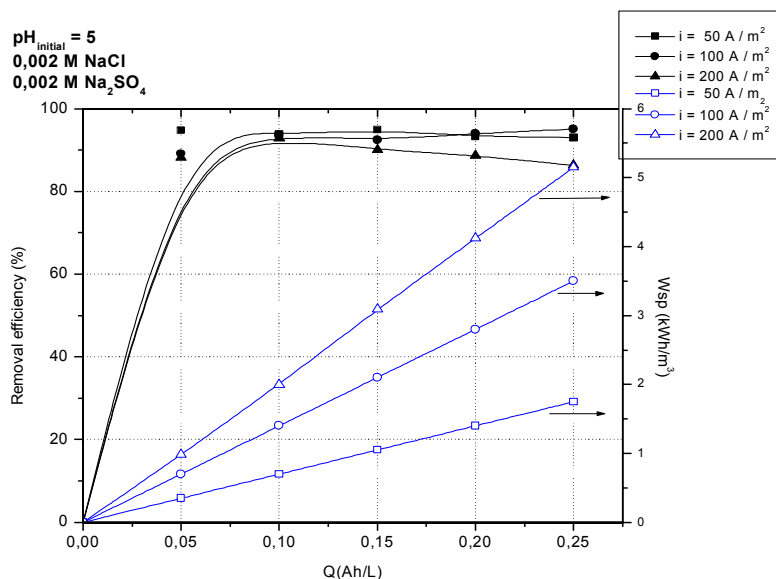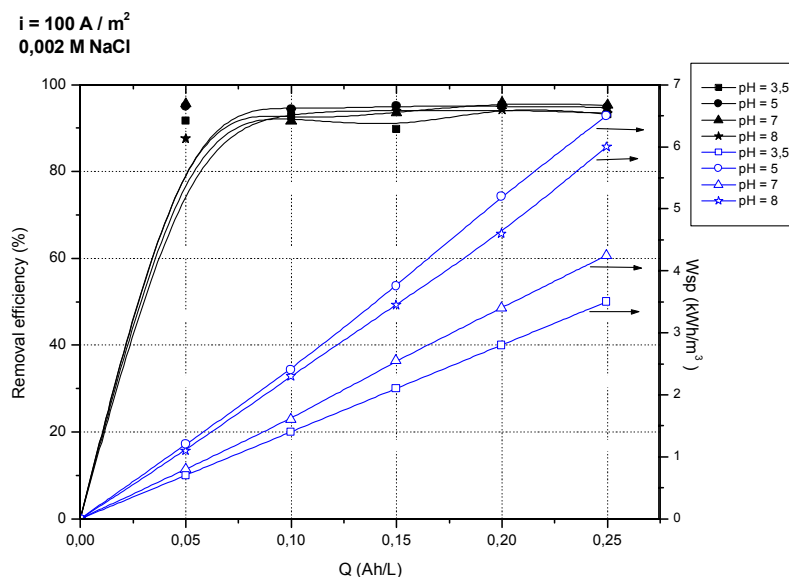

Figure 5. Evolution of the process control parameters at various initial pH values in the presence of Cl^- anion - humic acid concentration = 104.5 mg/L; 0.002 M NaCl; i=100 A/m^2

Discussion

Polarization curves presented in a previous paper (10), plotted in potentiostatic and galvanostatic conditions allowed defining the aluminum behaviour in the presence of SO_4^{2-} and Cl^- and the involvement of humic acid (anion) in the electrode processes that occurred on aluminum. Humic acid activated or inhibited the main anodic and cathodic electrode process partially by adsorption on electrode and involvement in surface film formation. Furthermore, galvanostatic polarisation curves offered a preliminary evaluation of the possibilities of application of galvanostatic-electrocoagulation treatment and cell voltage for polluted natural water.

The reactions can be described by active dissolution of anode (aluminium), chatodic hydrogen evolution, a pH increase and aluminium hydroxicomplexes species formation.. These precipitates adsorbed pollutants contributing to coagulation - flocculation processes. Finally, the pollutants are removed by flotation with cathodically generated hydrogen microbules.

In all cases, e.g for current densities of 100 A/m^2 (table 1), increase of pH and voltages versus time are observed. The pH and voltage values are differentiated as function of initial pH. Effects of NaCl, Na$_2$SO$_4$ additions (usually found in naturally waters) are presented in figure 2. It can be noticed the active (for NaCl) and inhibited (for Na$_2$SO$_4$) dissolution of aluminium anode, revealed in removal efficiencies of humic acids. Under these conditions, the electrofloto-coagulation process can be applied on natural waters, involving a very high practical applicability from point of view of both efficiency and specific electric energy consumption.

Figures 3, 4 show the influence of current densities on the treatment process in the presence of NaCl (figure 3) and NaCl, Na$_2$SO$_4$ (figure 4). Practically, it does not exist the difference between the removal efficiencies at the three current densities. Since electrical energy consumption is higher with increasing of current density, the use of high current density is not justify.

To verify the process flexibility, because of necessity of the water treatment having different pHs, the process has been carried out at various pH. The results are presented in figure 5, showing that the treatment efficiencies are same at all pH values; for this pH range it is not necessary to correct the water pH. From point of view of specific electrical energy consumption, after a certain electrolysis time, the application of the process at pH 8 is slight unfavourable versus pH.

Because the high removal efficiencies is reached for low quantity of electricity (0.05 Ah/L) and the increase of cell voltage is equivalent to extra specific energy consumption, it is important the correlation of electrolyte addition, type of anions (anodic activator or inhibitor), duration of electrolysis (current density and quantity of electricity).

Conclusion

Removal of humic acid by electrocoagulation has been possible in various situations. The application of electrocoagulation process in the conditions of anions presence on removal of humic acid has been given good results,the removal efficiency is ranged between 79-98%. The initial pH had a low influence on the simulated water treatment by electroflotocoagulation. To operate the cell in the optimum condition it is important the correlation of electrolyte addition, type of anions (anodic activator or inhibitor), duration of electrolysis (current density and quantity of electricity).

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