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Comparison of the "Fenton" and "Photo-Fenton" processes for the degradation of orange acid molecules 10

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Abstract

Introduction: Synthetic organic dyes are compounds that cannot be biologically degraded. This persistence is closely related to their chemical reactivity. If an organism has no specific mechanisms either to prevent resorption of a substance, or to eliminate it once it has been absorbed, then the substance accumulates.

Methodology: The present study is limited to monitoring the decolorization of aqueous solutions of orange acid 10 molecules as a function of time. More specifically, it aims to compare the performance of the "Fenton" process and the "photo-Fenton" process with regard to the degradation of orange acid 10 molecules. The "Fenton" and "photo-Fenton" processes are based on the attack of synthetic organic dyes by oxidizing, non-selective radical entities known as "hydroxyl radicals". These radicals can be generated by "Fenton" reagents (iron cations Fe^{2+} /hydrogen peroxide molecules H_2O_2), which have been extensively studied to remove organic matter from drinking water, explosives waste, industrial and agricultural waste, and polluted soil.

Results: The results of our experiments lead us to conclude that the "photo-Fenton" process increases, albeit slightly, the degradation of orange acid 10 molecules compared to the "Fenton" process, irrespective of whether the medium is acidic, neutral or basic.

Conclusion: These results are one way of overcoming the problems posed by synthetic organic dyes.

Keywords: Orange acid 10 molecules, function of azot, the process of fenton, process of photo-fenton

Introduction

Synthetic organic dyes are used in many industrial sectors (automotive, paper chemicals, textiles, etc.). They are characterized by strong colorations, high variations in hydrogen potential, abbreviated pH, high chemical oxygen demand, abbreviated COD, and increased bio-toxicity towards bacteria. Discharge of these colorants poses two major problems: The aesthetic problem, the public health problem, etc. (Bauer *et al.*, 2001) ^[1].

From an aesthetic point of view, synthetic organic dyes give different colors to the water in which they are discharged. Studies have shown that, when these pollutants are not directly implicated, it is their metabolites that induce diseases such as cancer, so that the pollution problem is displaced rather than eliminated (Weber *et al.*, 1993 ^[39]). The direct discharge of synthetic organic dyes into the natural environment is a major source of pollution, which can lead to eutrophication, the disruption of aquatic life and the accumulation of toxic substances resulting from their chemical or biochemical transformation (Rafols *et al.*, 1997 and Walber and Weatherley (2001) ^[33, 38]). Solving water pollution problems currently involves a multidisciplinary approach in which water quality depends on the demands of agriculture, urban planning, leisure activities, processing industries, population growth, etc. and Nigam *et al.*, 2001) ^[31]. Increasingly stringent regulations have been gradually introduced. These force the various players involved in pollution to significantly reduce the concentrations of pollutants discharged, either by adopting techniques to clean up urban and industrial wastewater before discharging it into the natural environment, or by implementing

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clean technologies. In terms of pollution control techniques, conventional water purification systems - most of which involve biological treatment, flocculation, filtration, etc. - are proving ineffective in totally degrading certain wastewater pollutants. Research has therefore been undertaken to develop new and improved methods for treating polluted water, and to gain a better understanding of the short- and long-term effects of this water on humans, animals and ecosystems (Pagga and Taeger, 1994; Meshko *et al.*, 2001; Galindo *et al.*, 2001 and Barka, 2008) [32, 29, 16, 8].

The most encouraging results have been obtained with advanced oxidation processes. POA for short. These combine ultraviolet light and/or a catalyst (ferrous cations or titanium dioxide molecules) with strong oxidants such as hydrogen peroxide molecules (H_2O_2) to produce "in situ" radical species with very high oxidation potentials, notably hydroxyl radicals (HO). These oxidize a wide range of organic pollutants rapidly and non-selectively. Whether using homogeneous catalysis, as in the case of the coupling of hydrogen peroxide molecules with ultraviolet light, the "Fenton" process or the "photo-Fenton" process, or heterogeneous catalysis, as in the case of titanium dioxide particles suspended in a solution under ultraviolet light, all these processes have demonstrated their ability to degrade a wide range of organic compounds. All also have the advantage of destroying pollutants without transferring them to another phase (Arslan *et al.*, 1999) [4]. Balanosky *et al.*, 1999 [6] and Kesraoui, 2008 [25].

The present study is limited to monitoring the decolorization of aqueous solutions of orange acid 10 molecules as a function of time. More specifically, it aims to compare the performance of the "Fenton" process and the "photo - fenton" process with regard to the degradation of orange acid 10 molecules.

Materials and Methods

Materials

In this study, we used the orange acid 10 molecule as reagent.

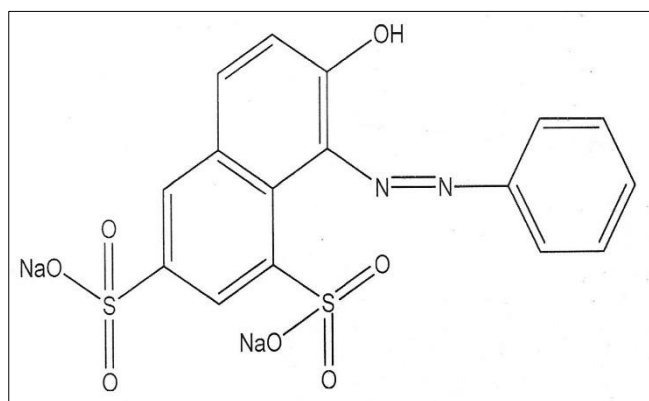


Fig 1: Chemical structure of the orange acid 10 molecule

With its IUPAC name "sodium hydroxy-7 phenylazo-8 naphthalene disulfonate - 1,3", the orange acid 10 molecule has the molecular formula $C_{16}H_{10}N_2S_2O_7Na_2$.

Methods

Fenton process

We proceeded as follows: weigh out 1 g of orange acid 10 molecules; then place in the 1-liter volumetric flask, add distilled water and stir to homogenize; bring the volume up to the mark using the distilled water molecules, then stir to homogenize the solution (a solution of 1000 ppm orange acid 10 molecules is obtained); dilute this solution to 10 ppm orange acid 10 molecules; take 15 mL of this solution and add a given mass of ferrous sulfate molecules and a given volume of hydrogen peroxide solution, and shake the solution obtained; and finally, at desired time intervals, take a few milliliters of the solution until complete decolorization, while measuring the absorbances of the samples taken.

Photo-fenton process

The steps followed for these experiments are as described for the "Fenton" process, with the difference that the reactions were carried out under ultraviolet light at 254 nm.

Analysis of illuminated and non-illuminated solutions

Ultraviolet-visible spectrophotometry was used to study the degradation of orange acid 10 molecules according to the "Fenton" and "photo-Fenton" processes. The principle of this spectroscopy can be summed up by the fact that light rays change the electrons of molecular entities from a low-energy E1 state to a high-energy E2 state.

Results and Discussion

Table 1: Absorbances of orange acid 10 molecules (10 ppm) at pH 2.7 using the "Fenton" process, with concentrations of hydrogen peroxide and ferrous cation molecules of $10 \cdot 10^{-2}$ mol.l-1 and $2 \cdot 10^{-3}$ mol.l-1 respectively, or using the "photon-Fenton" process, with concentrations of hydrogen peroxide and ferrous cation molecules of $10 \cdot 10^{-2}$ mol.l-1 and $2 \cdot 10^{-3}$ mol.l-1 respectively. 1-1 or according to the "photon-Fenton" process, with concentrations of hydrogen peroxide and ferrous cation molecules of $10 \cdot 10^{-2}$ mol.l-1 and $2 \cdot 10^{-3}$ mol.l-1 respectively under time-dependent 254 nm ultraviolet photons

Times (min)	Optical densities	
	Fenton process	Photo-Fenton process
0	0,300	0,300
2	0,020	0,013
4	0,018	0,013
6	0,018	0,012
8	0,019	0,009
10	0,015	0,010
12	0,015	0,009
14	0,014	0,008
16	0,013	0,004
18	0,010	0,002
20	0,009	0,002

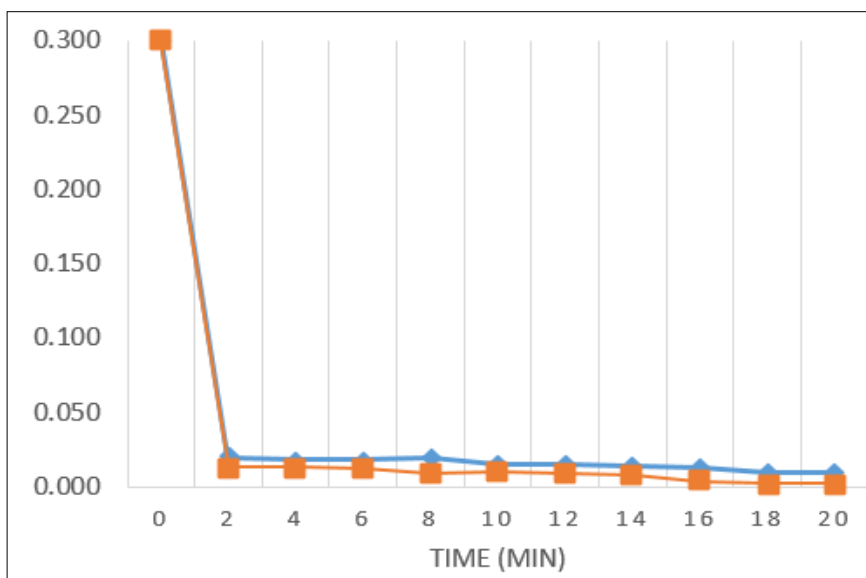


Fig 1: Oxidation evolution of acid orange 10 molecules (10 ppm) at pH 2.7 using the "Fenton" process (10^{-2} mol.l⁻¹ in hydrogen peroxide molecules and 2.10^{-3} mol.l⁻¹ in ferrous cations), or the "photo-fenton" process (10^{-2} mol.l⁻¹ in ferrous cations) under ultraviolet light at 254 nm

These curves show the evolution of absorbance as a function of time. The results show that the fonton effect is very active in the degradation of the orange 10 molecule.

Table 5: Absorbances of orange acid 10 molecules (10 ppm) at pH 2.7 using the "fenton" process, with concentrations of hydrogen peroxide and ferrous cation molecules of 2.10^{-2} mol.l⁻¹ and 2.10^{-2} mol.l⁻¹, or the "photo-fenton" process, with concentrations of hydrogen peroxide and ferrous cation molecules of 2.10^{-2} mol.l⁻¹ and 2.10^{-3} mol.l⁻¹ respectively under ultraviolet photons of 254 nm as a function of time

Time (min)	Optical densities	
	Fenton process	Photo-Fenton process
0	0,300	0,300
2	0,089	0,079
4	0,085	0,075
6	0,084	0,074
8	0,084	0,074
10	0,083	0,073
12	0,083	0,073
14	0,082	0,072
16	0,082	0,072
18	0,080	0,071
20	0,082	0,071

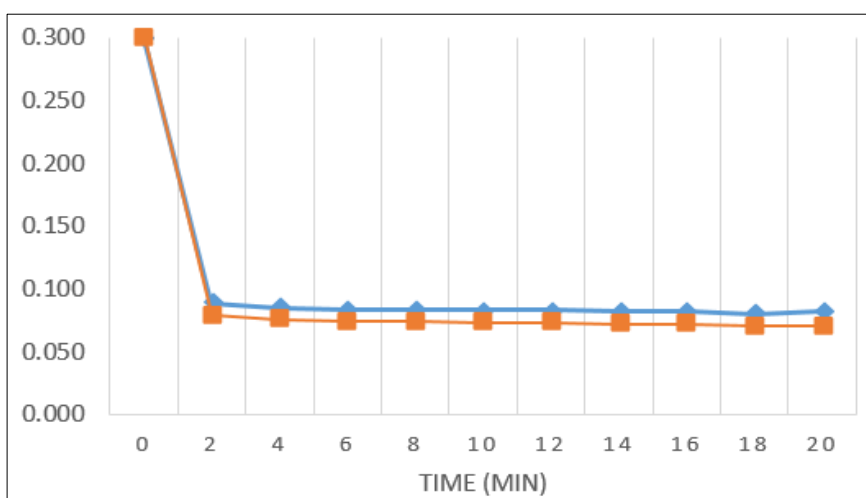


Fig 5: Oxidation evolution of orange acid 10 molecules (10 ppm) at pH 2.7 using the "Fenton" process (2.10^{-2} mol.l⁻¹ in hydrogen peroxide molecules and 2.10^{-3} mol.l⁻¹ in ferrous cations), or the "photo-Fenton" process (2.10^{-2} mol.l⁻¹ in hydrogen peroxide molecules and 2.10^{-3} mol.l⁻¹ in ferrous cations) under ultraviolet photons of 254 nm

All these data show that the "photo-Fenton" process increases, albeit slightly, the degradation of orange acid 10 molecules compared with the "Fenton" process, depending on the nature of the reaction medium (acidic, neutral or basic).

Conclusion

The aim of this study was to compare the performance of the "Fenton" process and the "Photo-Fenton" process with regard to the degradation of orange acid 10 molecules at acidic, neutral or basic pH. Discussion of the experimental results leads to the following conclusions:

That orange acid 10 molecules degrade best at very low pH; that the degradation under examination takes place substantially when not only the concentration of hydrogen peroxide molecules, but also that of ferrous cations is reduced; and, that, whatever the pH, the "photo-Fenton" process takes precedence over the "Fenton" process.

Nevertheless, this study needs to be continued to determine the favorable pH and optimum concentrations for the photo-degradation under consideration.

Conflicts of interest

The authors declare that there are no conflicts of interest.

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