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Enhanced Photocatalytic Reduction of Cr(VI) in Aqueous Solution by UV/TiO_2 process in the Presence of Fe(III): Performance, Kinetic, and Mechanisms

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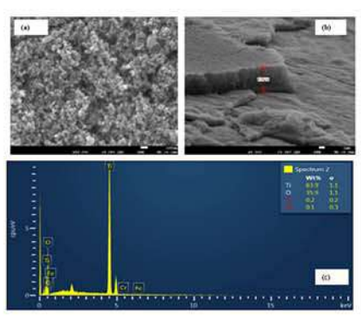
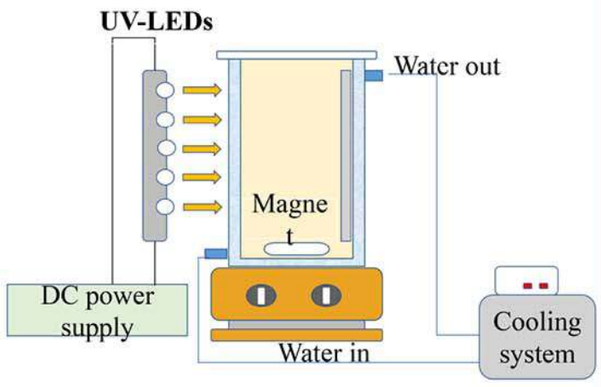
Highlights

- Fe(III) ions can enhance the photocatalytic reduction efficiency of Cr(VI) by 34% using TiO_2 film under UV illumination
- The photoreduction of Cr(VI) was highly dependent solution pH and occurred quickly in the acidic solution.
- Photogenerated Fe(II) and photogenerated electrons were identified as reactive reducing species.
- First report of dual-site kinetic model and proposed mechanism for the Cr(VI) photoreduction in aqueous solution by UV/TiO_2/Fe(III) process

Experimental





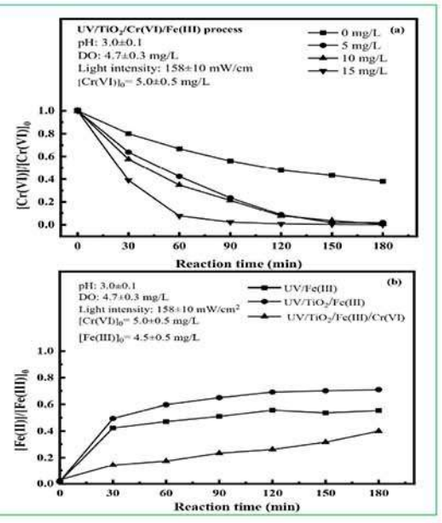
[Cr(VI)] = [Fe(III)]= 5 mg/L, pH 3, I = 158 mW/cm^2 , reaction time 180 min

Effect of Fe(III) ions

- Fe(III) presence significantly enhanced the photoreduction of Cr(VI) due to Fe(II) production for the chemical reduction of Cr(VI)

$$Fe(III) + H_2O + h\nu \rightarrow Fe(II) + HO\cdot + H^+$$

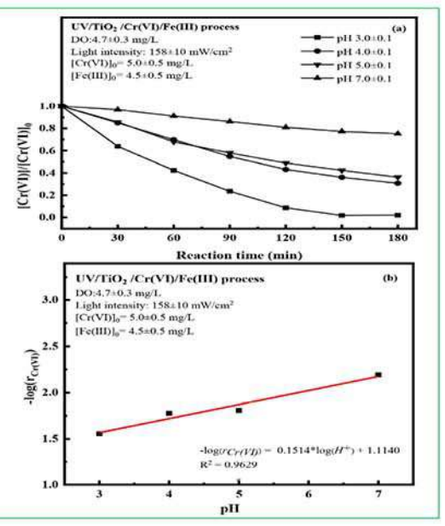
$$3Fe(II) + Cr(VI) \rightarrow 3Fe(III) + Cr(III)$$



Effect of solution pH

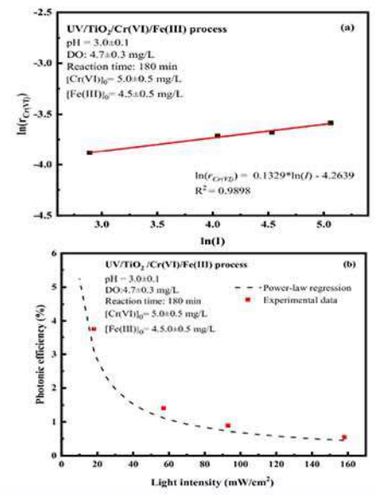
- Cr(VI) reduction experiments were conducted at acidic solution (pH 3) to avoid the lack of electrostatic attraction between Cr(VI) species and the surface charge or the precipitation Fe(III)/Cr(III) on the TiO_2 surface.
- The dependence of Cr(VI) photoreduction rate on solution pH by a power function:

$$\log(r_{Cr(VI)}) = 0.15\log([H^+]) - 1.11$$

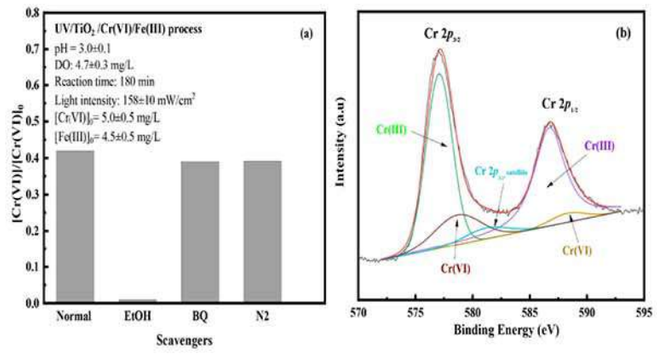


Effect of Light Intensity

- The removal of Cr(VI) was increased with the increase of UV light intensity (I) and a linear relationship between (I) and $r_{(Cr(VI)}$ with the reaction order against UV irradiance, n = 0.13
- The decreased photonic efficiency could be explained by the limitation of active sites on TiO_2, which reduces the UV light adsorption on the TiO_2 surface.



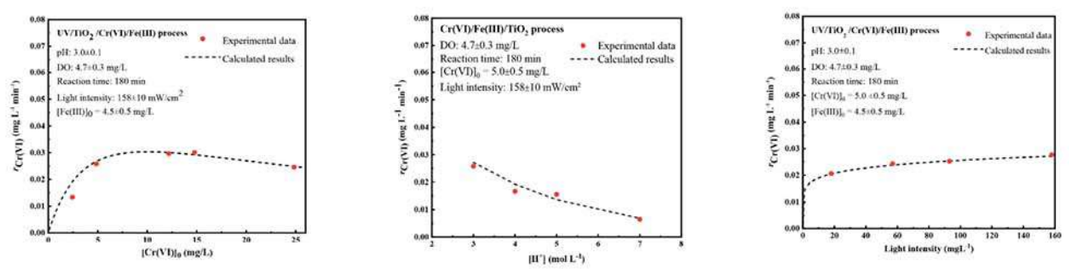
Kinetic Study and Mechanism



- Trapping experiment results indicated that photogenerated electrons was responsible for reducing Cr(VI) by TiO_2 under UV irradiation in the presence of Fe(III).
- No competitive influent between Fe(III) and Cr(VI) on TiO_2 surface

➢ Kinetic Models (Dual site Langmuir-Hinshelwood model)

$$r_A = \frac{k_a I^{0.13} (C_{H^+})^{0.15} C_{Cr(VI)}}{\left(1 + K_1 C_{Cr(VI)}\right)^2}$$



***This study was published**

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