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ORIGINAL ARTICLE

Utilization of Moving Bed Biofilm Reactor for Industrial Wastewater Treatment Containing Ethylene Glycol: Kinetic and Performance Study

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ABSTRACT
Ethylene Glycol (EG) is one of toxic and hazardous materials that was used in many industries such as; synthetic fibers, films, antifreeze, resins, explosives, fibers, paper, leather, protective coatings, printing inks and textile. Many environmental problems such as: negative effects on aquatic life, destruction of aquatic ecosystems, soil pollution, reducing the oxygenlevel in the water absorption through skin contact, brain damages, damage to the Central Nervous System (CNS) and joints, eye damage, toxicity, etc., have been reported related with EG. In this study, ozone as an advanced oxidation method was used for the treatment of EG containing wastewaters. For this purpose, the impact of contact timeand pH variations on EG removal by ozonation at two level including low and high concentration (low= 5, 10, 20, 50, 100 and high=500, 750, 1000, 1500 mg/L) were examined. An EG removal kinetic analysis was determined based on removal rates via several ozonation times.At concentrations of 10, 20 and 50 mg/L after 180 minutes, removal of EG were achieved 93.31, 89.96, and 85.01 % respectively. Increasing pH has a direct impact on system efficiency and maximum efficiency corresponds to a concentration of 1500 mg/L 20.26 % was observed. Very good correlation coefficients at this kinetic study at all concentrations, investigated thatEG removal will follow the first-order kinetics. Increasing and decreasing pH has a dramatic effect on the efficiency of the system, so that the efficiency increases significantly at alkaline pH. According to the results ozone system can be an excellent option for EGcontaining wastewater treatment.
Keywords: Biofilm, ozonation, wastewater treatment

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INTRODUCTION

In order to prevent water resources and environmental pollution, Industrial wastewater treatment is one of the requirements oftoday's world. For this purpose the removal of hazardous compounds present in these wastewaters is one of the main problems so that many biological methods have been used extensively. Ethylene Glycol (EG) is one of this hazardous materials that was used in many industries such as; synthetic fibers, films, antifreeze, resins, explosives, fibers, paper, leather, protective coatings, printing inks and textile. The first use of EG was happened as an engine coolant in 1925. This use was initially low but gradually increased because of the benefits of EG, and now the largest consume of EG is to produce the engine coolant. absorption through skin contact, brain damages, damage to the Central Nervous System (CNS) and joints, eye damage, toxicity, etc. are the main problems that EG containing wastewaters are responsible for them [1-3].

Several methodswere used for treatment of EG containing wastewaters. Zevra et al. [4] were used wet oxidation for treatment of oily wastewater containing alcoholic and phenolic compound with high concentration of organic matter (COD≈11000 mg/L). They studied in a high-pressure agitated autoclave reactor in the temperature range of 180–260 °C and oxygen pressure 1 MPa and Increasing COD removal rate with increasing temperature were reported. They observed that, ethylene glycol showed great resistance to this process, among another compounds contained in the wastewater and Temperatures above 240 ◦C were required for its effective degradation. At 240 ◦C, WO process could decrease the concentration of ethylene glycol from 0.04 to 0.003 mol/L, while at lower temperatures decreased to 0.025–0.03 mol/L. Advanced oxidation processes (AOPs) were defined as a process in which that in normal temperature and pressure is carried out for the production of free radicals (especially OH^-) by

Glaz et al. Reactions have been identified during this process cannot produce highly toxic compounds. Decomposition of whole organic materials also can be done by AOPs. Kinetics of these reactions will occur in order to produce high concentrations of OH and substrate oxidation by free radicals.Among the advanced oxidation methods, ozonation have been introduced as the best possible options [5].
Ozone was discovered by Schonbein during his experiments with electrolysis of sulfuric acid in 1840. However, the ability of ozone to disinfection of contaminated water was first recognized in 1866 by Martinenec and was used in a larger scale for Nice (France) and Oudshoorn (Netherlands) drinking water disinfection. Ozone is a blue gas with pungent odor and strong oxidizing ability [6, 7]. Ozone can react directly with a chemical composition or produce the hydroxyl radical, which then reacts with it. Now a day ozonation, because of ozone oxidation potential and become rigid degradability and biodegradability of compounds to carbon dioxide, was used in water and wastewater treatment widely. In addition of organic and inorganic contaminants removal, ozone has high ability to removing color and odor, and unlike other methods, leaving no waste and sludge [8].For all the positive features listed for ozonation, this study was conducted for removal of EG containing wastewater by ozone.

MATERIALS AND METHODS

Chemicals and laboratory supplies

All chemicals used in this study such as EG,Sulfuric acid and NaOH was purchased from Merck. Ozone was produced by an ozone generator (ARDA - France (COG-1A) with a production capacity of5liters per minute,2g/h gas output. In addition a closed reactor (in order to ozoneand wastewater contact) was used that Figure 1illustrated it schematically.

Experimental methods

All experimental methods used in this study were in accordance with the procedures described in the standard method reference handbook. Input ozone concentration was measured by titration iodometric method. Measurement ofpH was done with using pH Meter(WTW-Germany). The method was used for measuring EG in samples was gas chromatography (GC).

Kinetics of the reaction

The study of chemical reaction kinetic can be a great help to give better understanding of the process. With assuming that, first order reaction was accruing, EG elimination kinetic by ozone was determined from Equation (1):

$$- dc/dt=k.C \qquad (1)$$

Equation 2 will achieved with integration Equation 1.

$$\ln C/\ln C_0 = -kt \qquad (2)$$

With plotting (-lnC/lnC0)vs. time, reaction kinetic scan be calculated from scope of diagram.

RESULTS AND DISCUSSION

Effect of concentration

Figure2 and figure 3 demonstrate the results of thefirst and second phase of research respectively. As can be seen in Figure 2 clearly, increasing the EG removal efficiency was occurred with increasing ozonation time. In concentration of 100mg/L, the EG removal efficiencies was about 10%inthe first20minutesofozonation and Itseemedverylow.After180minutes this number improved toa maximum amountof 70 %. Itwas very different results for the concentration of5 mg/Lso that at the first hour,64.4% of EGwas removedbyozoneandafter180 min the removal efficiency increased to 95.85%. At other concentrations of10, 20and50mg/L, the removalof EG after 180minuteswas93.31,89.96, and 85.01 %respectively. In the last 60 minutes of all the contact times, a very low significant scope was seen in increasing the efficiency of ozonation. With a careful look at the removal efficiency of the EG at 120 min, it can be seen that, with increasing the ozonation time from 120 to 180 min this removal rate increased 6.33 % averagely. This confirms that the optimized time for ozonation was 120 min. This trend was not observed at higher concentrations, as can be seen in Figure 2this EG removal increasing rate at concentrations of500to 1500mg/L was 21.25 % in average. Maximum and minimum removal efficiencies in this phase, was Obtained 55.87fortheconcentration of 500 mg/L whit ozonation time of 180minand 2.47 %for the concentration of1500mg/L whit ozonation time of 30 min. because of economical aspect of ozonation time, to increasing the time up to180 min was avoided.

Effect of pH onozonation

After the time variation and obtaining optimized ozonation contact time, the effect of pH Changes ontheefficiencyofthe system was determined.The results of this stage are summarized in tables1 and2.Ascan be seen in the tables, best results was observed near alkaline pH due to OH^0 radicals

production and Whatever we went to the acidic pH, because of consuming the OH^0 radicals, efficiency declining was observed. At this stage, the concentrations of5, 10, 20, 50and100mg/L at120min of ozonation time was selected and pH of3, 5, 7, 9and11 was set for determination the optimized pH. As results shows, Whit increasing thepHto11,the system was showed increasing in EG removal efficiency dramatically, at Concentration of 100mg/L, sothatfrom65.05% improved to 86.12 %.This trend was followed in other concentrations and increasing the efficiency around33/13at concentration of50mg/L from18/78 to 51/91 % was achieved. This increasing of system efficiency at concentrations of 20, 10, and5mg/L was achieved 14.06, 10.79, and 8.8, respectively. But this manner was different at acidic pH so that, decreasing in system efficiency was happened and this decrease was more visible and more evident.As results shows, a decrease inpHfrom7to3at concentrations of 100, 50, 20, 10and5mg/L, reduction efficiencies equivalent to18.45, 27.79, 23.16, 22.66, 22.15% was observed.

Effect of pH on ozone removal efficiency results at higher concentrations was summarized in Table2. The decrease inefficiency(acidic pH) and an increase in efficiency (alkaline pH) were achieved in the same way. pH decreasing from7 to 3 at concentrations of 500, 750, 1,000 and 1,500mg/L lead to the efficiency decreasing equal to 4, 10.08, 9.85, 5.86 %.The significant increase in the EG removal rate in alkaline pH is Notable. As is clear from Table2, with increasing pH from7to11 at 500 mg/L, improving the system performance was equal to17.72%.Thistrendforconcentrations of750, 1000and 1500mg/L was achieved16.94,14.02 and 20.26 %respectively.

Kinetics study of ethylene glycol ozonation

Kinetic analyses can help to better understanding of the reactions mechanism, so in this study kinetic of treatment of EG containing wastewater by ozone were also discussed. The reaction kinetics was studied in two stages. Figure 4 shows the kinetic analyses results at concentrationsof5, 10, 20, 50 and100mg/L. As is evident from the correlation coefficients for all the concentrations, investigated that EG removal was follow the first-order kinetic order.

The results of the reaction kinetics analysis at concentrations of500, 750, 1000and 1500mg/L were shownin Figure5. The results of the correlation coefficient were achieved equivalent 96.13, 95.92, 96.94and92.11 for concentrations of 500, 750, 1000 and 1500mg/L. K values and correlation coefficients obtained are summarized inTable3.

CONCLUSIONS

In this study, waste water containing ethylene glycol as an environmental problem was purified good byozone. Increasing and decreasing pH had a dramatic effect on the removal efficiency of the system, so that the alkaline pH improved it significantly. The effect of increasing the initial concentration of EG in the removal efficiency was negative and decreased with increasing the in let substrate concentration. Elimination kinetics study, confirm first-order kinetic rate and for the design of the systems must be carefully examined and considered.

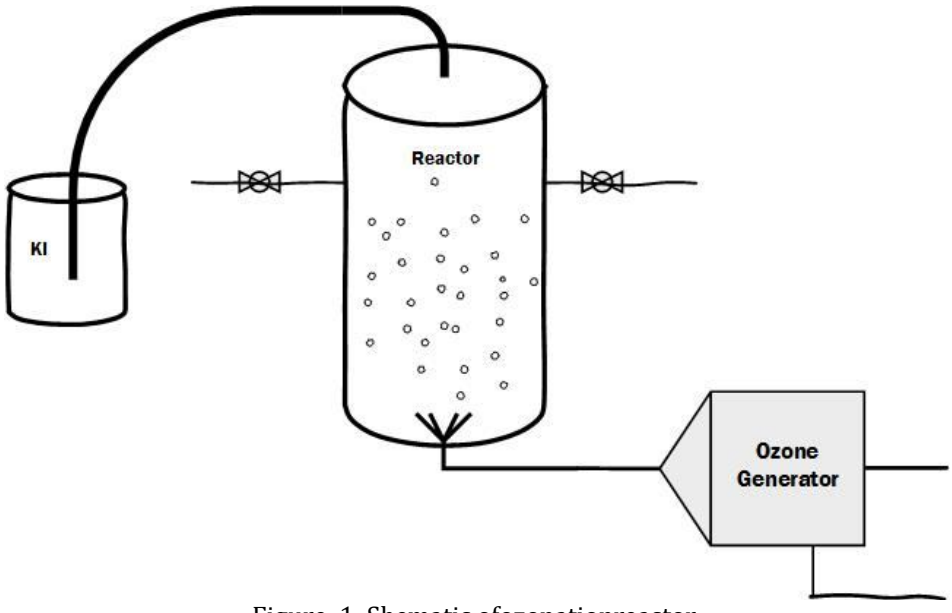

Figure :1: Shematic ofozonationreactor

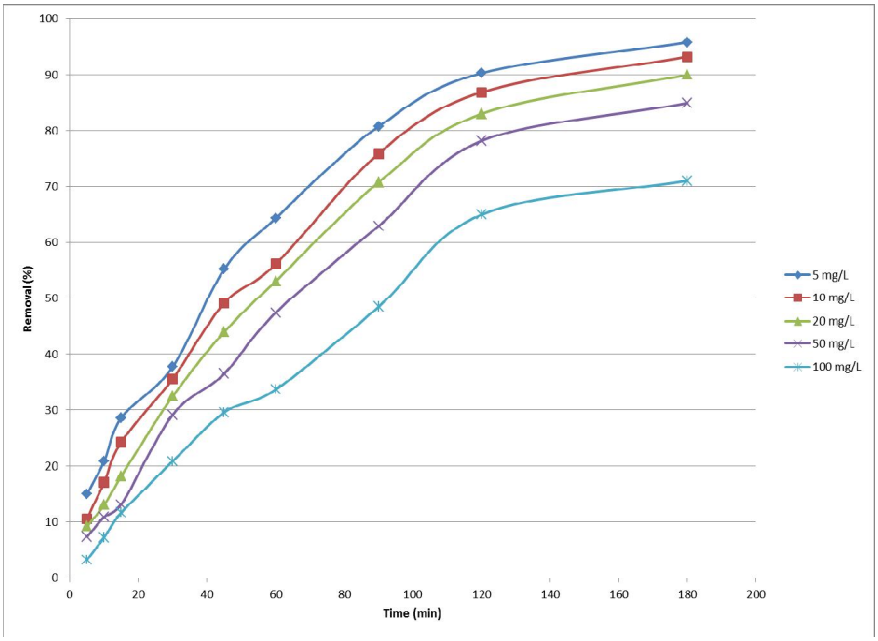

Figure 2 effect of ozonation time on EG removal efficiency (low concentration)

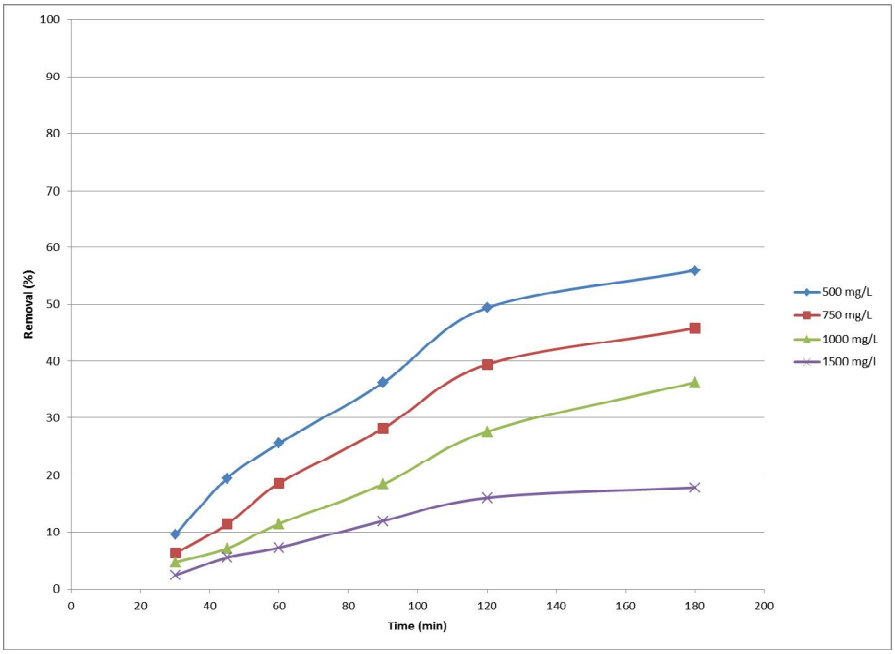

Figure 3 effect of ozonation time on EG removal efficiency (high concentration)

Table 1 effect of pH on EG removal by ozone (low concentration)

T (min)	pH	5	10	20	50	100
120	3	68.14	64.21	59.93	50.39	46.60
	5	79.31	75.41	70.29	63.84	49.96
	7	90.29	86.87	83.09	78.18	65.05
	9	93.31	91.22	90.92	84.44	77.21
	11	99.10	97.66	97.15	91.51	86.12

Table 2 effect of pH on EG removal by ozone (high concentration)

T (min)	pH	500	750	1000	1500
180	3	39.31	29.54	20.88	10.21
	5	43.00	32.21	23.11	12.31
	7	49.39	39.39	27.65	16.07
	9	58.76	51.32	34.12	28.66
	11	67.11	56.33	41.67	36.33

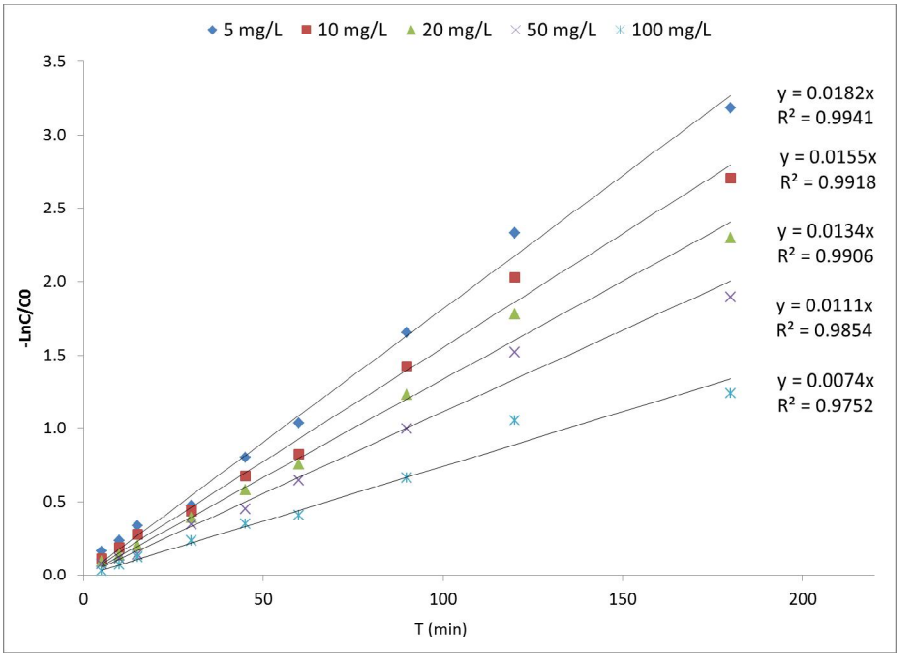

Figure 4 kinetic study of EG oxidation by ozonation (low concentration)

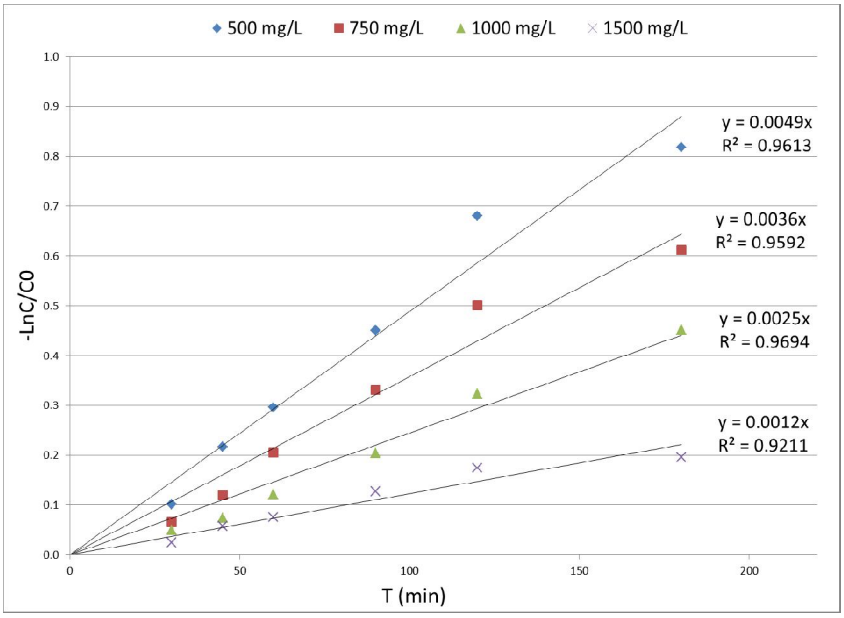

Figure 5 kinetic study of EG oxidation by ozonation (high concentration)

REFERENCES

1. P.M. Leth, M. Gregersen, (2005). Ethylene glycol poisoning,Forensic Sci. Int. 155 179-184.
2. WHO, (2002). Ethylene glycol: environmental aspects (Concise international chemical assessment document; 22), World Health Organization, Geneva.
3. C.A. Staples, J.B. Williams, G.R. Craig, K.M. Roberts. (2001). Fate, effects and potential environmental risks of ethylene glycol: a review, Chemosphere43 377-383.
4. Zerva, C., Z. Peschos, S. G. Poulopoulos and C. J. Philippopoulos (2003). "Treatment of industrial oily wastewaters by wet oxidation." Journal of Hazardous Materials 97(1–3): 257-265.
5. Tomiyasu H. Fukutomi H. Gordon G(1985). Kinetics and Mechanisms of ozone Decomposition in Basic Aqueous solutions.
6. Staehelin J. HoigneJ (1985). Decomposition of ozon in water in the prescence of organic solutes Acting as promoters and Inhibitors of Radical chein Reaction. Environment science & technology 19:1206- 1213.
7. Bruno, L.- David. A.R- Deborah , R.B. (1991). ozone in water treatment , application and engineering, AWWA .
8. Beltran FJ ,Garcia – Accdo B (1994). Advanced oxidation of atrazine in water – I ozonation water Research 28: 2153-2164.

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