$CoFe_2O_4/TiO_2$-Nb_2O_5 Magnetic Photocatalysts Applied to Chromium Reduction

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Introduction

Cr(VI) is a highly toxic and carcinogenic form of chromium. The reduction of Cr(VI) to Cr(III) is an exciting strategy for water treatment [1,2]. The possibility of reducing Cr(VI) to Cr(III) by photocatalysis using TiO2 has already been considerably studied over the years [1,3–5]. The development of magnetic photocatalysts has expanded the application possibilities of the process, given the ease of magnetic separation [6].

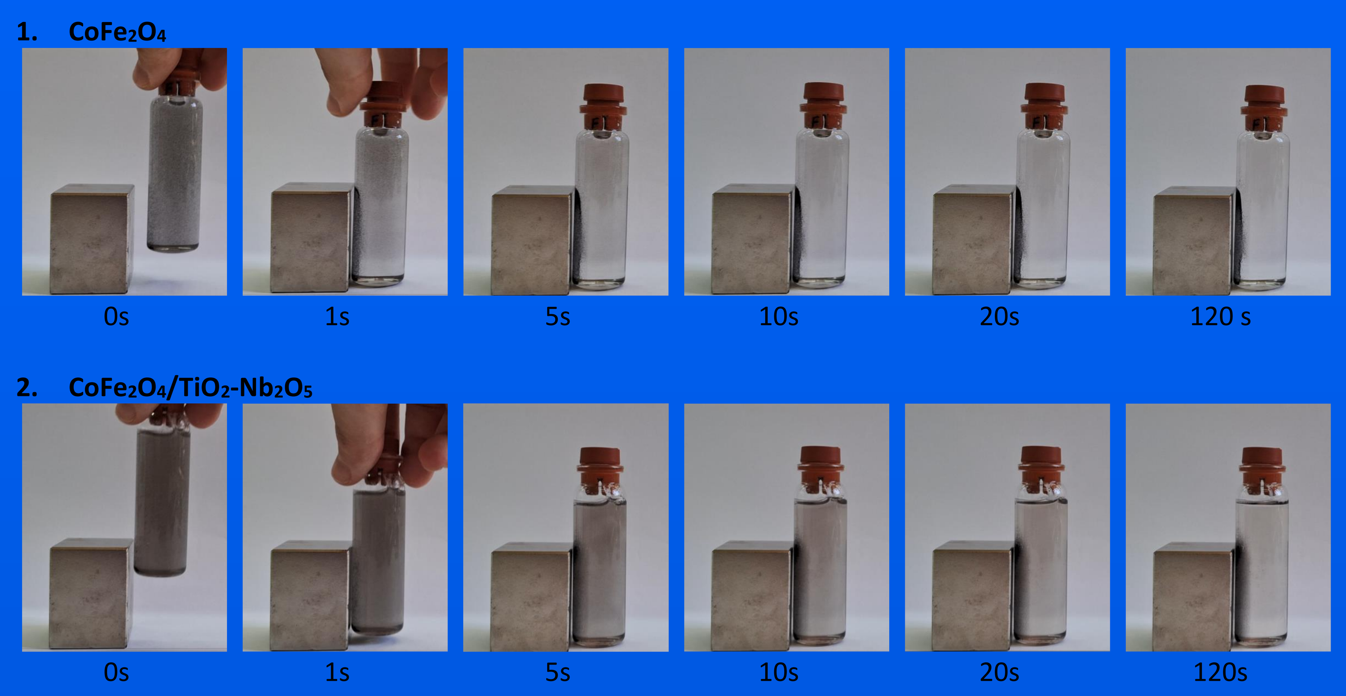

Figure: Magnetic separation of photocatalysts

In this context, the present work proposes the use of a $CoFe_2O_4/TiO_2$-Nb_2O_5 magnetic photocatalyst to improve the chromium photocatalytic reduction process. The study encompasses both its application in a synthetic effluent and in a real tannery effluent, considering the effect of factors such as $CoFe_2O_4$ and TiO_2-Nb_2O_5 combination method, pH, the addition of hole scavenger, the proportion between $CoFe_2O_4$ and TiO_2-Nb_2O_5 and catalyst concentration

Results & Discussion

The results presented in Figure 2 indicated that the best conditions for Cr(VI) reduction are pH 2 and sodium formate as a hole scavenger. This condition was chosen to be applied to the following tests

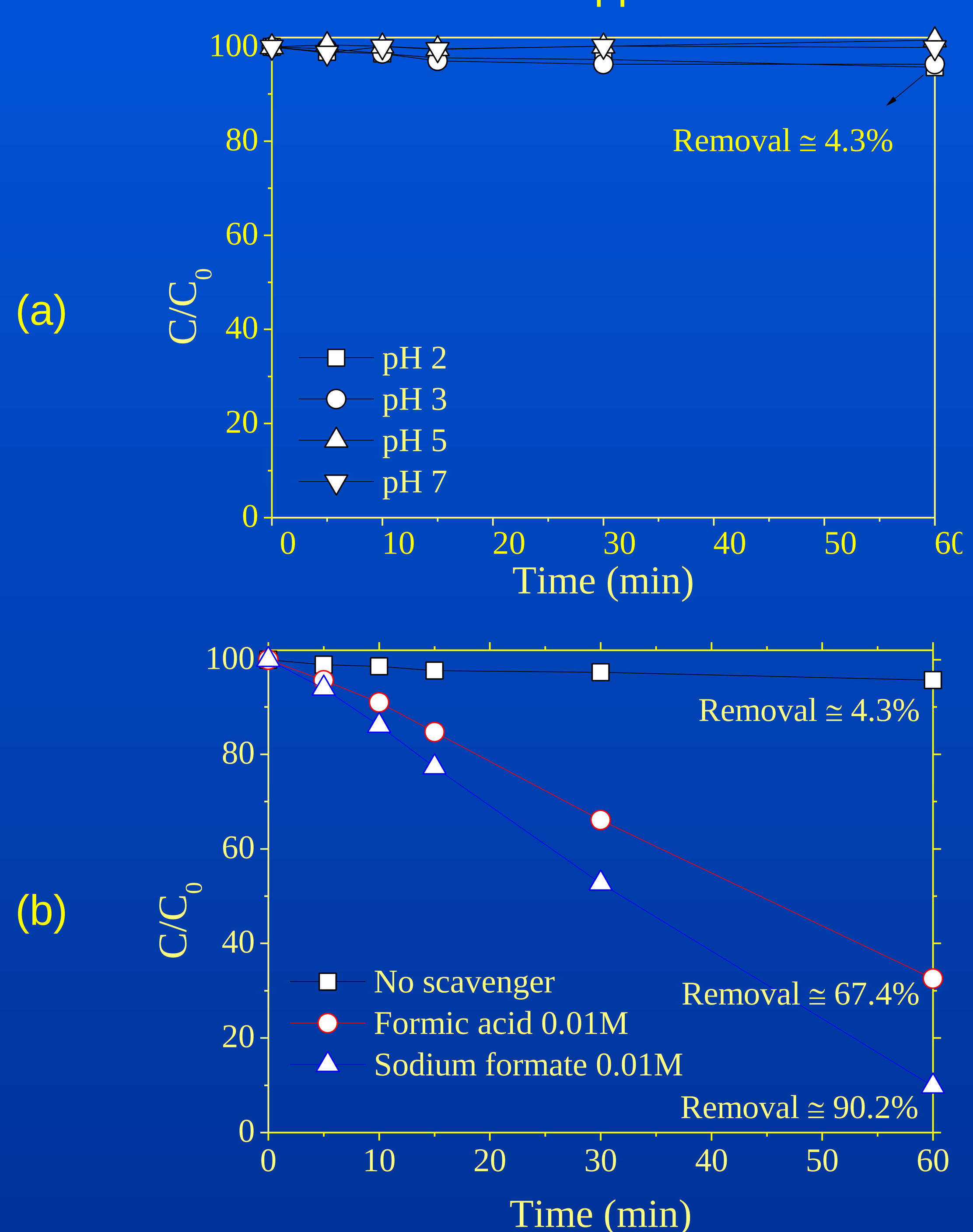

Figure 2: Photocatalytic reduction of Cr(VI) using $CoFe_2O_4/TiO_2$-Nb_2O_5 photocatalyst (chem., sol-gel) (a) at different pH with no hole scavenger and (b) with and without the use of hole scavengers at pH 2. $[Cr(VI)]_0$ = 20 $mg.L^{-1}$, photocatalyst concentration = 0.5 $g.L^{-1}$.

Another important factor to evaluate was the way in which the magnetic catalyst was prepared, comparing the mixture of $CoFe_2O_4$ and TiO_2/Nb_2O_5 by chemical mixture (sol-gel synthesis) or physical mixture (mortar and pestle). The results are presented in Figure 3

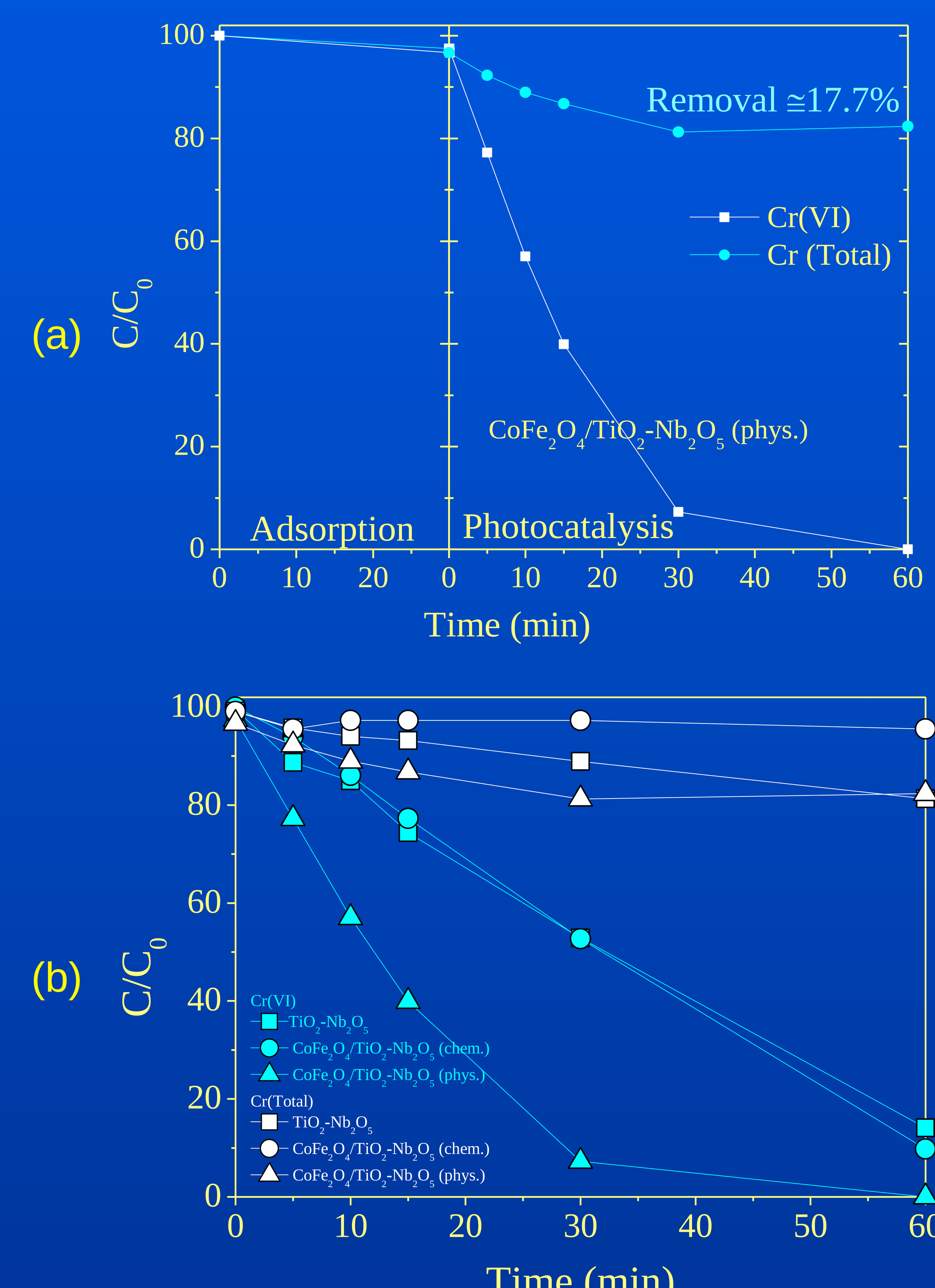

Figure 3: Photocatalytic reduction of Cr(VI) (black) and total Cr (red) using (a) $CoFe_2O_4/TiO_2$-Nb_2O_5 magnetic photocatalyst obtained through physical mixture. In (b) a performance comparison between $CoFe_2O_4/TiO_2$-Nb_2O_5 (phys.), $CoFe_2O_4/TiO_2$-Nb_2O_5 (chem.) and TiO_2-Nb_2O_5 photocatalysts are presented. $[Cr(VI)]_0$ = 20 $mg.L^{-1}$, photocatalyst concentration = 0.5 $g.L^{-1}$, pH = 2, [sodium formate] = 0.01 M.

The results showed the good performance of the photocatalyst obtained by physical mixing, , compared to the chemical mixture of the components, in reducing chromium, both in hexavalent and total chromium forms.

Conclusions

The present work presented the viable application of a magnetic photocatalyst to chromium removal. The magnetic catalyst obtained by physically mixing the oxides proved to be quite active in reducing Cr(VI), the most toxic form of chromium, and reasonably active in removing total chromium.

References

1. Wang, L. et al. J Hazard Mater 152, 93–99, (2008), doi:10.1016/j.jhazmat.2007.06.063.
2. Cappelletti, G. et al. Appl Catal B 78, 193–201, (2008), doi:10.1016/j.apcatb.2007.09.022.
3. Acharya, R. et al. Cr(VI) Remediation from Aqueous Environment through Modified-TiO2-Mediated Photocatalytic Reduction. Beilstein Journal of Nanotechnology (2018), 9, 1448–1470.
4. Litter, M.I. Curr Opin Green Sustain Chem (2017), 6, 150–158.
5. Islam, J.B. et al. ChemEngineering 3, 1–10, (2019), doi:10.3390/chemengineering3020033.
6. Sin, J.C. et al. Environ Res 212, (2022), doi:10.1016/j.envres.2022.113394.

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