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# Sulfite assisted rotating disc electrocoagulation on cadmium removal: parameter optimization and response surface methodology

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## Abstract:

Redox conditions is an extraordinary parameter as it controlled the generation of functional products in iron–electrocoagulation process. In the present study, a newly designed rotating disc electrocoagulation system (RDEC) on cadmium removal from wastewater assisted by sodium sulfite is investigated. The oxidation and reduction environment are adjusted and controlled with rotate speed and sodium sulfite, respectively. In the first stage, single effect factors such as initial pH ( $pH_i$ ), current density ( $j$ ), electrode distance ( $d$ ), rotate speed ( $n$ ),  $Na_2SO_3$  dosage ( $C_S$ ), and initial  $Cd^{2+}$  concentration ( $C_0$ ) in RDEC process are evaluated using iron disc as sacrificial electrodes. Results indicate that initial pH, current density, and  $Na_2SO_3$  dosage have a positive influence on  $Cd^{2+}$  removal, whereas rotate speed and electrode distance exhibit an opposite affect. The increase of  $Cd^{2+}$  removal efficiency at low rotate speed or high  $Na_2SO_3$  dosage might be attributed to the generation of Fe(II)–Fe(III) layered double hydroxides (LDHs), which is identified to be an vital intermediate in on the removal of cadmium because of an oxygen–free solution environment is maintained. Finally, Response Surface Methodology (RSM) is carried out to investigate the interactional influences between current density, rotate speed, and  $Na_2SO_3$  dosage and the optimal parameters based on the result of single factor experiments. The actual removal efficiency of  $Cd^{2+}$  and energy consumption ( $EEC$ ) are respectively calculated as 98.11% and 2.98 kWh/m<sup>3</sup> at the optimum operating conditions:  $C_0$  25 mg/L,  $pH_i$  7,  $j$  10.85 mA/cm<sup>2</sup>,  $C_{Cl}$  1000 mg/L,  $C_S$  114.5 mg/L,  $d$  20 mm, and  $n$  44.16 rpm.

**Keywords:** Electrocoagulation; Disc electrodes; Sodium sulfite; Cadmium; Response surface methodology.

## 1. Introduction

The discharge of toxic metals from industrial production has attracted increasing public attention due to their high biotoxicity, carcinogenicity, refractory and mobility[1]. Cadmium, one of the most harmful toxic heavy metals possessed high solubility could easily accumulate in living body via the respiratory tract and mouth[2]. It is serious harm to our smell, liver, kidney and skeleton even in trace amounts. Based on these facts and serious impacts, a very strict guidance that the highest concentration of  $Cd^{2+}$  in drinking water must be limited to 0.003 mg/L have been put forward by WHO (2011)[3]. Thus, seeking a practical and economical technique for the treatment of wastewater containing  $Cd^{2+}$  before being directly or indirectly discharged to ecosystem has attracted environmentalists' attention.

Recently, various kinds of techniques, such as chemical coagulation[4], adsorption[5], ion exchange[6], reverse osmosis[7] and membrane filtration (NF and UF)[8] are widely employed in the treatment of heavy metals wastewater. Among these methods, chemical coagulation tends to cause a large quantity of sludge and secondary pollution though it characteristics of a mature processing and relatively low investment[9]. On the contrary, physical processes usually required high cost, complex equipments, sophisticated systems, and strict management. In recent years, iron electrocoagulation method (Fe–EC) is considered to be an alternative technology to treat wastewater containing  $Cd^{2+}$  as reported by many researchers and our previous works [10,11]. Compared to chemical coagulation, this method dose not require any chemicals and the cost of electrocoagulation process is relatively low. As we know that the cost of EC is mainly consists of electric energy consumption ( $EEC$ ) and electrode material consumption ( $EMC$ ) according to Eqs. (1) and (2). The basic mechanism of EC is presented in Eqs. (1) to (6):  $Fe^{2+}$  ion dissolved directly from sacrificial iron anode could spontaneously hydrolyzed into monomeric and polymeric  $Fe^{2+}/Fe^{3+}$  hydroxides, which has a high adsorption capacity on heavy metals, and eventually

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