

RADON ADSORPTION IN ACTIVATED CARBON BY OPEN SYSTEM

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Introduction

Previous studies [1, 2, 3, 4, 5] have shown the elution behavior of radon through granular activated carbon (AC) and activated carbon fiber (ACF) of an open system. The elution times depends on AC and carrier gases. The shortest and longest elution times were observed in carbon dioxide and helium, respectively. Results suggested that elution is closely related to the pore characteristics of AC and ACF. In the present paper, we studied the elution behavior of radon through some special prepared activated carbon by using the open system. And calculated dynamic adsorption coefficient over activated carbon in He. Results suggest that surface oxide block radon adsorption in pores of activated carbon and some wood charcoal show a good radon adsorbent.

Experimental

Surface oxide rich activated carbons (SORAC) were prepared by two methods, and characterized by Tanaka of Kuraray Chemical CO. LTD.

(1) raw activated carbon in a variety volume of nitric acid were heated at 400 °C for 30 minutes under nitrogen flowing (3 l/min).

(2) raw activated carbon in 20 ml nitric acid heated at 400, 500, 600, 700, and 800 °C for 30 min. under nitrogen flowing (3 l/min).

Surface functional groups were analyzed by titration method and the results are summarized in Table 1.

Wood charcoal were prepared by following method, and characterized by Abe of Osaka Municipal Technical Research Institute

A block of Japanese cypress (33x33x220 mm) in a special made stainless steel vessel was heated to 900 °C, heating rate was 5 °C/min. and retention time was 3 (HM9-3) and 4.5 (HM9-4.5) hours, in a muffle furnace.

Commercial wood charcoal of Quercus aliena (IWATE)

(QA-IWA) and Quercus Phillyraeoides (KOCHI) (QP-KO) were also used. Characteristics of wood charcoal determined by BET method and calculated pore distribution by Cranston and Inkley method and the results are summarized in Table 2.

In a standard experimental, 3 g of SORAC or 1.5g of wood charcoal was packed in the U-tube which was placed in a thermostated bath at 50°C and helium flowing at 30 ml/min. Radon was injected into the tube just before the U-tube.

Results and Discussion

The radon elution times from the activated carbon and wood charcoal were studied. The dynamic adsorption coefficient (DAC (ml/g)) was calculated by equation (1).

$$DAC = Ft/w \quad (1)$$

where F, t and w are flow rates of carrier gas (ml/min), elution time (min) and weight of sample (g), respectively.

1) Surface oxide rich activated carbons

DAC at 50 °C in helium of SORAC were calculated and the results summarized in Table 1.

code	nitric acid	Functional group meq/g			DAC at 50 °C
	ml	I*	II*	III*	ml/g
AC400-1	1	0	0.012	0.126	1300
AC400-5	5	0	0.25	0.224	1100
AC400-10	10	0.154	0.265	0.356	900
AC400-20	20	0.267	0.224	0.468	800

*I: carboxyl group, II: lactone, III: phenolic hydroxyl.

Functional groups in Table 1 show lactone increased quickly, but saturated around 0.25 meq/g, soon. Carboxyl group appeared slowly. Phenolic hydroxyl appeared quickly and increased with with volume of nitric acid.

DAC decreased with functional groups increase. Lactone would produced near to rim of pores and blocked radon adsorption in pores. Carboxyl group and phenolic hydroxyl produced also near to rim of pores and disturbed radon adsorption in pores, because of it's volume and rotational movement. Totally, the oxide groups caused decreases of DAC.

These results suggest that radon adsorption on activated carbon is disturbed by surface oxide. And another type of oxide would another type of steric hindrance to radon adsorption. Surface functional groups of activated carbon deteriorate performance as adsorbent.

2) wood charcoal

code	A.S.A.	pore Volume	mean pore diameter	DAC at 50°C
	m ² /g	ml/g	nm	ml/g
QA-IWA	50	0.04	3.1	90
QP-KO	200	0.12	2.2	70
HM9-3	570	0.266	1.86	1200
HM9-4.5	720	0.319	1.76	4000

In Table 2, DAC values would classified to 2 types. Type 1 is QA-IWA and QP-KO, commercial wood charcoal. Type 2 is HM9-3 and HM9-4.5, Abe's wood charcoal. Type 2 have larger apparent surface area (A.S.A.), and pore volume and smaller mean pore diameters than type 1. These characteristics are preferable for radon adsorption. Although a ratio of DAC between HM9-3 and HM9-4.5 are more than 3 times, but differences of the characteristics are not so large. Previous studies [3] we have shown surface area of pore diameter less than 1 nm are greatly affected for radon adsorption in activated carbon. Surface area of less than 1 nm for these wood charcoal are 25, 17, 80, and 140 m²/g for QA-IWA, QP-KO, HM9-3, and HM9-4.5, respectively.

These values not clearly elucidated the 3 times difference. Some special pore on size and/or structure would produced in HM9-4.5

DAC at 0 °C in helium was 60 for QA-IWA, and 80 for QP-KO. Radon elution through HM9-3 and HM9-4.5 cannot detected more than 6 hours and DAC cannot calculated.

These results suggest that HM9-3, and HM9-4.5 have pores for radon adsorption, but QA-IWA and QP-KO have no. And DAC would closely related to porosity than surface area. Abe's method with optimal condition would produce good radon adsorbent.

Conclusions

- 1) Radon adsorption on activated carbon is disturbed by surface oxide, and another type of oxide would another type of effects to radon adsorption. Less surface functional groups is favorable for radon adsorption.
- 2) Some commercial wood charcoal have no pores for radon adsorption.
- 3) Special prepared wood charcoal with optimal conditions would good radon adsorbent.

References

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