

# REMOVAL OF HYDROGEN CHLORIDE GAS ON COPPER OXIDE IMPREGNATED ACTIVATED CARBON FIBERS

S. R. CHOI<sup>1</sup>, S. K. RYU<sup>1</sup>, S. J. PARK<sup>2</sup>, D. D. Edie<sup>3</sup>

<sup>1</sup> Dept. of Chemical Engineering, Chungnam University, Daejeon 305-764, Korea

<sup>2</sup> Korea Research Institute of Chem. Tech., P.O.Box 107, Daejeon 305-600, Korea

<sup>3</sup> Center for Advanced Engineering Fibers and Films, Clemson University, Clemson SC 29634-0909, USA

E-mail: [skryu@cnu.ac.kr](mailto:skryu@cnu.ac.kr)

## Introduction

Hydrogen chloride (HCl) is pungent and very toxic, and used as a model gas of chemical warfare agents. There are many studies on the removal of air pollutants, Inorganic gases can be removed from air by metal-impregnated activated carbons[1,2]. Activated carbon fibers (ACF) is a fibrous carbon adsorbent, known as an effective adsorbent for the removal of air pollutants[3]. However, there are few reports as against activated carbons in using catalyst supports for the removal of air pollutants. In this paper, copper oxide was impregnated on ACF to remove HCl gas.

## Experimental

### 2.1 Copper oxide impregnated ACF

A chopped ACF (KF-1500, Toyobo Co.) was added to  $\text{Cu}(\text{NO}_3)_2 \cdot 3\text{H}_2\text{O}$  solution. The  $\text{Cu}(\text{NO}_3)_2$  impregnated ACF was dried and heated up to  $500^\circ\text{C}$  to obtain copper oxides ( $\text{CuO}/\text{Cu}_2\text{O}$ ) and copper particles on ACF. The adsorption characteristics of copper oxide impregnated ACFs were measured by  $\text{N}_2$  adsorption at 77 K. The samples denoted in Cu-5, Cu-10, and Cu-20 were 5, 10, and 20wt%  $\text{Cu}(\text{NO}_3)_2 \cdot 3\text{H}_2\text{O}$  solution for copper oxide impregnation, respectively.

### 2.2 HCl gas removal

Copper oxide impregnated ACFs were packed in an adsorption bed column (i.d=20 mm). The HCl concentration in influent was 29,700ppm and flowed into the column at  $25^\circ\text{C}$ . The effluent gas was monitored by gas chromatography (AD 600).

## Results and Discussion

### 3.1 Characteristics of copper oxide impregnated ACF

Fig.1 is the XRD analysis showing the copper nitrate change on ACF; (a)  $\text{Cu}(\text{NO}_3)_2$  impregnated, dried at  $105^\circ\text{C}$  shows copper nitrate hydroxide peaks, (b) the ACF heated up to  $200^\circ\text{C}$  shows  $\text{CuO}/\text{Cu}_2\text{O}$  peaks, and (c) the ACF heated up to  $500^\circ\text{C}$  shows Cu peaks, (d) the  $\text{CuO}/\text{Cu}_2\text{O}$  reacted with HCl gas shows  $\text{CuCl}_2$  peaks.

Table 1 shows the characteristics of copper oxide or copper impregnated ACFs. The BET specific surface area and the pore volumes decreased as the increase of copper nitrate concentration increased. It seems that that copper oxides or particles blocked the entrance of narrow micropores, resulting in the increase of average pore diameter.

### 3.2 Removal of HCl through $\text{CuO}/\text{Cu}_2\text{O}$ impregnated ACF

Fig.2 shows the breakthrough curves of HCl on as-received, copper oxides, and copper impregnated ACF at  $25^\circ\text{C}$ . The breakthrough time of as-received ACF was extremely short in spite of large surface area. The breakthrough time of copper-impregnated ACF was somewhat better than as-received. The time was extended by using  $\text{CuO}/\text{Cu}_2\text{O}$  impregnated ACF showing the catalytic decom[position of HCl gas

resulting in orange-yellow colored  $\text{CuCl}_2$ . Therefore, following mechanisms were derived for the removal of HCl gas by copper oxides.

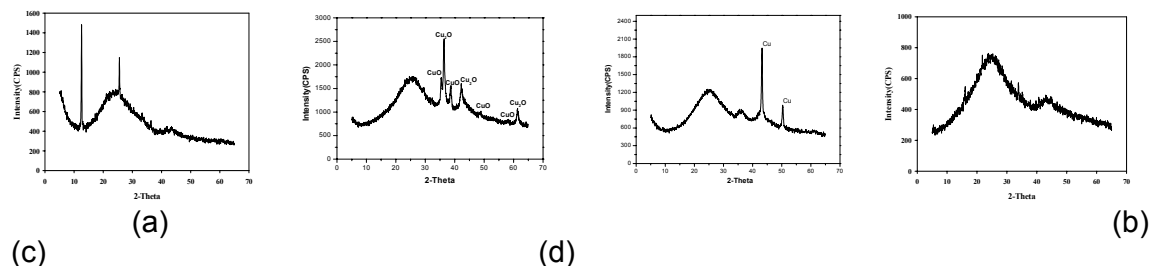
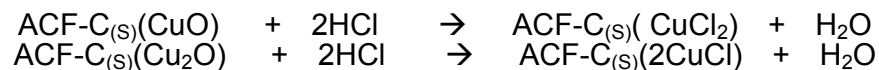


Fig.1. XRD curves of ACFs; (a)  $\text{Cu}(\text{NO}_3)_2$  impregnated, dried at  $105^\circ\text{C}$ , (b) heated up to  $200^\circ\text{C}$ , (c) heated up to  $500^\circ\text{C}$ , (d) after reaction with HCl gas at  $25^\circ\text{C}$

Table 1. Characteristics of copper oxide or copper-impregnated ACFs

| ACF (wt%/ $^\circ\text{C}$ ) | BET surface area ( $\text{m}^2/\text{g}$ ) | Total pore volume ( $\text{cc}/\text{g}$ ) | Micropore volume ( $\text{cc}/\text{g}$ ) | Average pore dia. ( $\text{\AA}$ ) |
|------------------------------|--|--|---|------------------------------------|
| Cu- 0                        | 1497                                       | 0.83                                       | 0.79                                      | 14.9                               |
| Cu- 5 /160                   | 1100                                       | 0.45                                       | 0.42                                      | 16.8                               |
| Cu-10/160                    | 840  | 0.33                                       | 0.30                                      | 16.9                               |
| Cu-10/200                    | 880  | 0.36                                       | 0.33                                      | 16.9                               |
| Cu-10/500                    | 1005                                       | 0.42                                       | 0.40                                      | 16.5                               |
| Cu-20/160                    | 610  | 0.27                                       | 0.22                                      | 18.9                               |

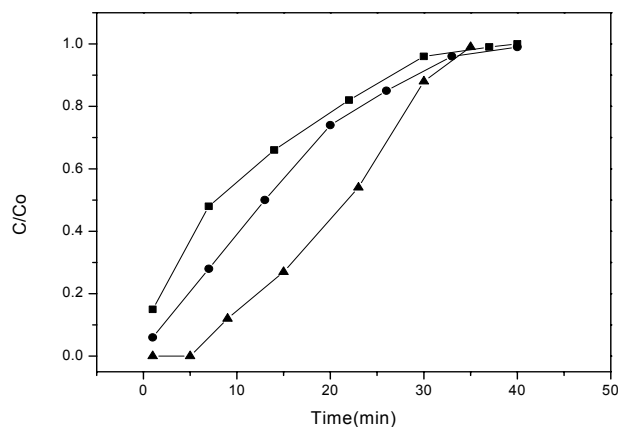


Fig.2. Breakthrough curves of HCl(g) on ACFs at  $25^\circ\text{C}$ . --■-- ; as received ACF, --●-- ; Cu-impregnated, --▲-- ;  $\text{CuO}/\text{Cu}_2\text{O}$ -impregnated ACF,  $C_0=29,700$  ppm,  $W=0.5\text{g}$ ,  $Q=0.5$  //min..

## Conclusions

Hydrogen chloride (HCl) gas can be removed by copper oxide ( $\text{CuO}/\text{Cu}_2\text{O}$ )

impregnated ACF at room temperature. The removal efficiency increased as the increase of copper oxide on ACF. Copper oxide was converted into copper chloride through the reaction with HCl gas.

## References

- [1] Illan-Gomez,MJ., Raymundo-Pinero,E., Garcia Garcia,A., Linares-Solano,A., Salinas-Martinez de Lecea C. *Applied Catalysis B: Environ.*1999:20:267-275.
- [2] Kaneko K., Ozeki S., Inouye K. Dynamic NO desorption characteristics of Iron-treated ACF. *Atmospheric Environ.* 1987:21(9):2053-2055.
- [3] Ryu SK. Porosity of Activated Carbon Fibers. *High Temp.-High Press.*, 1990:22: 345-354.