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Comparison between Electrocoagulation, Electrochemical Fenton and Fenton processes for the treatment of dyes

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Abstract

The textile industry is a major water consumer, and also a major generator of polluted wastewaters; despite these effluents contain surfactants, finishing agents, salts, chlorine compounds, etc., dyes represents the main pollutants, in particular due to their resilience to conventional wastewater treatments [1]. Electrocoagulation with an iron anode, alone (EC) and combined with H₂O₂ (ECF), and the Fenton reaction, were studied as alternative treatments for the removal of two dyes, methylene blue (MB) and reactive black 5 (RB5), from aqueous solution. The effect of pH, [H₂O₂]₀ and [Fe(II)] on the degradation rate (*r*) was analyzed, and both the electrical energy consumed (*EEC*) and the amount of final wastes generated (*ENC*, kg of Fe per kg of dye removed) were calculated.

The experimental conditions were: [AM]₀ = 5 or 50 mg L⁻¹, [NS]₀ = 50 mg L⁻¹, 0.18 m M ≤ [H₂O₂] ≤ 3.5 m M, pH₀ 3 or 6, κ = 3.5 mS cm⁻¹. In EC and ECF, the effect of *I* (0.01 – 0.05 A) was analyzed, while for Fenton, the effect of [Fe(II)]₀ was studied (0.8 μM ≤ [Fe(II)] ≤ 250 μM, with [H₂O₂]₀ = 3.5 mM).

At pH 6 with EC, MB removal is completed after 15 min at *I* = 0.01 A and after 7 min at *I* = 0.05 A, while for RB5, complete removal was obtained after 16 min at *I* = 0.05 A, with an induction period of 6 min; for both dyes, partial redissolution was observed after 24 hs. Complete and irreversible MB removal was obtained with ECF after 4 min at *I* = 0.01 A. Under optimal EC conditions, *EEC* values of 12 kWh kg⁻¹ (MB) and 13 kWh kg⁻¹ (RB5), and *ENC* values of 2.2 kg kg⁻¹ (MB) and 1.1 kg kg⁻¹ (RB5) were obtained, better values than others reported in the literature. With ECF of MB at pH 6, *EEC* and *ENC* decreased to 1.4 kWh kg⁻¹ (MB) and 0.28 kg kg⁻¹, respectively.

At pH 3, the degradation of MB by ECF at *I* = 0.01 A is completed in 2 min, being *r* independent of [H₂O₂]₀; with Fenton *r* is 30 times lower than ECF under similar conditions, with a linear dependence with [Fe(II)]₀. RB5 degradation at pH 3 by both ECF and Fenton showed *r* values lower than those obtained for MB, with a strong dependence on [H₂O₂]₀ in the case of ECF, and a linear relation with [Fe(II)]₀ for Fenton. An insoluble organic compound was detected after MB degradation by ECF and Fenton; Raman and FTIR analysis indicated that the structure was very similar to MB and/or toluidine blue. Optimal values of 0.066 kWh kg⁻¹ and 0.17 kg kg⁻¹ were obtained for *EEC* and *ENC*, respectively, after the ECF treatment of both MB and RB5; these values are lower than other reported in the literature for electrochemical AOPs used in the treatment of MB and RB5. For Fenton, an *ENC* of 0.11 kg kg⁻¹ was calculated.

ECF proved to be the most efficient treatments for both MB and RB5, being faster at pH 3 than at pH 6 and with *EEC* and *ENC* values lower than other reported in the literature. RB5 is more resilient than MB, but MB generates a solid waste after ECF and Fenton treatment.

References

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