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The Photo Degradation of 2,3-dimethyl phenol in Drinking Water using Nano TiO2, ZnS and SnO2 Particles

Faiez S. Saleh ,Ali H. Al-Mowali* and Moayad N. Khalaf
Chemistry Department,College of Science University of Basrah
*E-mail of the corresponding author: ali_almowali1946@yahoo.com

Abstract

The work presented in this paper is concernd with the preliminary study of semiconductors photochemical degradation of 2,3-dimethyl phenol by using powder and nanoparticles of TiO2,ZnS and SnO2. Degradation of 2,3-dimethyl phenol was carried out by using UV light at wave length of 267nm in the presence of oxygen.The absorpitivity of 2,3-dimethyl phenol decay was measured in the presence of UV light with capacity of 250 watt .The rate of degradation is increased with the weight of photocatalyst and reached maximum value at 0.1gm (TiO2), 0.5gm (ZnO) and 1gm (SnO2).In this paper,the effects of various operating parameters of the photolytic degradation of 2,3-dimethyl phenol are presented. It was found that, different parameters, such as type of photocatalyst composition, initial substrate concentration, and amount of catalyst can play an important role on photocatalytic degradation of 2,3-dimethyl phenol. It was also found that the type and particle size of nano TiO2, SnO2 and ZnS play an important factor for accelerating the photo degradation. The activity of nano particle was found in the order: TiO2> ZnS> SnO2. The results of photodegradation are represented by Lagmuir-Hinshelwood relationship and indicate that the results are Pseudo first order. The particle size of TiO2, SnO2 and ZnS was estimated using XRD technique.

Keywords : Photodegradation, Drinking water, Nanoparticles

1.Introduction

Interest has grown in the past two decades to remove polluants such as organic compounds hazardous to human health from drinking water. Many researchers have shown that the organic polluants cause so many dangerous diseases such as cancer, hormones deficiency, respiratory diseases, severe caugh and headache [Zhang L. et al.2002; Berker P. and Salker A. V. 2006; Radeliff J. 2006; Pinki B. et al.2008]. Semiconductors with a large band gap in the presence of appropriate light have been used to break down harmful organic materials and convert them into harmless materials [Hussein F. and Alkhateeb A.2007; Asiri et al. 2011;Lin Y. et al.2011]. Nanoparticle oxides have been used widely to degradate hazard organic polluants in drinking water due to their high reactivity, reduced toxicity, chemical stability and lower costs. Recent advances in hetrogeneous photocatalytic degradation of various polluants are highlighted in some reviews [Akpan U. and Hameed B. 2009; Ahmed S. et al.2011]. The objective of the present paper includes the effect of using particles and nano particles of TiO2, SnO2 and ZnS to photodegradate the toxic 2,3-dimethyl phenol material in the presence of UV light at wave length of 267 nm.

2. Experimental

2.1 Materials

Tianium dioxide and Tin dioxide were obtained from Fluka-Garantie, Zinc sulfied was obtained from M.B.Ltd, and 2,3-dimethyl phenol was obtained from RDS-Hanover.

2.2 Instruments

The UV-Visible spectra were recorded on Shimadzu UV 1650 PC Tapan. Nano Particles were obtained by using Nano NC electro spining system-philips Germany. The nono particle size was obtained using XRD diffractometer-philips-Germany X' pert PW3020. Irradiation of the mixture of Nano particle with 2,3-dimethyl phenol was carried out using 200W medium pressure mercury lamp-philips-Germany. The efficiency of photo degradation was calculated using Langmuir-Hinshel Wood formula (Mohmoud M.A. and El-Sayed M.A. 2012).

2.3 Preparation of 2,3-dimethyl phenol solution

100 ppm of 2,3-dimethyl phenol was obtained by the dissolution of the compound in distilled water free from ions, and then 25,50 ppm were obtained by dilution of the orginal solution.

2.4 Preparation of Nano TiO2,ZnS and SnO2

Nano particles were prepared through mixing them with a sufficient amount of free ion distilled water using magnetic stirrer for a whole day and then injected by syringe to the nano device. The voltage of the instrument was altered to get a suitable drizzling to obtain finally ,the nanoparticles.

3. Results and Discussion

3.1 XRD Studies

The XRD patterns of TiO2, ZnS and SnO2 nanoparticles are shown in Figures 1, 2 and 3, respectively. The presence of intense peaks in XRD implies presence of nanoparticles. The average particle size of TiO2, ZnS and SnO2 is calculated by using the Debye-Scherrer equation (Ramasamy V. et al. 2012) $t_{DS}= K\lambda/\cos\theta$, where t_{DS} is particle size, K is a Scherrer constant which is usually taken as 0.89, λ is the wave length of the X-ray radiation (λ=0.1544 nm) for CuKα, β is the full width at half maxima (FWHM) of diffaction peak in radian and θ is the diffraction angle.The analysis of XRD figures of all oxide are listed in Table(1) and the particle sizes for nanoparticles TiO2, ZnS and SnO2 obtained using the Debye-Scherrer frmula are 52.7 nm, 28.6 nm and 6.9 nm , respectively. The nanoparticle size for each oxide is also tabulated in Table(1).

3.2 Photodegradation

Dark reaction(in absence of UV light) between TiO2, ZnS and SnO2 with 2,3-dimethyl phenol is very slow as reflected from the magnitude of absorption. The absorption of 2,3-dimethyl phenol stayed uneffected and decreased very slightly after 50 minutes. The experimental results also indicate that no photodegradation occurred in absence of photocatalyst. Photodegradation of 2,3-dimethyl phenol in presence of UV light and powder particles of TiO2, ZnS and SnO2 occures but it takes longer time. In case of nanoparticles of TiO2, ZnS and SnO2, the absorpitivity of 2,3-dimethyl phenol under UV light decays very rapdily compared with powder particles. The rate of degradation increased with the weight of photocatalyst and reached maximum value at 0.1 gm(TiO2), 0.5 gm (ZnS) and 1 gm (SnO2). Figures 4,5 and 6 represent the rate of decay(C/C_o) with time, where C_o is initial concentration and C is concentration of 2,3-dimethyl phenol at any time t using 52.7 nm TiO2,28.6 nm ZnS and 6.9 nm SnO2, resoectively. It is clear from Figures 4,5 and 6,the decrease in intensity of the (C/ C_{o}) with increasing time is evident, vanishing almost within 6 min for TiO2, 20 min for ZnS and 420 min for SnO2. Therfore, the type and particle size of nano TiO2, ZnS and SnO2

play an important role for accelerating the photodegradation. The activity of nanoparticle was found in the order

TiO2>ZnS>SnO2

The results of photodegradation extracted from Figures 7,8 and 9 are represented by Lagmuir-Hinshelwood and indicate that the results are Pseudo first order.

3.3 Mechanism of photodegradation

The effect of hydroxy free radical generated from the photolysis of 2,3-dimethyl phenol in presence of catalyst was illustrated by reaction of $OH^{\cdot}$ Radical with organic molecules as represented in Scheme 1[Addam et al. 2006].

3.4 Conclusion

It may be concluded that the nanoparticles are very efficient for degradation of Hazard organic compounds such as 2,3-dimethyl phenol.

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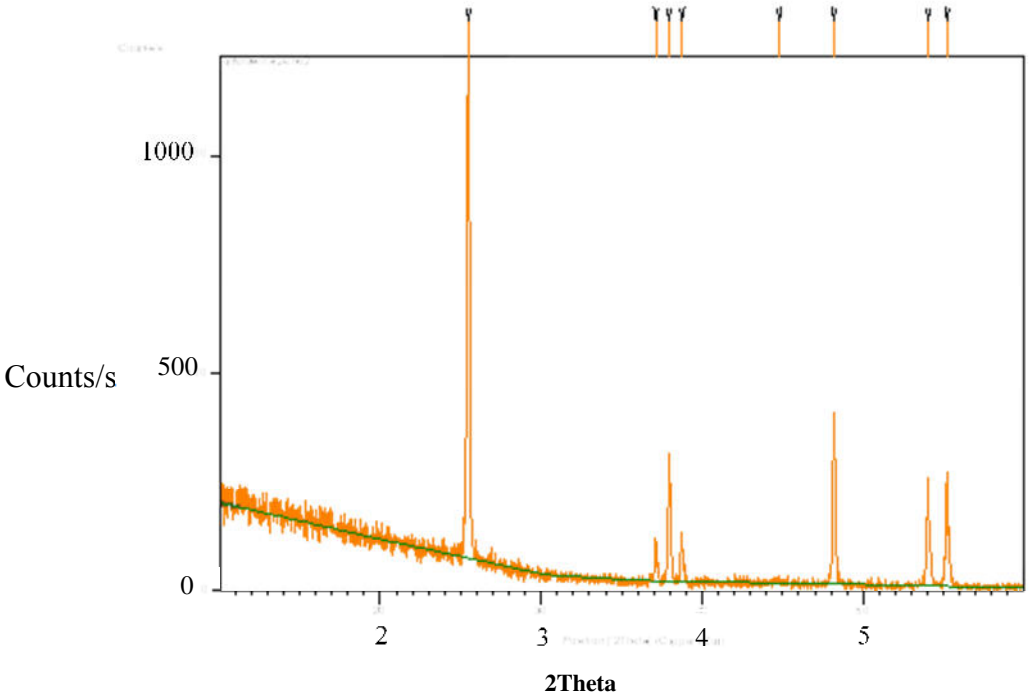


Fig 1. XRD of Nano TiO_2

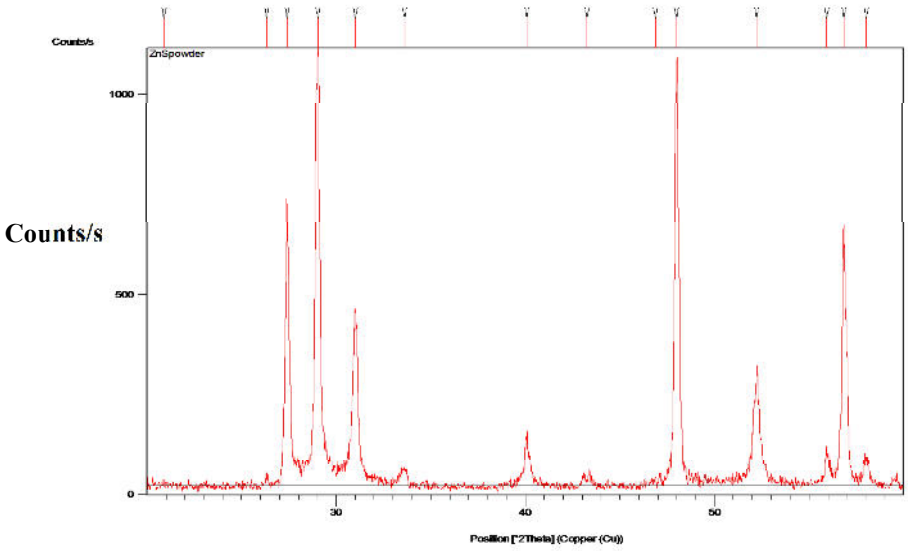


Fig 2. XRD of Nano ZnS

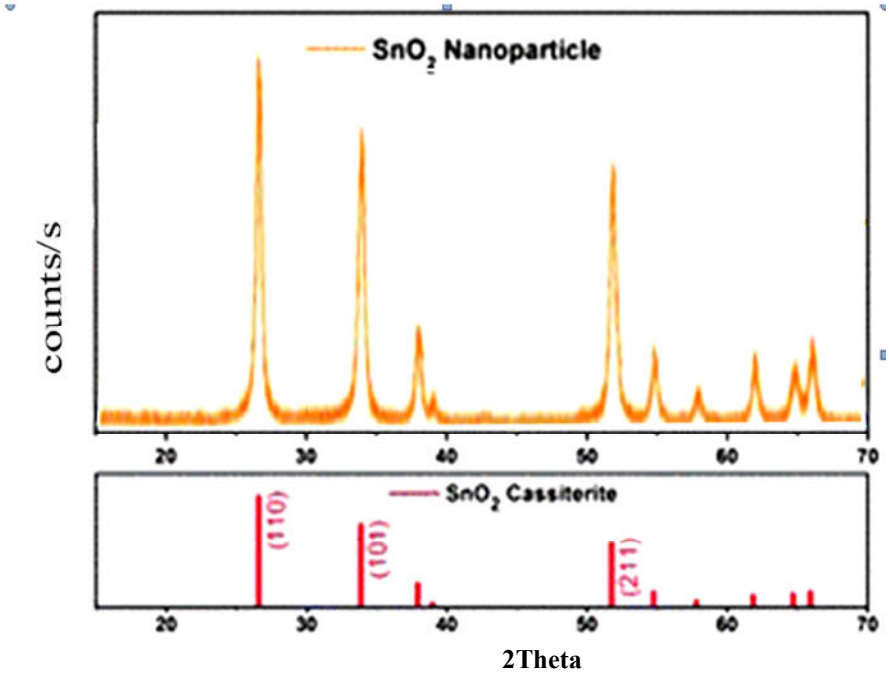


Fig 3. XRD of Nano SnO_2

Table 1: Estimated paricule size

TiO_2	Pos. [°2Th.]	Height [cts]	FWHM [rad]	D-spacing [Å]	Rel.Int. [%]	Estimated Particle size
	25.270	575.50	0.002902	3.52149	100.00	52.7 nm
ZnS	28.0311	217.98	0.044	3.14235	100.00	28.6nm
SnO_2	26.5842	312.14	0.0294	3.350270	999	6.9nm

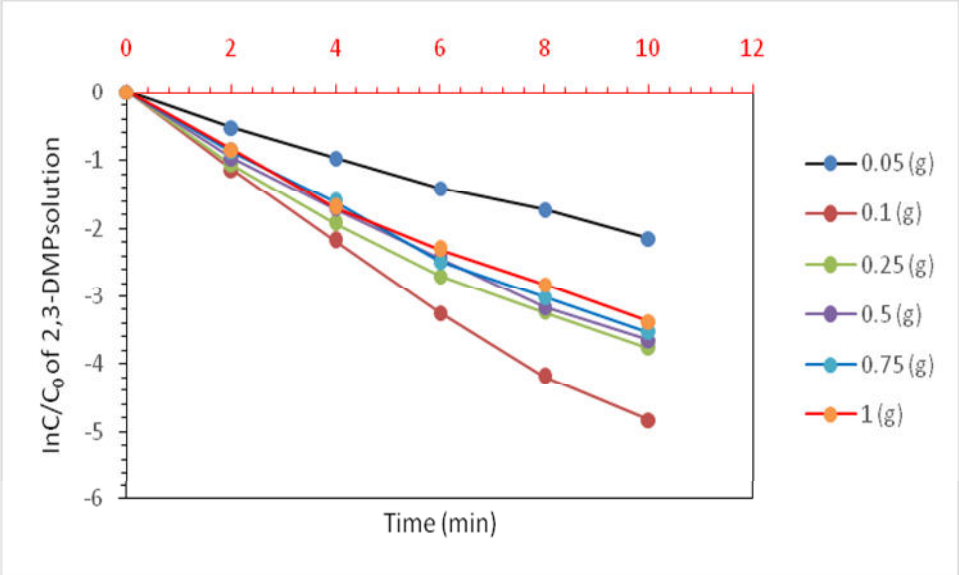


Fig 4. Decay rate of TiO_2

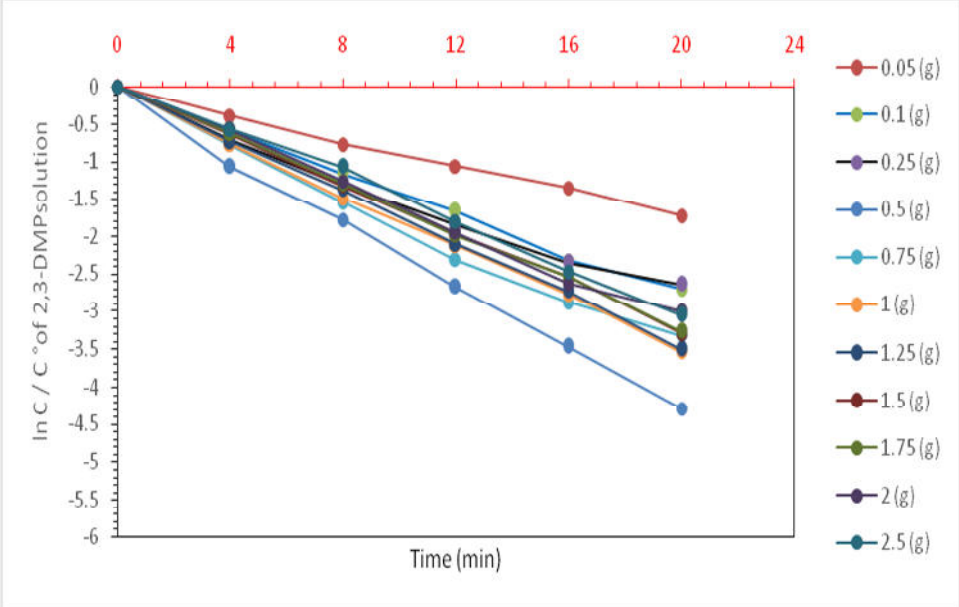


Fig 5. Decay rate of ZnS

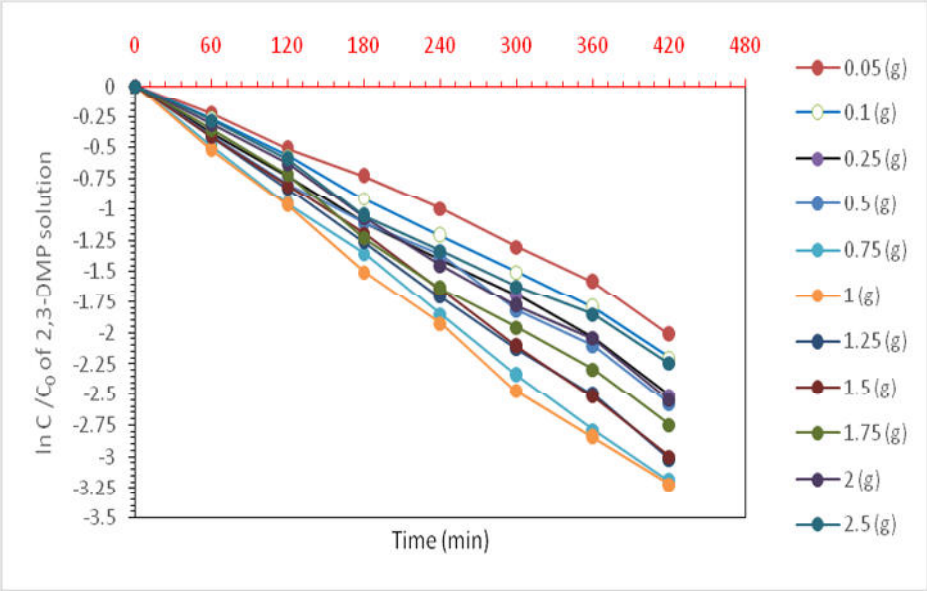
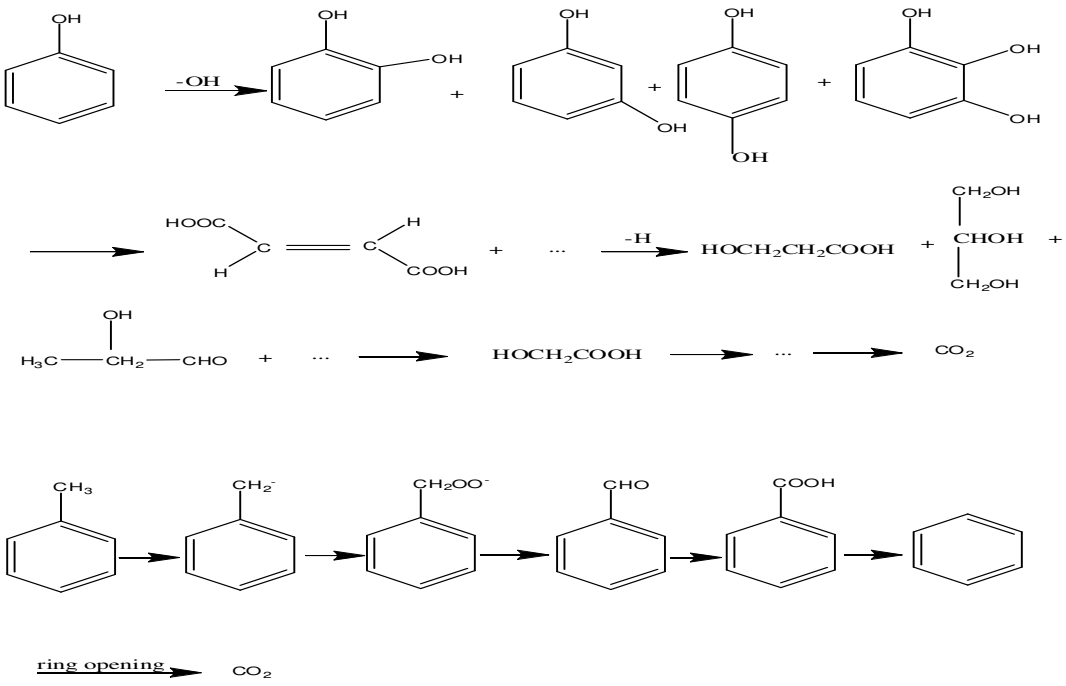


Fig 6. Decay rate of SnO_2



Scheme 1. Mechanism of photodegradation of 2,3-dimethyl Phenol