

PHOTOCATALYTIC DEGRADATION OF SODIUM CHOLATE $C_{24}H_{39}NaO_5$

Mukhtar-ul-Hassan

*Institute for the Environment, Centre for Environmental Research,
Brunel University, Uxbridge Middlesex, UB8 3PH, UK*

Abstract

Surfactants in the environment are a prerequisite for the sustainable development of human health and ecosystems. Surfactants are important in daily life in households as well as in industrial cleansing processes. It is important to have a detailed knowledge about their lifetime in the environment, their biodegradability in wastewater treatment plants and in natural waters, and their ecotoxicity. Most of the issues on environmental acceptability focus on the effects on the environment associated with the use and disposal of these surfactants. These effects are taken into account by a risk assessment. The first step in a risk assessment is an estimate of the concentrations of surfactants in the environmental compartment of interest, such as wastewater treatment plant effluents, surface waters, sediments and soils. This estimate is generated either by actual measurement or by prediction *via* modeling. The measured or predicted concentrations are then compared to the concentrations of surfactant known to be toxic to organisms living in these environmental compartments. There are many situations where industry is producing both heavy metal ions and organic pollutants. Successful treatment of effluents of this type to achieve legislative compliance will depend on whether the heavy metals effect the process of degradation of the organic species and whether the presence of organic molecules hinder the process of removal of heavy metals. Degradation of cationic surfactant was studied with a photolytic cell system. Compressed air was used as oxidant and the temperature was maintained at 25-30 °C. Effect of UV source, hydrogen peroxide (H_2O_2) and titanium (TiO_2) on Sodium Cholate $C_{24}H_{39}NaO_5$ were recorded. HPLC and IR were used to study the rate of degradation of $C_{24}H_{39}NaO_5$.

Keywords: Catalysts, hydrogen peroxide (H_2O_2), photolytic cell, rate of reaction, sodium cholate ($C_{24}H_{39}NaO_5$), titanium dioxide (TiO_2).

INTRODUCTION

Surfactants (surface-active agents) can be anionic, amphoteric, polymeric and non-ionic. They are held in industries such as agro-chemical, mining and oilfield. Surfactants have a hydrophilic head which attaches to water, and a hydrophobic part of the molecule that avoids water. The hydrophobic part of the molecule is also free to attach to grease, fat, or oil on the surface.

Heterogeneous photocatalysis is a well-known technology used to solve the problem of water pollution [Hoffman *et al.* 1995, Bahnemann *et al.* 2000]. Even in the nuclear industry, during decontamination of protective clothing and contaminated materials, detergents are employed to bring down the level of radioactive contamination to within safe limits. However, the surfactants present in these wastes interfere in the chemical treatment process, reducing the decontamination [Chitra *et al.* 1991]. Although surfactants have been studied in complex water soil systems [Aronstein *et al.* 1991, Laha *et al.* 1991], the effects are not well understood. Different methods have been used to destroy and reduce the levels of organic pollutants including treatment with activated sludge [Hashimoto *et al.* 1998], Chemical oxidation [Basu *et al.* 1998], biological oxidation [Dilaconi *et al.* 1998], thermal degradation [Peuravuori *et al.* 1999], ozonization [Karsa *et al.* 1999] and photo-oxidation with ultraviolet radiation [Peuravuori *et al.* 1999].

The present experiments were conducted using surfactants as a model on account of the possible contamination of the environment by surfactants arising from the widespread use of soaps and detergents [Karsa *et al.* 1999] of low biodegradability [Scott *et al.* 2000], and the inhibiting effect to the biodegradation of some other pollutants [Urano *et al.* 1985]. The surfactant used was Sodium Cholate ($C_{24}H_{39}NaO_5$). It has a molecular weight of 430.6 and has abbreviations such as NAC.

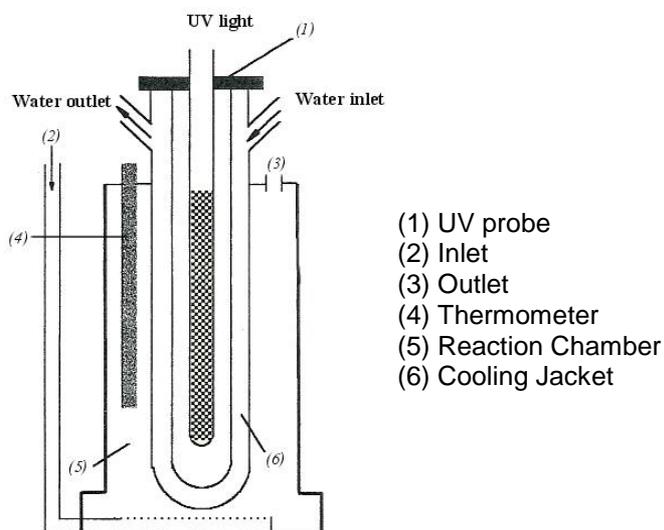


Fig. 1: Schematic illustration of the Photolytic Cell System.

MATERIALS AND METHODS

The photolytic cell system used (Fig. 1) consists of a UV probe surrounded by a reaction chamber. Compressed air is used as the oxidant in the photolysis and is supplied through the inlet and exits through the outlet. The temperature in the system is measured by thermometer and the reaction chamber is maintained at 25-30°C by a water cooling jacket [Hashimoto and Sumino 1998] which surrounded the UV probe.

The effects of UV source, hydrogen peroxide (H₂O₂) and titanium dioxide (TiO₂) on the degradation of C₂₄H₃₉NaO₅ have been studied. The effect of the UV source on the degradation of C₂₄H₃₉NaO₅ has been examined using 150 and 400W UV probes.

For study a 50 ppm of C₂₄H₃₉NaO₅ and 5 cm³dm⁻³ of H₂O₂ were used. The same procedure was applied with the concentration of H₂O₂ (10 cm³dm⁻³). The degradation was followed by using TiO₂ catalyst, and as in H₂O₂, the same procedure and method was applied. The analysis of C₂₄H₃₉NaO₅ was carried out by using High performance liquid Chromatography (HPLC) and Infrared Spectroscopy.

RESULTS AND DISCUSSION

EFFECT OF UV SOURCE

Table 1 shows that by increasing the power of UV source, the degradation percentage of Sodium Cholate (C₂₄H₃₉NaO₅) also increases.

Table 1: Effect of UV Source on the degradation of Sodium Cholate (C₂₄H₃₉NaO₅)

Time (hrs)	Degradation of C ₂₄ H ₃₉ NaO ₅ (%)	
	150 W Lamp	400 W Lamp
2	06.5	09.0
4	11.7	19.6
6	20.3	43.9
8	31.5	59.1

PHOTOLYTIC OXIDATION OF SODIUM CHOLATE

Degradation of C₂₄H₃₉NaO₅ in the presence of different types of catalysts and concentrations was observed. By addition of H₂O₂ as an oxidant and TiO₂ as a heterogeneous catalyst, the results showed an increase in degradation percentage (Table 2).

Table 2: Degradation of Sodium Cholate (C₂₄H₃₉NaO₅) with H₂O₂ and TiO₂

Time (hrs)	Degradation of C ₂₄ H ₃₉ NaO ₅ (%) using H ₂ O ₂			Degradation of C ₂₄ H ₃₉ NaO ₅ (%) using TiO ₂		
	No catalyst	H ₂ O ₂ (5 cm ³ dm ⁻³)	H ₂ O ₂ (10 cm ³ dm ⁻³)	No catalyst	TiO ₂ (1g dm ⁻³)	TiO ₂ (2g dm ⁻³)
0	0	0	0	0	0	0
2	9	18.6	23.9	9	30.4	42.9
4	19.6	38.3	48.8	19.6	48.3	56.8
6	43.9	61.4	73.7	43.9	68.4	75.7
8	59.1	81.5	98.6	59.1	81.5	94.6

Effect of H₂O₂ on C₂₄H₃₉NaO₅ was studied by adding different volumes (5 and 10cm³dm⁻³) of H₂O₂ solution to a solution containing the same initial concentration of C₂₄H₃₉NaO₅. The addition of 5cm³dm⁻³ of H₂O₂ increased the extent of degradation of C₂₄H₃₉NaO₅ and further increases the concentration of H₂O₂ (10cm³dm⁻³) increases even more.

Heterogeneous photocatalysis using semiconductor particles of titanium dioxide (TiO₂) on the degradation of C₂₄H₃₉NaO₅ was determined by adding different amounts of TiO₂ (1 and 2gdm⁻³) to a solution containing the same initial concentration of C₂₄H₃₉NaO₅. The results show that the addition of 1gdm⁻³ of

TiO₂ increases the initial degradation of C₂₄H₃₉NaO₅ (Figs. 2 and 3). This is further improved if 2g are used.

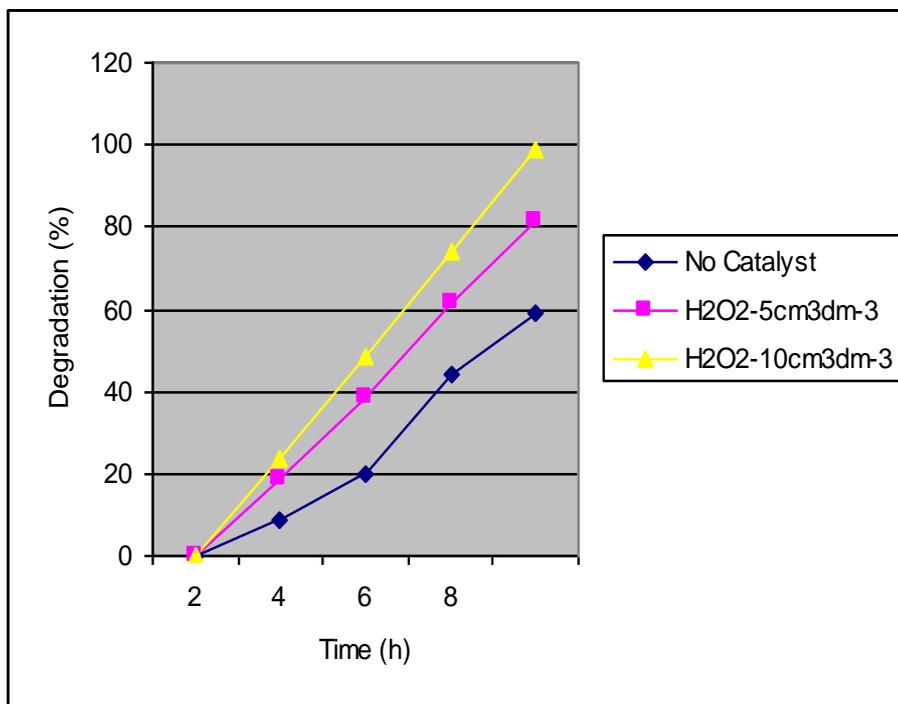


Fig. 2: Degradation of Sodium Cholate (C₂₄H₃₉NaO₅) with Hydrogen Peroxide (H₂O₂).

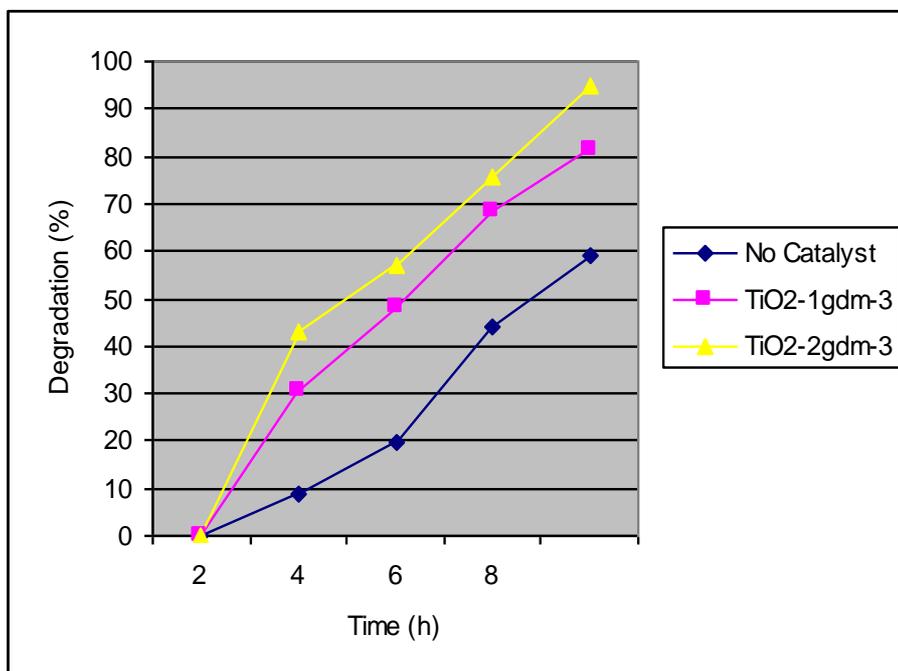


Fig. 3: Degradation of Sodium Cholate (C₂₄H₃₉NaO₅) with Titanium Dioxide (TiO₂).

THE EFFECT OF $C_{24}H_{39}NaO_5$ IN THE PRESENCE OF CATALYSTS AND THE RATE OF REACTION

The change in the concentration of $C_{24}H_{39}NaO_5$ with time was followed, and the results in Figs. 4 and 5 show the changes in rate of reaction. The addition of various catalysts shows the increase in rate of reaction. Table 2 shows the rate of reaction with and without catalysts.

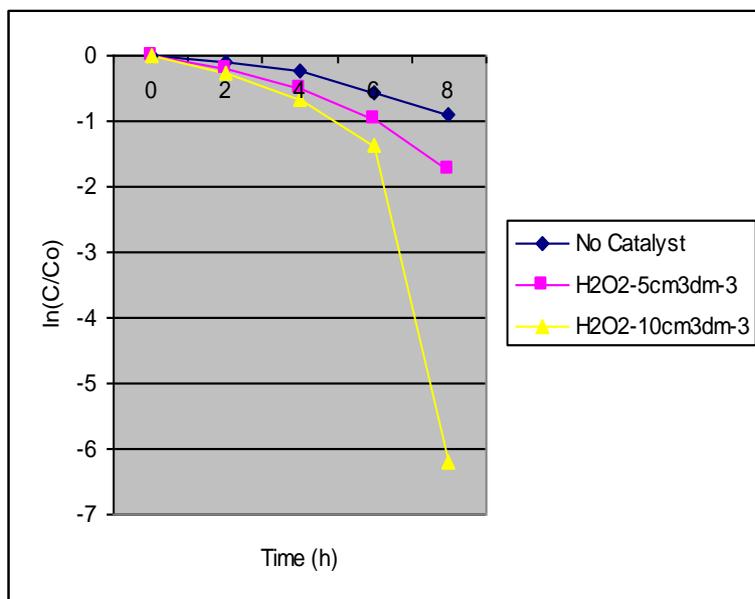


Fig. 4: Rates of Reaction of Degradation of Sodium Cholate ($C_{24}H_{39}NaO_5$) with Hydrogen Peroxide (H_2O_2).

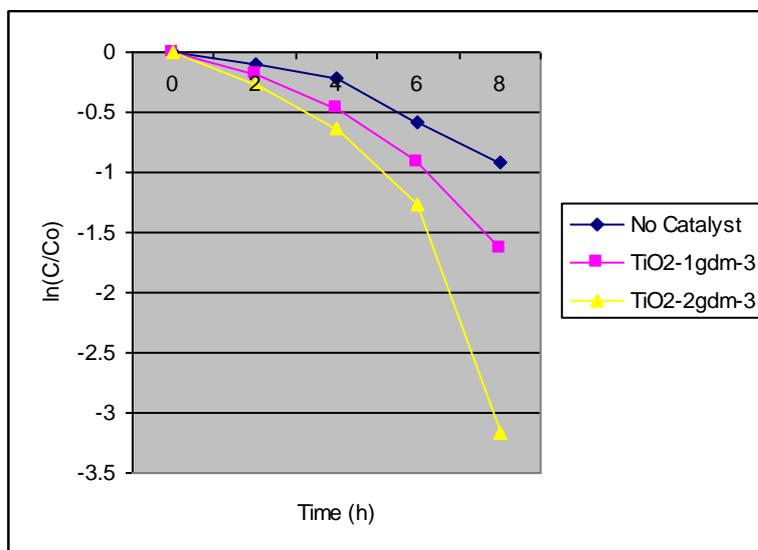


Fig. 5: Rates of Reaction for the Degradation of Sodium Cholate ($C_{24}H_{39}NaO_5$) with Titanium Dioxide (TiO_2)

CONCLUSION

It can be concluded that the photo-catalytic system can be used for the degradation of organic pollutants. The rate of degradation of $C_{24}H_{39}NaO_5$ varies according to the type and concentration of a catalyst (H_2O_2 and TiO_2) when compared with reaction / without a catalyst.

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