Applicability of Synthetic Resin Sorbents for PFOS Removal from Water– Batch and Column test

GSE, Kyoto University	Student	○STMLD. Seneviratna
GSGES, Kyoto University	Assoc. Professor	S. Tanaka
GSGES, Kyoto University	Professor	S. Fujii
GSGES, Kyoto University	Assistant Professor	H. Harada
GSGES, Kyoto University	Post doc Researcher	C.Kunacheva

1.INTRODUCTION

Perfluorooctane Sulfonate (PFOS) is an anthropogenic organic pollutant, which was recently categorized as a Persistent Organic Pollutants. From the available literature, tap water and surface water samples in several countries were found to be contaminated with PFOS [1]. The objective of this study was to investigate and to compare the sorption behaviors of PFOS onto non ion-exchange synthetic commercial adsorbents including activated carbon. In this study, the sorption isotherms of PFOS for Dow V493, Dow L493 and Amb XAD and Filtrasorb 400 (GAC) were studied in detail by a series batch and column experiments.

2.MATERIALS AND METHODS

2.1. Isotherm and Kinetic Experiment

Adsorption isotherm experiment and kinetic experiment were performed with four granular materials using the bottle-point technique [2]. The conditions of the experiment are summarized in

Table 1. Experimental condition for the batch test experiment

Parameter	Selected value
Shaking duration	100 hrs
Shaking volume	100mL
Initial PFOS concentrations	10-50,000 μg/L
Sorbate added	0.1 g/bottle
Temperature	25 ^{o}C
Shaking speed	140 r.p.m

2.2 Column Experiment

PP columns with dimensions of 30 cm length and 2 cm internal diameter were used to contain four types of filter materials as fixed-bed adsorbers (20 cm^3 of each bed volume). Tap water filtered with an activated carbon filter (to eliminate residual chlorine) was mixed with PFOS stock solution to adjust the feed concentration to 10 μg/L. The mixed PFOS solution was fed through four columns with filter materials and a control column in down-flow mode. The effluents of each column were collected periodically and analyzed for the remaining PFOS concentration using a LCMS/MS.

3. RESULTS AND DISCUSSION

3.1 Sorption isotherms and kinetics

Fig 1 shows the variation of solid phase PFOS concentration with time. GAC reached the equilibrium concentration within 4 hrs, Amb XAD4 within 10 hrs and other materials took more than 80 hrs.

The adsorptive capacities of four granular materials were compared by fitting the experimental data to Freundlich equation (equation 1) and determining Freundlich adsorption constant.

$$q_c = K_f C_e^{1/n} \quad (1)$$

where q_c (μg/g) is the concentration in the solid phase, C_e (μg/L) is the equilibrium concentration of solute in solution, K_f (μg /g)(μg /L)$^{-1/n}$ is the Freundlich adsorption constant and n is the Freundlich exponent.

Isotherm parameters determined by this experiment is shown in **Table 2**. It was found that

isotherms of all filter materials were nicely fixed with Freundlich isotherm (R^2 = 0.92 – 0.99). Distribution of homogeneous pore size in the surface of synthetic polymers may be the reason

Table 2. Freundlich isotherm constants K_f((μg /g)(μg /L)$^{-1/n}$) and *n* for the adsorption of PFOS onto various filter materials at 25°C

Adsorbent	Isotherm parameters	
	K_f	*1/*n
Dow L493	54.6	0.84
Amb XAD 4	79.1	1.61
Dow V493	81.3	0.94
Filtrasorb 400	28.4	2.20

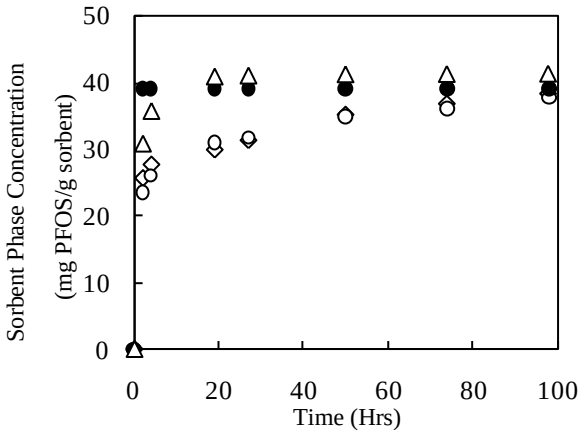

Fig. 1 Adsorption kinetic of PFOS onto GAC and synthetic polymers. Dow L493 (◇),Amb XAD 4 (△), V493(○), F400(GAC)(●)

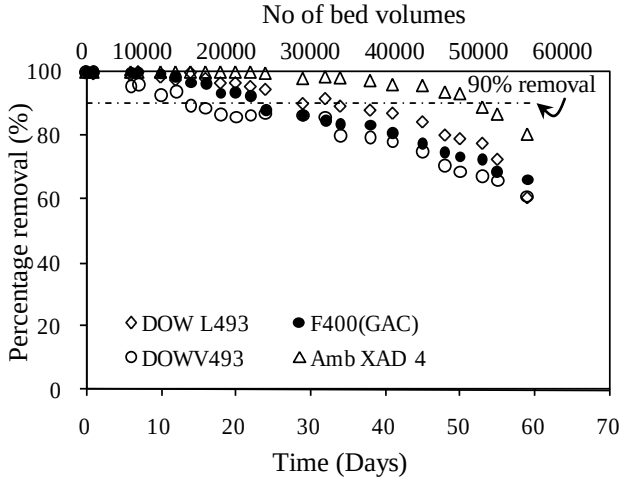

Fig. 2 The change of the rate of PFOS removal with time (60 days) for different filter materials in the column experiment

for higher K_f than GAC. In this study, GAC gave comparatively higher Freundlich exponent (n) than other filter materials, may be due to sorption site heterogeneity

3.2 Column Experiment

Figure.2 shows the percentage removal of PFOS in each column over the time (60 days). It was noticed for all polymers that the percentage removal efficiency for first 5000 bed volume is more than 99%. Amb XAD showed excellent performance by removing more than 99.99% PFOS from first 23,000 bed volumes passing through it.

Dow V493 first reached the 90% removal level after filtering 13,000 bed volume followed by F400 (GAC), Dow L493 and Amb XAD 4 after filtering the bed volumes of 25,000, 35,000 and 55,000 respectively. The results of column experiment can be explained by the results of batch experiments. Isotherm experiment gives an idea on available vacant sites and sorption kinetic implies the speed of attachment. Amb XAD4 showed higher sorption rate (**Fig 1**) and Freundlich isotherm constant (K_f = 79.1) and it was the best material in the column test also. GAC also showed higher sorption rate, but lower Freundlich isotherm constant (K_f = 28.4) whereas for Dow L493 and Dow V493 showed higher Freundlich isotherm constants (K_f = 54.6 and 81.3*)* but lower sorption rates.

References

[1]S. Fujii, C. Polprasert, S.Tanaka, P.H. Lien, Y.Qiu, New POPs in the water environment: distribution, bioaccumulation and treatment of perfluorinated compounds- a review paper, Water Sup Res. and Technol. - *AQUA*. 56.5 *(*2007) 313-326.

[2] Valeria, O. and Reyes, S. 2008. Removal of perfluorinated surfactants by sorption onto granular activated carbon, zeolite and sludge, Chemosphere. 72 (2008) 1588-1593.