The 2016 World Congress on
Advances in Civil, Environmental, and Materials Research (ACEM16)
Jeju Island, Korea, August 28-September 1, 2016

Degradation of Trace Ibuprofen in Water by a Novel Adsorption-Desorption-Biodegradation Process

* Yu-Tsung Chung[1)] and Meng-Hau Sung[2)]

[1), 2)] *Department of Environmental Science and Engineering, THU,Taichung Xitun District 40704, Taiwan*
[1)] *mhsung@go.thu.edu.tw*
[2)] *tw0933628879@gmail.com*

ABSTRACT

The objective of this study is to test the feasibility of the adsorption-desorption-biodegradation (ADB) process for the removal of trace organics in water, exemplified by ibuprofen, a well-known emerging contaminants frequently found in wastewater effluents. In adsorption, activated carbon (F-400) is employed to adsorb ibuprofen. Then, ozonated water produced by the micro-bubble reactor is injected to the column to remove ibuprofen by oxidative desorption. Finally, the desorbed solution is fed to a bioreactor to further remove residual organic byproducts. The rationale behind the ADB concept is to effectively treat concentrated ibuprofen, to efficiently minimize ozone usage, and to produce byproducts eligible for low-cost biodegradation. In experiments, adsorption isotherms at pH 5, 7, and 9 have been obtained, and desorption efficiencies at these respective pHs have also been tested. It was found that at pH 7, a desorption efficiency of over 90% can be achieved. In addition, the rate of biodegradation is significantly enhanced as a result of ozonation treatment. A mineralization of 72% was attained. From our results, it seems promising that this easy and low-cost ADB process can be used in future water reclamation processes when trace emerging contaminants are of high concerns.

1. INTRODUCTION

Pharmaceuticals and personal care products (PPCPs) in the environment are an emerging concern recently [1]. In the broadest sense, PPCPs consist of prescription drugs, non-prescription drugs, and consumer chemicals including fragrances and sun-screen agents. These compounds enter aquatic ecosystems mainly through human excretion into sewage systems [2]

A large number of PPCPs are being detected in surface waters. They are susceptible to be bioaccumulated in the animal and human organisms. It was found that their metabolites could be even more harmful than the parent compounds [3]

Hospital wastewater, wastewater from pharmaceutical industries, domestic wastewater treatment plants effluents and landfill leachates are the main sources of pharmaceuticals in waters [4]. In general, they cannot be totally degraded by

---

[1)] Graduate Student
[2)] Associate Professor

conventional wastewater treatments. Their presence in surface waters could have endocrine-disrupting effects on humans [5].

2. Experiments

There are three experimental stages in this study. At the first stage, activated carbons (F-400) with high surface area were used to adsorb contaminants (i.e., ibuprofen) from water. At the second stage, ozonation was applied to remove pollutants from the activated carbons. At the final stage, solution from ozonation treatment was further treated biologically to mineralize remaining constituents in water. Details on each stage are described below.

2.1 Adsorption by activated carbon

The activated carbon used is Granular Activated Carbon (GAC) F-400 with the particle size around 0.55 mm - 0.75 mm. The measured Brunauer-Emmett-Teller (BET) area is around 1000 m2 /g - 1500 m2 /g. Batch adsorption experiments were first conducted to determine the adsorption capacity of the GAC F-400. In column experiment, 4 g of GAC was packed to a glass column of 12 cm in length and 1.5 cm in diameter. The flow rate was fixed at 10 ml/min, and each column is run for about 180 minutes. Effluent samples were collected at selected times and were analyzed by HPLC. Fig.1 shows the SEM image of the GAC we used for experiments.

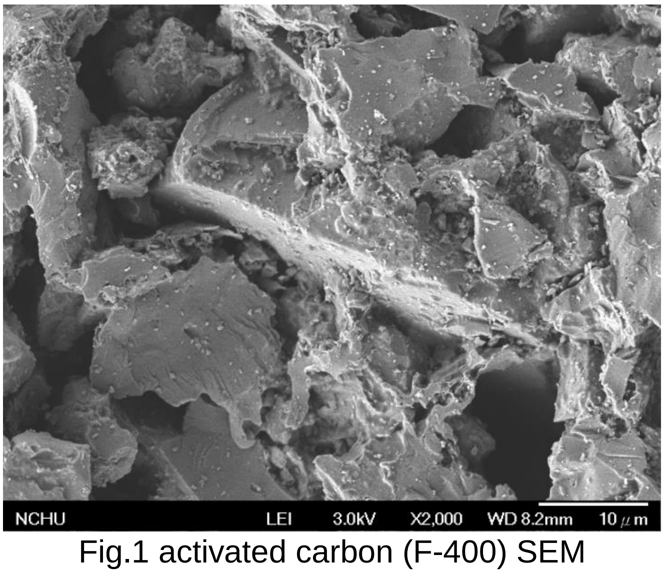

Fig.1 activated carbon (F-400) SEM

2.2 Ozonation treatment

Microbubble ozonation was employed to carry out the desorption process. A complete experimental reaction system is illustrated in Fig. 2. The microbubble has a mean size of 50 μm, capable of delivering highly efficient mass transfer. Experiments under different pH values were tested. Samples at selected times were collected and analyzed by both HPLC and TOC.

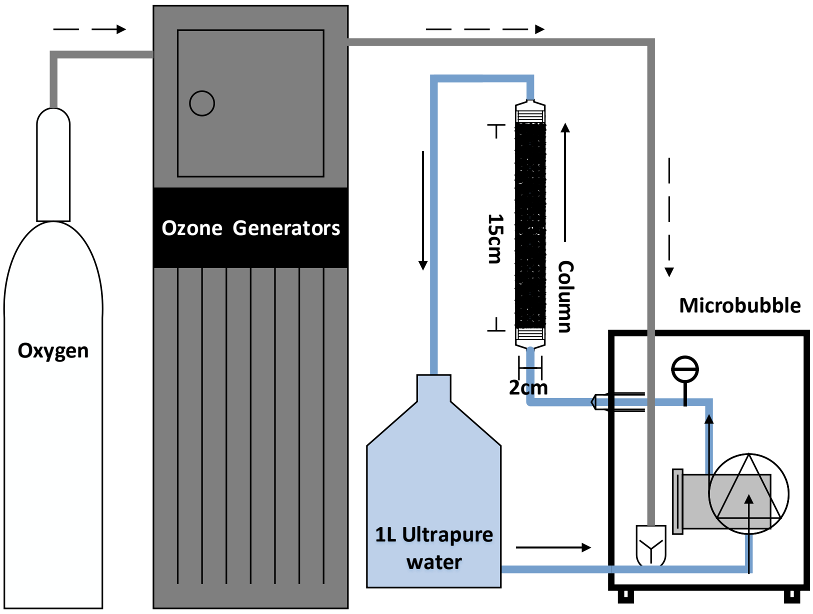

Fig.2 Experimental Reaction System

2.3 Biodegradation experiments

Solution at the end of ozonation-desorption process was further treated by biodegradation, using sludge obtained from a local hospital wastewater treatment plant. TOC content was analyzed daily in this experiment.

3. Results

Fig. 3 shows the adsorption isotherm of ibuprofen on GAC F-400 under three different pH conditions (5, 7, and 9). It is evident that the adsorption rate and capacity is large when pH values are between 5-7, close to the pH_{zpc} of GAC F-400.

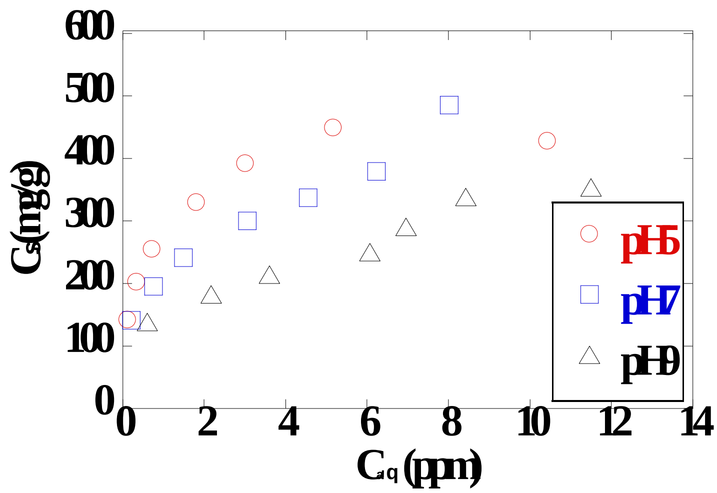

Fig.3 Adsorption isotherms of ibuprofen by GAC F-400

Table 1 shows the treatment efficiency at various stages under different pH conditions in column experiments. The adsorption efficiencies are all greater than 90%. The optimal pH for ozonation-desorption process is 7. Further biodegradation experiments are conducted only at this pH. So far, a mineralization efficiency of 72% can be achieved during biodegradation.

Table 1
The efficiency of the reaction in the various stages of different pH measured by TOC

	Activated Carbon Adsorption (%)	Ozone Microbubble Desorption (%)	Biodegradation(%)
pH5	**90%↑**	**40%**	x
pH7	**90%↑**	**88%**	**72%**
pH9	**90%↑**	**79%**	x

REFERENCES

[1] Jones OAH, Voulvoulis N, Lester JN. Human pharmaceuticals in the aquatic environment a review. Environ Technol 2001;22:1383– 94
[2] Daughton CG, Ternes TA. Pharmaceuticals and personal care products in the environment:agents of subtle change? Environ Health Perspect 1999;107:907– 38.
[3] S. Álvarez-Torrellas , A. Rodríguez, G. Ovejero, J. García, “Comparative adsorption performance of ibuprofen and tetracycline from aqueous solution by carbonaceous materials,” Chemical Engineering Journal 283(2016) 936–947
[4] J.V. Holm, K. Rugge, P.L. Bjerg, T.H. Christensen, Occurrence and distribution of pharmaceutical organic-compounds in the groundwater downgradient of a landfill (Grindsted, Denmark), Environ. Sci. Technol. 29 (1995) 1415–1420.
[5] A. Nikolaou, S. Meric, D. Fatta, Occurrence patterns of pharmaceuticals in water and wastewater environments, Anal. Bioanal. Chem. 387 (2007) 1225–1234.