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Degradation of azo dye Acid Red 14 (AR14) from aqueous solution using H_2O_2/nZVI and $S_2O_8^{2-}$/nZVI processes in the presence of UV irradiation

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Abstract

Azo dyes are mostly toxic and carcinogenic and cause harm to humans and the environment. This study was conducted to investigate the degradation of azo dye acid red 14 (AR14) from aqueous solution using hydrogen peroxide (H_2O_2)/nano zerovalent iron (nZVI) and persulfate ($S_2O_8^{2-}$)/nZVI processes in the presence of ultraviolet (UV) irradiation. This experimental study was carried out in a laboratory-scale batch photoreactor with a useful volume of 1 L. The nZVI was synthesized by the sodium borohydride ($NaBH_4$) reduction method. In these processes, the effects of parameters including initial pH, H_2O_2 concentration, $S_2O_8^{2-}$ concentration, nZVI dose, concentration of AR14 dye, and reaction time were studied. The results showed that decolorization increased by increasing the nZVI dosage, H_2O_2 and $S_2O_4^{2-}$ concentrations, and reaction time, or decreasing dye concentration and pH. However, a too high oxidant concentration (H_2O_2 and $S_2O_4^{2-}$) could inhibit the degradation. The experimental conditions for degradation of AR14 by UV/$S_2O_8^{2-}$/nZVI and UV/H_2O_2/nZVI processes were as follows: [H_2O_2] = 10 mM, [$S_2O_8^{2-}$] = 8 mM, AB14 dye = 100 mg/L, pH = 3, and nZVI dose = 0.05 g. Under these conditions, the highest removal efficiencies of AR14, chemical oxygen demand (COD), and total organic carbon (TOC) for the UV/$S_2O_8^{2-}$/nZVI process were 93.94%, 86.5%, and 81.6%, respectively, while these values were 89.3%, 79.57%, and 72.9% for the UV/H_2O_2/nZVI, respectively. Also, the average oxidation state (AOS) was decreased from 2.93 to 2.14 in the effluent of the UV/$S_2O_8^{2-}$/nZVI process and from 2.93 to 2.2 for the UV/H_2O_2/nZVI process. The results showed that the ratio of biochemical oxygen demand (BOD_5) to COD in the effluents of the UV/$S_2O_8^{2}$/nZVI and UV/H_2O_2/nZVI processes after 90 min was 0.63 and 0.74, respectively. These findings suggest biodegradability improvement.

Practitioner points

- Photocatalytic degradation of azo dye Acid Red 14 (AR14) was achieved using H_2O_2/nZVI and $S_2O_8^{2-}$/nZVI processes in the presence of UV irradiation.
- Effects of operating parameters on photocatalytic degradation AR14 dye were evaluated in the UV/H_2O_2/nZVI and UV/$S_2O_8^{2-}$/nZVI processes.
- Biodegradability and mineralization studies of AR14 dye photocatalytic degradation were performed for the UV/H_2O_2/nZVI and UV/$S_2O_8^{2-}$/nZVI processes.

Key words

acid red 14 dye degradation; hydrogen peroxide; nano zerovalent iron (nZVI); persulfate