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Letter to the Editor

Synthesis of Zero-Valent Iron Nanoparticles for Ultrasonic Assisted Dye Removal: Modeling and Optimization

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Dear Editor-in-Chief

The existence of dyes has been led to carcinogenesis and mutagenesis as well as discoloring water resources by penetrating into the surface and underground water. It has been led to reducing light penetration in water and being a serious threat to marine life. Accordingly, it is necessary to purify the colored wastewater before discharging them into the environment and essentially needed to remove these contaminants from the environment (1). "Different methods have been presented to remove the dyes from the wastewater; including coagulation and flocculation, chemical oxidation, membrane filtration, electrochemical filtration, ion exchange, advanced oxidation, enzyme catalysis, adsorption, degradation of electrochemical and use of photocatalysts" (2). Among these techniques, adsorption has been taken into consideration due to its beneficial features such as insensitivity to toxic compounds, low initial cost, flexibility and feasibility, convenient operation, the potential to remove compounds that produce odour and the organic and inorganic compounds like dyes (2). In recent years, zero-valent iron has been used as a regenerating factor. During recent years, iron nanoparticles have been used as an important factor to reduce pollutants due to the frequency, the reduction in toxicity and the reduction to the costs. Traditional optimization methods have been considered as a variable at a time, which are used to monitor the influence of operational parameters. It is a costly and time-consuming method. So, nowadays, optimization of the influential parameters is accomplished by multivariate statistical techniques. Response Surface Methodology (RSM) is a robust statistical technique for evaluating the effects of different individual factors at different levels, and has been successfully applied to optimize the pollutants removal (3). The main advantages of the response surface methodology were introduced to reduce the number of the tests, saving energy, time and materials to be used. The results (actual response) are processed by a polynomial model near the optimal response and the model is used to predict the response.

Thus, as mentioned before, due to the high efficiency of this process, the research is mainly aimed to optimize the process of the removal of

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Reactive Red 120 using zero-valent iron nanoparticles from aqueous solutions.

In this study, four independent factors were investigated; including the amount of pH (3-11), the amount of catalyst (0.1-0.9 g), ultrasound time (20- 100 s) and dye concentration (5-25 mg L^{-1}) and each factor was coded at five levels. The removal of Reactive Red 120 was studied on the laboratory scale at the closed circumstances. The experiments were performed by adding zero-valent iron nanoparticles to the dye solution (250 ml). An ultrasonic device equipped with timer and temperature controller was used for the ultrasound-assisted procedure. The remaining dye concentrations in solution were measured using the maximum peak of the absorbance of UV-Visible spectrophotometer at 530 nm. All the adsorption experiments were repeated three times and their mean values were used in calculations as the final results.

As conclusion, increase in catalyst mass led to an improved removal percentage, and increase in concentration led to reduction in removal percentage. This is because there are no more sites for the dye removal due to an increase in concentration and stability of the catalyst; thus, the removal percentage will be naturally lowered. On the other hand, the more the catalyst mass, the more desirable result would be obtained due to the increase in sites. Increasing the interaction time results in an increase in removal percentage, since the catalyst has sufficient time for removal on its own level (4).

The interaction of two effective parameters (i.e. ultrasound time and dye concentration) in dye removal has been investigated. It was observed that dye percentage has reasonably been increased during the interaction and a reduction in dye concentration and the more the time of interaction at the same concentration, the more the removal percentage. The removal percentage was higher for a weakly acidic pH and high catalyst mass. This is because zero-valent iron catalyst level has positively charged in acidic pH and since Reactive Red 120 is an anionic dye, it can absorb the dye toward the catalyst. While the removal percentage was significantly decreased in alkaline pH and the reason is that there is repulsion between the catalyst and Reactive Red 120 because both catalyst and Reactive Red 120 are negatively charged (5).

Dye concentration (20 mg L^{-1}), catalyst dosage (0.4 g), ultrasound time (80 s) and pH (5) were the optimal conditions, which led to highest dye removal (91.48%). According to the obtained results, short reaction time and high removal efficiency are the main advantages of zero-valent iron nanoparticles, which can be proposed as a viable option for the removal of Reactive Red 120 from the aquatic environments.

Conflict of interest

The authors declare that there is no conflict of interest.

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