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Opinion

Optimizing the Annealing Effect of Zn/Ac Nanoparticle Synthesis on Dye Wastewater Treatment by Combination of Ultrasonic and Photocatalytic Methods

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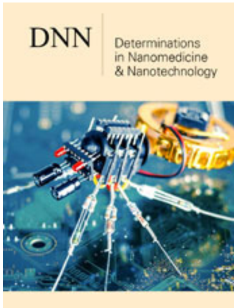

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Opinion

Many different environmental researches were done on the treatment of water, wastewater and air pollutants by different biological, physical and chemical processes. Pollution of water sources by dye pollutants from various industries such as textile, paper, rubber and plastic industries is a major environmental problem. Organic dyes cause irreparable damage to the environment due to the avoiding the light entry to water, disruption of photosynthesis, reduction of oxygen transfer to water, occurrence of eutrophication, interference with the ecology of the receiving waters, toxic effects as well as unpleasant appearance [1-18]. Different methods are used for the treatment of dye wastewater [19-25].

One of the new methods in dye wastewater treatment is oxidation using cavitation and ultrasound as well as sono-electrochemical methods. In fact, the photocatalytic oxidation process by visible or UV light in the presence of catalysts such as titanium dioxide or zinc oxides one of the advanced oxidation processes in the removal of organic pollutants, that is more efficient than other processes [26]. Also, using the ultrasonic and acoustic wave motion in the aquatic environment oscillates the molecules, which creates contractile and expansion cycles [27,28], breaking the bonds and thus accelerating the purification process.

In this study, the combination of photocatalytic and ultrasonic methods in the treatment of dye wastewater was investigated. The studied catalyst is zinc oxide which is highly resistant to light and chemical corrosion. Also, it was applied for oxidizing the wide range of organic compounds due to its non-toxicity, insolubility, ability to decompose toxic organic compounds, ability to absorb a wide range of electromagnetic waves and the photocatalytic capability for radiation.

We used the response surface methodology, the best multivariate techniques [29]. For this purpose, Visible Light Source (W), Ultrasonic Power (W), Dye Concentration (mg/L), pH, Synthesis Temperature (C), nano-particle concentration (gr/L) as variable and percentage of dye removal as the answer were considered.

In this study, a cubic reactor with dimensions of 30 * 30 * 20cm Figure 1, incandescent lamps and ultrasonic device with the power 0 to 400w and 20KHz driving frequency were used. $Zn(CH_3COO)\ 2.2H_2O$ and Poly Vinyl Pyrrolidone (PVP) manufactured by Merck were used for this synthesis. The catalyst synthesis was performed at various temperatures (300, 325, 284.33, 350 and 365.66 °C). The synthesized nanoparticles had almost similar colors and were close to dark gray. Finally, the optimum temperature was determined after photocatalytic tests were performed on each of these nanoparticles in the presence of ultrasound and visible light. In this study, the model was presented based on response surface methodology tests using Design Expert 10 software and Quadratic model to evaluate the nonlinear behavior of the results. The target contaminant is methylene blue dye with the chemical formula of $C_{16}H_{18}N_3SCl$ and molecular weight of 319.85gr/mol made by Merck, Germany. It is a cationic dye that has a pH=3 at 20 °C and is one of the aromatic chemical dyes. For this reason, it is carcinogenic, mutagenic, often toxic and resistant to biodegradation. According to the results, the simultaneous effect of the variables on the dye removal percentage was investigated presented in Figure 2.

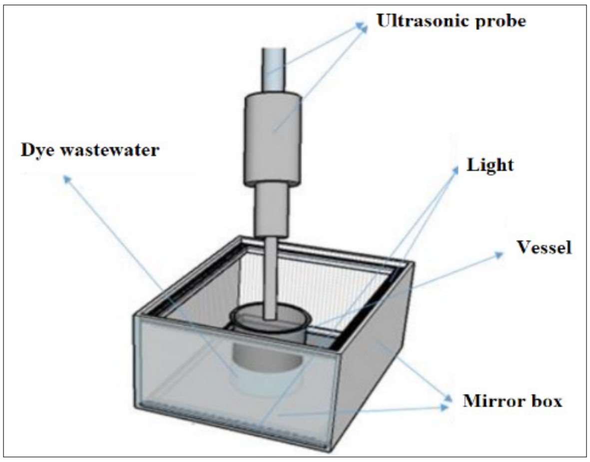

Figure 1: The schematic of used reactor.

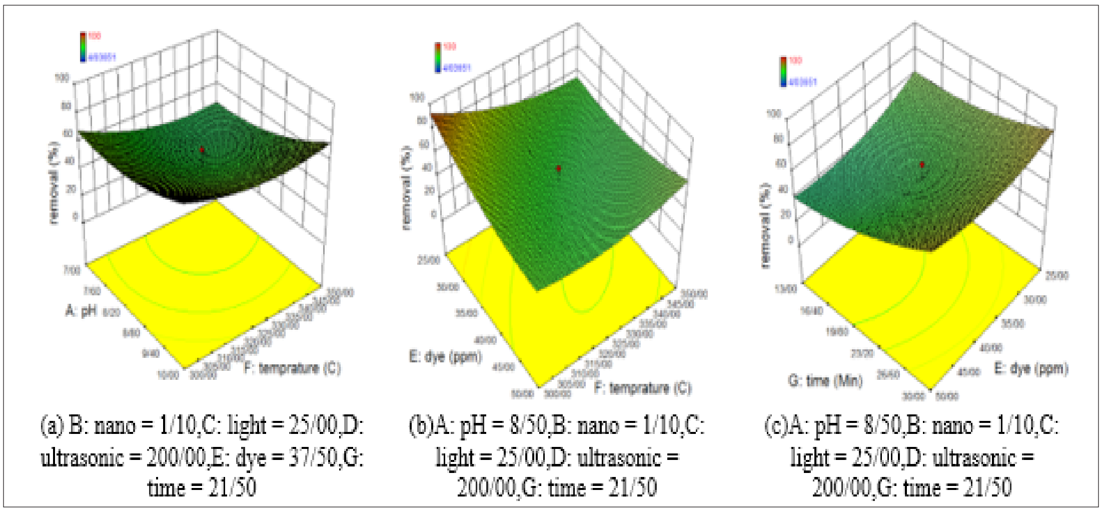

Figure 2: Simultaneous effect of variables on removal percentage.

As can be seen, the higher synthesis temperature caused the lower removal rate; The better synthesis temperature for the ZnO nanoparticles is 300 °C. The above nanoparticles also perform better at the alkaline pH (about 10) and the removal rate increases Figure 2(a). According to Figure 2(b), as the dye concentration decreases, the removal percentage also increases. By increasing the synthesis temperature, the removing ability of the nanoparticles and consequently the dye removal percentage decreased. So, the optimum synthesis temperature and contaminant concentration is 300 °C and 25ppm. On the other hand, it observed a better removal percentage in 30 minutes because the nano-particle bonds broke under irradiation and ultrasound waves and produced more negative hydroxyl. So, higher removal rates could be observed at higher times. As shown in Figure 2(c), the optimum time and dye concentrations 30 minutes 25ppm. Also, the interaction graphs showed the antagonistic effect of pH on temperature and temperature on dye concentration. But time has a synergistic effect on the color concentration pollutant removal percentage.

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