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Numerical and experimental study for the design of electrocoagulation reactor for dye removal

Claudia Luiza Manfredi Gasparovic[a,*], Eduardo Eyng[a], Laercio Mantovani Frare[a], Fábio Orssatto[a], Marcelo Risso Errera[b]

[a]*Graduate Program in Environmental Technologies, Federal University of Technology, Parana, Brasil Avenue, 85804-000, Medianeira, Parana, Brazil, emails: claudiagasparovicea@gmail.com (C.L.M. Gasparovic), eduardoeyng@utfpr.edu.br (E. Eyng), laercio@utfpr.edu.br (L.M. Frare), orssatto@utfpr.edu.br (F. Orssatto)*
[b]*Department of Environmental Engineering, Federal University of Parana, Av. Francisco H. dos Santos, Centro Politécnico, 81531-980, Curitiba, Parana, Brazil, email: errera@ufpr.br*

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ABSTRACT

Water resources are increasingly scarcer and more expensive to collect, treat and distribute. Advanced industrial wastewater treatment methods, such as electrocoagulation (EC), have become more viable. However, the design of EC reactors is very complex and costly since it varies significantly with wastewater composition. In order to ease the efforts in design, this paper proposes a novel procedure for the simulation of EC systems, which couples computational fluid dynamics (CFD) with a kinetic model for pollutant removal. A CFD model was calibrated with an experimentally fitted kinetic model for Reactive Blue dye 5G removal from synthetic solution to predict the residual concentration profile in a lab-scale continuous flow reactor. Simulations were carried out with a current density of 8.65 $mA\cdot cm^{-2}$, initial dye concentrations of 25 and 40 $mg\cdot L^{-1}$, and flow rates of 0.5–2 $L\cdot min^{-1}$. Results were compared to experimental data from a 23-point sampling mesh of the reactor. The model successfully predicted the reactor concentration profile for a range of low flow velocities (from 0.5 to 1 $L\cdot min^{-1}$), presenting a relative error of less than 2% for a dye removal of 87%–98% at the reactor exit. This paper shows that coupling a kinetic model for pollutant removal based on experimental observation with CFD offers reliable information for EC reactor design with a good compromise between time and resources. The use of computational tools with the proposed methodology can aid in designing EC reactors, thus helping to solve a major obstacle to expanding this promising technology.

Keywords: Electroflocculation; Electrocoagulation; Computational fluid dynamics; Kinetics; Dye removal; Textile wastewater treatment

* Corresponding author.