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Enhancement of Reactive Red 198 dye photo catalytic degradation using physical mixtures of ZnO-graphene nanocomposite and TiO_2 nanoparticles: an optimized study by response surface methodology

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ABSTRACT

The photo catalytic activity of ZnO-graphene (ZnO-G) nanocomposite and TiO_2 nanoparticles physical mixtures for the enhanced degradation of reactive red dye 198 (RR198) under UVC light was evaluated and established. The photo catalytic results revealed that the RR198 was degraded at around 34.4% and 37.7% after 180 min of irradiation, respectively, in the presence of ZnO-G nanocomposite and TiO_2 nanoparticles, solely. Interestingly, physical mixtures of both catalysts induced an enhanced catalytic activity comparing to the bare ones. The ideal mixing ratio was found to be 66:34 wt% (ZnO-G:TiO_2) with 71.8% degradation performance after 180 min of irradiation. Moreover, the response surface methodology using the best mixture was employed to optimize and determine the interaction effects between three independent operational parameters which are photo catalyst dosage (0.4 – 0.025 mg), initial pH (3–11), and initial dye concentration (5 – 15 mg/L). Based on the results obtained, it was found that a maximum predicted degradation efficiency of RR 198 reached 99% was in agreement with the average of three experimental values (96%) under the following optimal conditions: 0.4 g mixture dose, initial pH of 3.8, and 5 mg/L initial dye concentration. This convergence between the predicted and experimental results indicates the validity of the model for predicting the maximum percentage degradation of RR198 under the above-mentioned optimum conditions. The ANOVA result indicated that the model is significant with the *P* value of 8.683×10^{-10} is less than 0.0001, which implies that the model terms are highly significant. Regression analysis with an R^2 value of 0.986 indicated a satisfactory correlation between the experimental data and predicted values. Additionally, non-toxic metabolites with respect to *Daphnia Magna* and high total organic carbon reduction after treatment with the mixture evidenced that this process can significantly decrease toxicity and mineralize the dye. Finally, the universal degradation ability of the photo catalysts mixture was evaluated and proven towards many model substrates.

Keywords: ZnO-graphene; TiO_2; Physical mixture; Photo catalytic degradation; Response surface methodology; Reactive red 198

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