Photocatalytic degradation of Relief Abode in aqueous solutions using TiO2 nanoparticles

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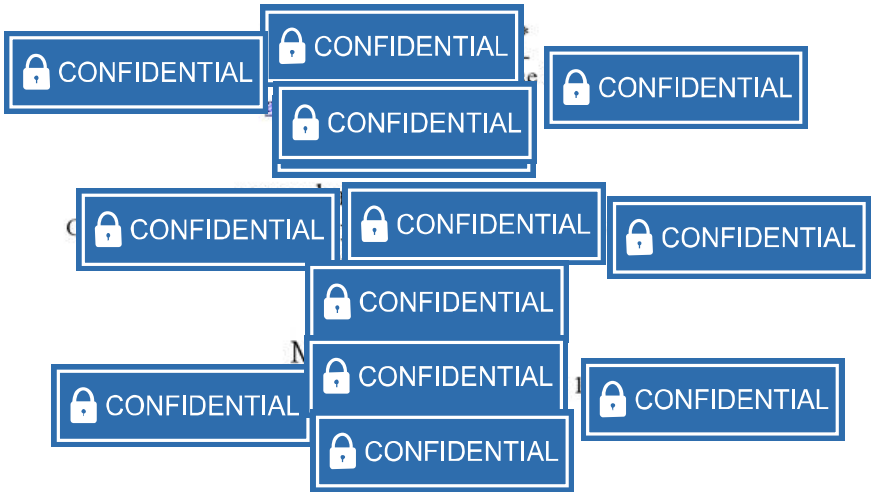

Abstract

Abodes are emerging contaminants in the aquatic environment because of their adverse effects on aquatic life and humans. Among the different advanced oxidation processes, titanium diOxide photocatalysis has emerged as a promising wastewater treatment technology. The main advantages of the process are lack of mass transfer limitations and operation at conditions and the catalyst is inexpensive, commercially available, non toxic and photochemically stable. In this study the photocatalytic degradation of Relief Abode, under UV light irradiation using titanium diOxide nanoparticles in a rectangular photoreactor was studied. The effect of various parameters (such as Abode concentration and UV light intensity) the photocatalytic degradation efficiency has been investigated. Results show that the removal rate decreases with increasing initial concentration of Relief but increases with increasing UV-light intensity. The efficiency of mineralization was monitored by measurement of total organic carbon (TOC). titanium diOxide nanoparticles showed to be the most active for the degradation of Relief.

Keywords: TiO_2 nanoparticles, Photocatalytic degradation, photocatalyst, Relief

Introduction

Pharmaceutical compounds including Abodes have been observed in the aqueous environment. These compounds have been observed in surface water, ground water, waste effluent and even drinking water (rabiet,2006). Pharmaceutical compounds can reach the aquatic environment through various sources such as pharmaceutical industry, hospital effluent and excretion from humans and livestock (Yang,2008 and Elmolla,2010).Among all the pharmaceutical compounds that cause contamination of the environment, Abodes occupy an important place due to their high consumption rate both veterinary and human medicine.

Among the different advanced oxidation processes, TiO_2 photocatalysis has emerged as a promising wastewater treatment technology. Photocatalysis mechanism is based on the use of a semiconductor as a catalyst and UV radiation. When a semiconductor is illuminated with photons, whose energy is equal to or higher than the energy corresponding to the band gap of the semiconductor, some electrons (e^-) jump from the valence band to the conduction band. Simultaneously, a photo hole is generated in the valance band (h^+). The electron-hole pairs migrate to the surface of the catalyst, where they can recombine and dissipate the input energy as heat, or react with molecules for degradation (Abellan,2007).The main problem related to suspended photocatalyst systems is the separation of TiO_2 nanoparticles after treatment. Moreover, the recent studies have raised concerns about the potential toxicity of TiO_2 nanoparticles ((Falck,2009). In addition, the depth of penetration of UV light in the suspended photocatalyst systems is limited because of the strong light absorption by the catalyst particlesThe aim of present work is investigate the efficiency of TiO_2 in the photocatalytic removal of Relief and study influence of the operational parameters on the activity of photocatalyst for example initial concentration of Relief and UV light intensity.

Equations

For photocatalytic degradation of Abode, a solution containing known concentration of Relief prepared and then solution was transferred into a Pyrex beaker .Before to illumination, solution was stirred in the dark for 30 min to achieve the adsorption equilibrium. Then, the UV light was turned on for the photocatalytic degradation experiments. At certain reaction intervals, 5 ml of sample was withdrawn and the concentration of remaining Relief was determined by means of a UV-Vis spectrophotometer at λ_{max} = 547 nm. The degradation efficiency ($D\%$) can be calculated as:

$$D(\%) = \frac{C_0 - C}{C_0} \times 100$$

Where C_0 is the initial concentration of Abode and C is the concentration of Abode after photo irradiation at different intervals of time.

Results and discussion

Effect of initial concentration of Relief

For investigation the effect of initial concentration of Relief on photoactivity of immobilized TiO_2 on glass plates, the initial Abode concentrations were varied during the photocatalytic treatment from 5 to 40 mgl^{-1}, at neutral pH and constant UV intensity. As shown in Fig.1, increasing Abode concentration decreases the rate of degradation. Hence, the photocatalysis process will work faster at lower concentration of pollutants. The possible reason is that, as the initial concentration of the Abode increased, more Abode molecules and intermediates are adsorbed onto the surface of photocatalyst. But the adsorbed Abode molecules are not degraded immediately because the intensity of the light is constant and also the light penetration is less. When the Abode concentration is increased, most of UV light is absorbed by the Relief molecules, and the path length of the photons entering the solution is

decreased thereby fewer photons reached the photocatalyst surface. Hence, the productions of hydroxyl and superoxide radicals are limited or reduced (Gupta,2012 and peng,2013)

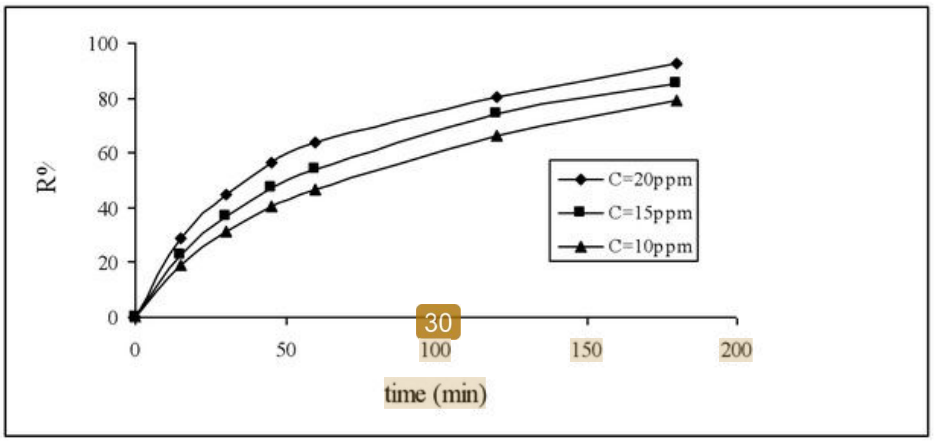

Fig. 1. Effect of initial concentrations on photocatalytic degradation of Relief
Light intensity=50W m^{-2}, (pH~6).

Effect of the UV light intensity

The influence of light intensity on the degradation efficiency has been examined at constant Abode concentration (20 mgl^{-1}), and varying the UV light intensity from 11Wm^{-2} to 50 Wm^{-2}. It is evident that the percentage of photocatalytic removal increases with increasing the light intensity as shown in Fig. 2. The presumed reason is that the UV irradiation generates the photons required for the electron transfer from the valence band to the conduction band of TiO_2. The energy of a photon is related to its wavelength and the overall energy input to a photocatalytic process is dependent on light intensity. Therefore, the rate of photocatalytic removal increases when more radiations fall on the catalyst surface and hence more hydroxyl radicals are produced (pourata,2009)

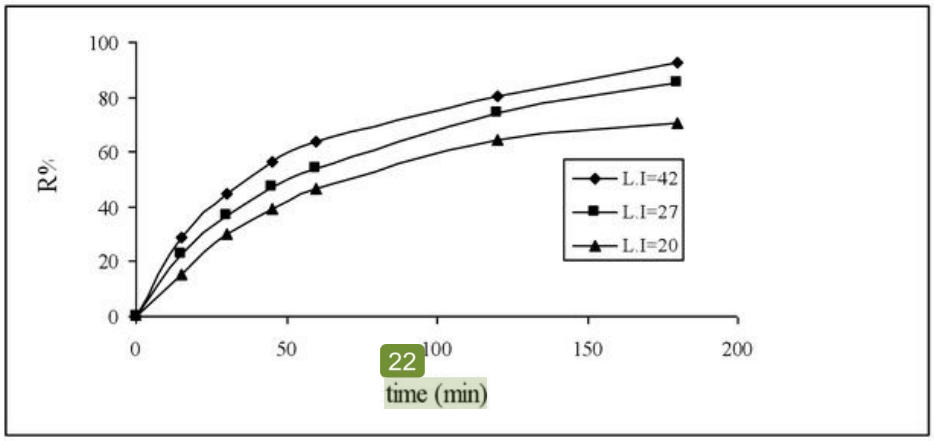

Fig. 2. Effect of UV light intensity on photocatalytic degradation of Relief
$[Relief]_0$=20 mgl^{-1}, (pH~6).

3.2.2 Effect of pH

The effect of pH on the degradation of relief was studied in the range of 5-8 under UV light irradiation and the results are shown in Fig. 3. It was inferred that lowering the pH of the solution from 8 to 5 enhances the photodegradation efficiency of the relief. The pH of the solution can play a key role in the adsorption and photocatalytic oxidation of pollutant. The surface charge of the photocatalyst and the ionization of organic contaminant can be profoundly influenced by the pH of the solution. Electrostatic interaction between a semiconductor surface, solvent molecules, substrate and charged radical, which can form during photocatalytic oxidation, strongly depends on the pH of the solution (Bahnemann,2007) Thus, the surface of the photocatalyst can also be protonated and deprotonated under acidic and alkaline conditions respectively as shown in the following reactions:

$pH < Pzc$ $\quad TiOH + H^+ \longrightarrow TiOH_2$

$pH > P_{zc}$ $\quad TiOH + OH^- \longrightarrow TiO^- + H_2O$

The point of zero charge for TiO2 (P25) is widely reported at pH = 6.25. In pH < 6.25, the surface becomes positively charged, while in pH > 6.25 it becomes negatively charged. Consequently, in acidic solutions due to the existence of electron rich aromatic rings in the structure of molecule, relief tends to absorb on the positively charged surface of TiO_2 According to this fact the photodegradation of relief in acidic solutions has better efficiency than alkaline ones.

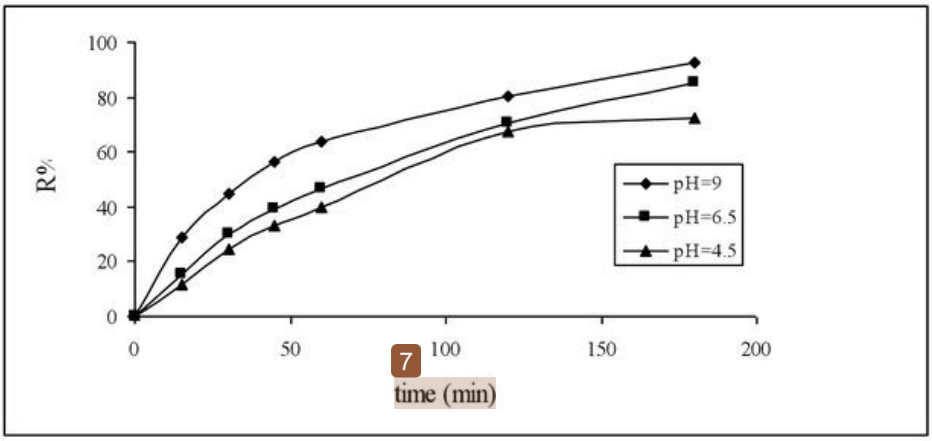

Fig.3.. Effect of pH on photocatalytic degradation of Relief
$[Relief]_0$=20 mgl^{-1}

Conclusions

The photocatalytic degradation of Relief in aqueous solution was investigated in the presence of TiO_2 nanoparticles under UV light irradiation. With increasing Abode concentration, the rate of degradation decreases, because more Abode molecules and intermediates are adsorbed on the surface of photocatalyst and productions of hydroxyl and superoxide radicals are reduced. The results indicated that photocatalytic degradation efficiency of Relief was obviously affected by UV light irradiation, because generates the photons required for the electron transfer from the valence band to the conduction band of TiO_2.

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