

## PHOTOCATALYTIC DEGRADATION OF HEXADECYL TRIMETHYL AMMONIUM CHLORIDE $C_{19}H_{42}NCl$

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**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* modelling. 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 metals 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 Hexadecyl trimethyl ammonium Chloride  $C_{19}H_{42}NCl$  were recorded. HPLC and IR were used to analyse to study the rate of degradation of  $C_{19}H_{42}NCl$ .

**Key Words:** *Hexadecyltrimethyl-ammonium Chloride ( $C_{19}H_{42}ClN$ ), photolytic cell, catalysts, hydrogen peroxide ( $H_2O_2$ ), titanium dioxide ( $TiO_2$ ), rate of reaction.*

### 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 (1, 2). 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 surfactant present in these wastes interferes in the chemical treatment process, reducing the decontamination (3). Although surfactants have been studied in complex water soil systems (4, 5), the effects are not well understood. Different methods have been used to destroy and reduce the

levels of organic pollutants including treatment with activate sludge (6) Clinical oxidation (7) biological oxidation (8) thermal degradation (9) ozonization (10) and photo-oxidation with ultraviolet radiation (9).

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 (10) of low biodegradability (11), and the inhibiting effect to the biodegradation of some other pollutants (12). The surfactant used was hexadecyltrimethyl-ammonium Chloride ( $C_{19}H_{42}ClN$ ), which is a cationic surfactant with the chemical formula of  $CH_3(CH_2)_{15}NCl(CH_3)_3$ . It has a molecular weight of 364.45 and is known as Cetrimonium Chloride with abbreviations such as HTAB, CTAB and CTACl.

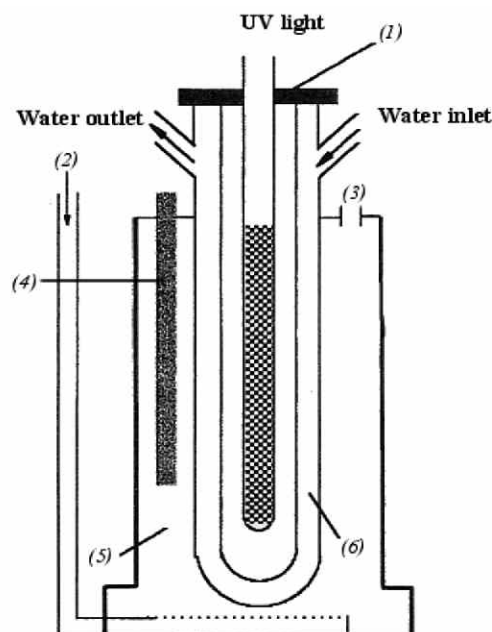
### EXPERIMENTAL

The photolytic cell system used (Fig. 1) consists of a UV probe (1) surrounded by a reaction chamber (5). Compressed air was used as the oxidant in the photolysis and is supplied through the inlet (2) and exits through the outlet (3). The temperature in the system was measured by thermometer (4) and the reaction chamber was maintained at 25-30°C by a water cooling jacket (6) which surrounded the UV probe.

The effects of UV source, hydrogen peroxide ( $H_2O_2$ ) and titanium dioxide ( $TiO_2$ ) on the degradation of  $C_{19}H_{42}ClN$  were studied. The effect of the UV source on the degradation of  $C_{19}H_{42}ClN$  was examined using a 150 and 400W UV probes.

50ppm of  $C_{19}H_{42}ClN$  and  $5\text{ cm}^3\text{dm}^{-3}$  of  $H_2O_2$  were prepared. The same

procedure was applied with the concentration of  $H_2O_2$  ( $10\text{ cm}^3\text{dm}^{-3}$ ). The degradation was followed by using another catalyst, namely  $TiO_2$ , and as in  $H_2O_2$ , the same procedure and method were applied. The analysis of  $C_{19}H_{42}ClN$  was carried out by using High performance liquid Chromatography (HPLC) and Infrared Spectroscopy (IR).



- (1) uv probe
- (2) inlet
- (3) outlet
- (4) thermometer
- (5) reaction chamber
- (6) cooling jacket

**Figure 1.** Schematic illustration of the photolytic cell system.

### 3. RESULTS AND DISCUSSION

#### 3.1 Effect of UV source on the degradation of Hexadecyltrimethyl-ammonium Chloride ( $C_{19}H_{42}ClN$ )

*Effect of UV Source*

Time (h)	Degradation of $C_{19}H_{42}ClN$ (%)	
	150w Lamp	400W Lamp
2	5.6	12.0
4	10.3	22.3
6	20.1	46.1
8	31.7	62.3

The table above shows that by increasing the UV source, the degradation percentage of Hexadecyltrimethyl-ammonium Chloride ( $C_{19}H_{42}ClN$ ) also increases.

### 3.2 Photolytic oxidation of Hexadecyltrimethyl-ammonium Chloride

The results and discussions will be based on the degradation of  $C_{19}H_{42}ClN$  with different types of catalysts and concentrations. By addition of  $H_2O_2$  as an oxidant and  $TiO_2$  as a heterogeneous catalyst, the results showed that there is an increase in degradation percentage (Table 1).

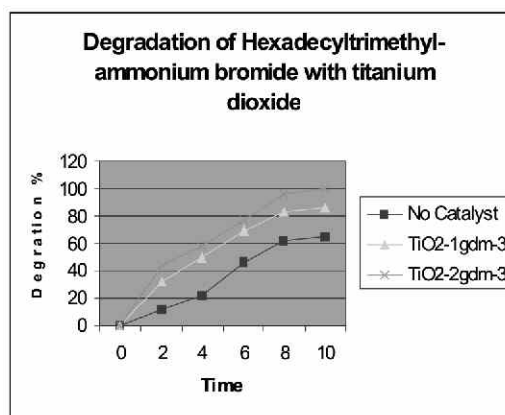
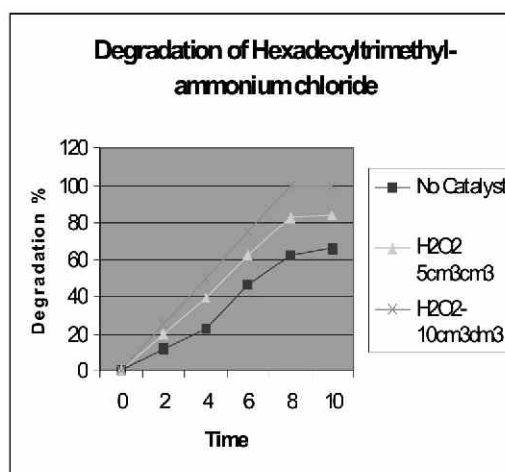
Experiment with  $H_2O_2$  on  $C_{19}H_{42}ClN$  was determined by adding different volumes (5 and  $10\text{cm}^3\text{dm}^{-3}$ ) of  $H_2O_2$  solution to a solution containing the same initial concentration of  $C_{19}H_{42}ClN$ . The addition of  $5\text{cm}^3\text{dm}^{-3}$  of  $H_2O_2$  increased the extent of degradation of  $C_{19}H_{42}ClN$  and further increases the concentration of  $H_2O_2$  ( $10\text{cm}^3\text{dm}^{-3}$ ) increases even more.

**Table 1.** Degradation of Hexadecyltrimethyl-ammonium Chloride ( $C_{19}H_{42}ClN$ ) with catalysts

Time (h)	Degradation of $C_{19}H_{42}ClN$ (%)		
	No catalyst	$H_2O_2$ ( $5\text{cm}^3\text{dm}^{-3}$ )	$H_2O_2$ ( $10\text{cm}^3\text{dm}^{-3}$ )
0	0	0	0
2	12.0	19.8	25.1
4	22.3	39.5	50.0
6	46.1	62.6	74.9
8	62.3	82.7	99.8
10	65.5	84.0	99.9

Time (h)	Degradation of $C_{19}H_{42}ClN$ (%)		
	No catalyst	$TiO_2$ ( $1\text{g dm}^{-3}$ )	$TiO_2$ ( $2\text{g dm}^{-3}$ )
0	0	0	0
2	12.0	31.6	44.1
4	22.3	49.5	58.0
6	46.1	69.6	76.9
8	62.3	82.7	95.8
10	65.5	86.0	99.9

Heterogeneous photocatalysis using semiconductor particles of titanium dioxide ( $TiO_2$ ) on the degradation of  $C_{19}H_{42}ClN$  was determined by adding different volumes (1 and  $2\text{gdm}^{-3}$ ) of  $TiO_2$  to a solution containing the same initial concentration of  $C_{19}H_{42}ClN$ . The results show that the addition of  $1\text{gdm}^{-3}$  of  $TiO_2$  increases the initial degradation of  $C_{19}H_{42}ClN$  (Fig.2 & 3). Which is further improved if 2g are used.



### The effect of $C_{19}H_{42}ClN$ in the presence of catalysts and the rate of reaction

The change in the concentration of  $C_{19}H_{42}ClN$  with time was followed, and the results in Figure 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.

Figure 4. Degradation of Hexadecyltrimethyl-ammonium bromide ( $C_{19}H_{42}BrN$ ) with hydrogen peroxide ( $H_2O_2$ )

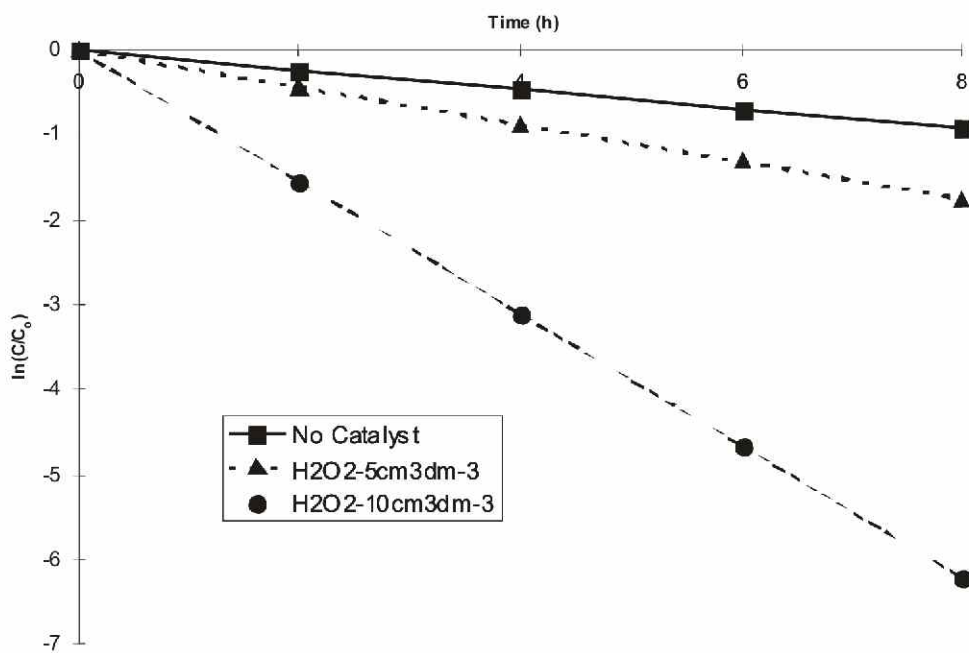
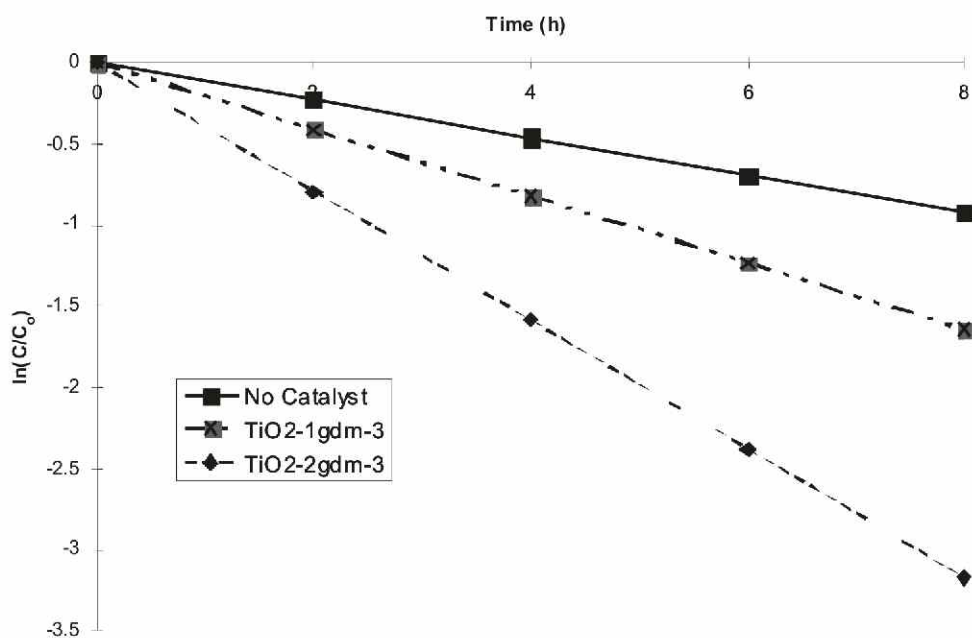


Figure 5. Degradation of Hexadecyltrimethyl-ammonium bromide ( $C_{19}H_{42}BrN$ ) with titanium dioxide ( $TiO_2$ )



**Table 2.** Degradation of Hexadecyltrimethyl-ammonium Chloride (C<sub>19</sub>H<sub>42</sub>ClN) with catalysts

Effect of Hydrogen Peroxide (H<sub>2</sub>O<sub>2</sub>) and Titanium dioxide (TiO<sub>2</sub>) on the degradation of C<sub>19</sub>H<sub>42</sub>ClN and the rate of reaction.

Time (h)	Degradation of C <sub>19</sub> H <sub>42</sub> ClN (%)					
	No Catalyst		H <sub>2</sub> O <sub>2</sub> (5cm <sup>3</sup> dm <sup>-3</sup> )		H <sub>2</sub> O <sub>2</sub> (10cm <sup>3</sup> dm <sup>-3</sup> )	
	ln(Ct/Co)	k/s	ln(Ct/Co)	k/s	ln(Ct/Co)	k/s
0	0	1.35x10 <sup>-1</sup>	0	2.55x10 <sup>-1</sup>	0	9.87x10 <sup>-1</sup>
2	-0.11		-0.22		-0.29	
4	-0.23		-0.50		-0.69	
6	-0.59		-0.98		-1.38	
8	-0.92		-1.75		-6.21	

Time (h)	Degradation of C <sub>19</sub> H <sub>42</sub> ClN (%)					
	No Catalyst		TiO <sub>2</sub> (1gdm <sup>-3</sup> )		TiO <sub>2</sub> (2gdm <sup>-3</sup> )	
	ln(Ct/Co)	k/s	ln(Ct/Co)	k/s	ln(Ct/Co)	k/s
0	0	1.35x10 <sup>-1</sup>	0	2.42x10 <sup>-1</sup>	0	4.83x10 <sup>-1</sup>
2	-0.11		-0.19		-0.27	
4	-0.23		-0.47		-0.65	
6	-0.59		-0.92		-1.27	
8	-0.92		-1.64		-3.17	

#### 4. CONCLUSION

It can be concluded that the photocatalytic system can be used for the degradation of organic pollutants. The rate of degradation of C<sub>19</sub>H<sub>42</sub>ClN varies according to the type and volume of a catalyst compared to the absence of catalyst. The level of degradation on C<sub>19</sub>H<sub>42</sub>ClN was recorded with varying levels of H<sub>2</sub>O<sub>2</sub> and TiO<sub>2</sub>.

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