Homogeneous photocatalytic degradation of Papanicolaou's solution 3b by

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Problem definition and objectives

Biological stains are widely used in biomedical research laboratories and also for diagnostic purposes. Although the volume of the stain solutions used in these kind of laboratories is relatively small, the high concentration of dyes in them and the presence of harmful additives, results in the formation of wastewater of high toxicity, low light transparency and high organic carbon content. Moreover, some of these stains are known to be carcinogenic and toxic to the reproductive and nervous systems.

Numerous methods have been utilized to remove dyes from polluted waters. Although some conventional techniques can efficiently remove them from wastewater, these methods have limitations such as expensive raw materials and equipment, secondary pollution, and large quantities of sludge. The application of alternative, non-biological methods of wastewater treatment, such as advanced oxidation processes (AOPs), has demonstrated highly encouraging results in the field of decomposing biological stains. Most effective AOPs for the inactivation of biological stains in water or wastewater are based on homogeneous photocatalytic oxidation (i.e. photo-Fenton). Photo-Fenton is an attractive oxidative system, which produces in a very simple way $HO^{\bullet}$ radicals. On the other hand, AOPs employing sulfate radicals (SR-AOPs), as alternative to the traditional hydroxyl radical based AOPs, have attracted great interest on wastewater applications recently.

In the present work homogeneous photocatalysis of Papanicolaou's solution 3b activated by UV-A, has been studied. Papanicolaou's solution 3b is a mixture of three dyes, Eosin Y, Light green SF and Bismarck brown, dissolved in organic solvents. It is used for cytological cancer and cycle diagnosis and is toxic in nature with suspected carcinogenic and genotoxic effects. The effects of initial concentration of Pap's solution 3b, H_2O_2 and Fe^{3+} on mineralization rates were evaluated in a bench-scale Pyrex reactor for the photo-Fenton/UV-A process. Additionally, an SR-AOP was evaluated in terms of Papanicolaou's solution mineralization. Sulfate radicals were generated by utilizing sodium persulfate in the presence of UV-A and Fe^{3+} .

Strategy and methods

Experiments were performed in a closed Pyrex cell of 500 ml capacity. The reaction vessel was fitted with a central 9 W lamp and had inlet and outlet ports for bubbling CO_2 free air during the photocatalytic process. The spectral response of the UV-A irradiation source ranged between 350-400 (max: 366 nm), while that of the visible irradiation source ranged between 400-520 nm (max: 450 nm). Experiments were conducted under constant magnetic stirring. The reaction temperature was kept constant at 25^{o}C.

Acknowledgements

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Results

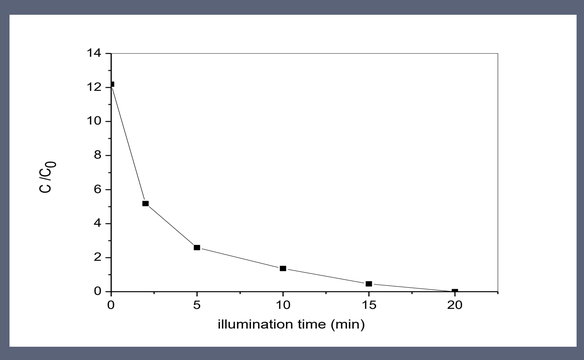

Figure 1: Homogeneous photocatalytic degradation of Papanicolaou stain vs. illumination time for the system H_2O_2/Fe^{3+}/UV-A. $[H_2O_2]$=4000 mg L^{-1}; $[Fe^{3+}]$=14 mg L^{-1}; [Pap.stain]=10 mgL^{-1} ; pH_0 =3.2.

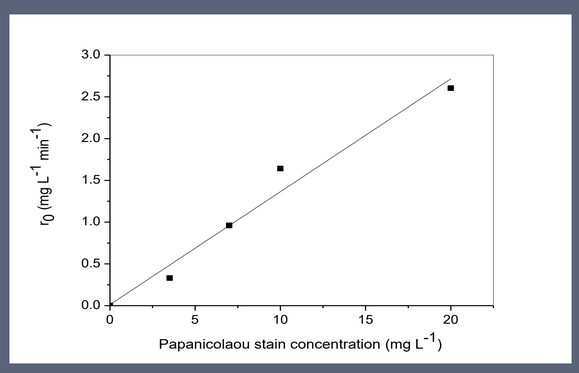

Figure 2: Effect of Papanicolaou stain concentration on initial mineralization rate during photo-Fenton/UV-A oxidation. $[H_2O_2]$=2000 mg L^{-1}; $[Fe^{3+}]$=14 mg L^{-1}; pH_0 =3.2.

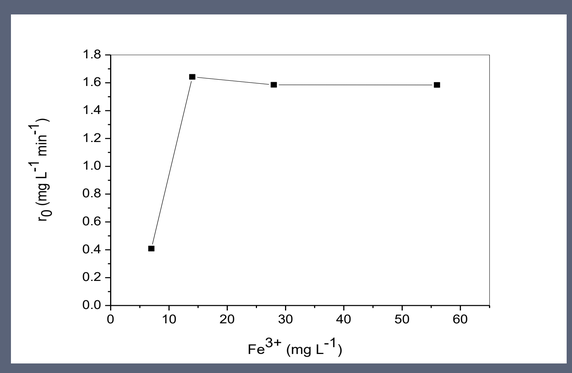

Figure 3: Effect of Fe^{3+} concentration on initial mineralization rate during photo-Fenton/UV-A oxidation. $[H_2O_2]$=2000 mg L^{-1}; [Pap.stain]=10 mgL^{-1} ; pH_0 =3.2.

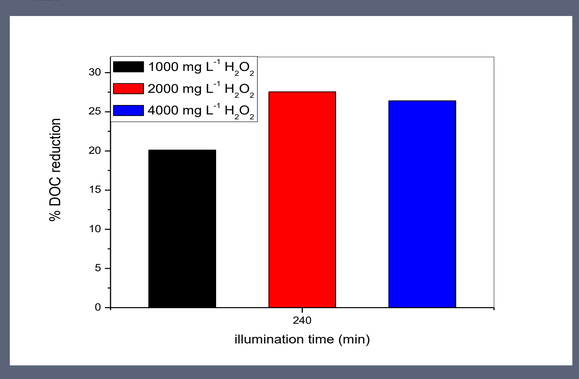

Figure 4: Effect of H_2O_2 concentration on % DOC reduction of 10 mgL^{-1} Pap. stain during photo-Fenton/UV-A oxidation and after 240 min of illumination: $[Fe^{3+}]$=14 mg L^{-1}; pH_0 =3.2.; $[DOC_0]$= 1400 mg L^{-1}

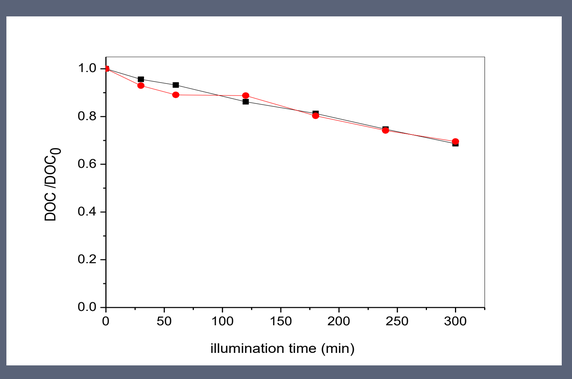

Figure 5: Photocatalytic mineralization of 10 mgL^{-1} Pap. stain vs. illumination time for the systems: H_2O_2/Fe^{3+}/UV-A (■); Persulfate anion/Fe^{3+}/UV-A (●); $[H_2O_2]$, [PS]=59 mmole; $[Fe^{3+}]$=28 mg L^{-1}; pH_0 =3.2.

Conclusions

- **Degradation and decolorization of Papanicolaou stain during H_2O_2/Fe^{3+}/UV-A process is completed within 20 minutes of illumination**
- **The initial mineralization rate increases nearly linearly with Papanicolaou stain's concentration, which is characteristic of first order kinetics.**
- **An increase of Fe^{3+} concentration up to 14 mg L^{-1} leads to an increase of the mineralization rate. Increasing the concentration from 14 to 56 mg L^{-1} has no effect on the rate.**
- **H_2O_2 concentration has only a slight effect on % DOC reduction of Papanicolaou stain.**
- **H_2O_2/Fe^{3+}/UV-A and persulfate anion/Fe^{3+}/UV-A processes showed almost the same efficiency concerning Papanicolaou stain's mineralization.**