Parametric Investigations on the Retention of Methyl Iodide by Activated Carbons

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Introduction

The retention of raodioiodine in the form of methyl iodide ($CH_3{}^{131}I$) by impregnated activated carbons is of considerable importance. This iodine species is one of the major compounds to be retained by iodine filters (adsorbers) operated in the exhaust air of nuclear power plants. It is used in tests on the suitability of carbons for use in iodine filters.[1,2]

In order to obtain relevant and reliable data, in recent years we have performed investigations on the influence of various parameters on the retention of $CH_3{}^{131}I$ by impregnated activated carbons. This paper covers the influence of the temperature, relative humidity and face velocity on the retention of $CH_3{}^{131}I$ by the carbons 207B (KI) and 207B (TEDA). More details of the investigations with 207B (KI) can be found elsewhere.[3]

Principles

The retention of $CH_3{}^{131}I$ by impregnated activated carbons is a complicated reaction involving many steps.[2] If the impregnant consists of KI, isotopic exchange is one of the steps. With TEDA and similar compounds as the impregnant, the formation of a salt is part of the reaction. The overall reaction is generally an irreversible reaction of (pseudo) first order. There is no theory by which the rate constant can be calculated from basic physico-chemical data as with homogeneous gas reactions.

The efficiency of sorbents to trap radioactive compounds is often characterized, amongst others, by the penetration P (%) and by the performance index K (s^{-1}). These are related to the rate constant k (s^{-1}) as follows:[3]

$$P = 100 \cdot \exp(-k\tau) \qquad (1)$$

$$K = (\log e) \cdot k = \sim 0.43\ k \qquad (2)$$

(τ: residence time in s)

In this paper the performance index is used.

Experimental

As already mentioned, the measurements were performed with the activated carbons 207B (KI) and 207B (TEDA). The content of impregnant is 1.5% and 5%, respectively. The base material is coal, the grain size 8 to 12 mesh. 207B (KI) is widely used in the iodine filters of nuclear power stations.

The measurements were carried out according to our standard procedure: ^{131}I, in the form of CH_3I, was injected in an air stream passing through a sequence of test beds (sections) followed by a sequence of backup beds.[1] 20 test beds were employed (diameter and depths: 2.5 cm).

The values of the parameters used in the tests covered in this paper are given in Table 1. Both standard values and the range of values are indicated. In each test only one value differed from the standard value. The range of values used frequently in various laboratories for routine tests is also indicated in Table 1.

Results

At standard conditions (30 °C, 70% R.H., 50 cm/s) the following performance indexes were obtained for the two carbons (average values and standard deviations for the bed sections):

207B (KI) : $K = (12.5 \pm 0.3)$ s

207B (TEDA): $K = (17.1 \pm 0.4)$ s

Both the average values and the standard deviations are quite typical. They are consistent with the finding that at ambient temperatures the K values of 207B (KI) are mostly at least two units lower than those of 207B (TEDA). As for the error of K, a value of ± 5% must be expected in general. It is mentioned that, according to Eqs. 1 and 2, this error in K numerically translates to a much higher error in penetration. With K = 12.5, for instance, the ratio of maximum and minimum values of penetration is about 2 at a residence of 0.25 s. Values obtained in different laboratories may differ by much higher factors.[4,5]

Table 2 contains the performance indexes of the two carbons as a function of the parameters investigated. The equations for K are of the same type for both carbons. K increases linearly with increase of the temperature, it decreases sublinearly (exponentially) with increase of the relative humidity and it increases sublinearly with increase of the face velocity.

Table 1. Test Parameters*

Parameter	Unit	Value		
		Used in these tests		Used frequently in various laboratories
		Standard	Range	
Temperature	°C	30	20 - 80	20 - 30
Relative humidity	%	70	20 - 99	70 - 99
Face velocity	$cm \cdot s^{-1}$	50	10 - 90	20 - 50

* Preconditioning time: 20h; injection time: 1h; purging time: 2h; I-127 concentration: 1 mg/m^3

Table 2. Performance Index K of the Activated Carbons 207B (KI) and 207B (TEDA) as a Function of Various Parameters

Parameter	Equation for $K(s^{-1})$	Values of constants a,b,c*			
		Index 1		Index 2	
		207B (KI)	207B (TEDA)	207B (KI)	207B (TEDA)
Temperature (t, °C)	$K = a_1 + a_2 \cdot t$	1.0(+1)	1.4(+1)	8.4(-2)	1.0(-1)
Relative humidity (h, %)	$K = b_1 \cdot e^{-b_2 \cdot h}$ **	3.5(+1)	4.7(+1)	1.5(-2)	1.4(-2)
Face velocity (v, $cm \cdot s^{-1}$)	$K = c_1 \cdot v^{c_2}$	1.9(0)	5.0(0)	5.0(-1)	3.0(-1)

* $1.0(+1) = 1.0 \cdot 10^1$ etc. ** 207B (TEDA): for 60 - 99% R.H. only

As for the constants in the equations, those with index 1 express the fact already mentioned above that K of 207B (KI) is lower than K of 207B (TEDA). The constants with index 2 show that the influence of the temperature and relative humidity is nearly the same for the two carbons. However, the influence of the face velocity is clearly different.

A further theoretical analysis must be performed to explain the similarities and differences mentioned in terms of rate controlling steps of the reaction. The importance of the functions with respect to the precision of tests on the retention of $CH_3{}^{131}I$ is dealt with elsewhere.[3]

It is mentioned that the results of our investigations are apparently compatible with those to be found in the literature for the same carbons.[6]

References

1. Wilhelm, J.G., "Iodine Filters in Nuclear Installations," Commission of the European Communities, V/2110/83 (1982)

2. Kovach, J.L., "The Evolution and Current State of Radio-Iodine Control," 16th DOE Nuclear Air Cleaning Conference, San Diego, 20.-23.10.1980, CONF-801038 (1981) 417

3. Deuber, H. and Gerlach, K., "Parametric Investigations on the Retention of Methyl Iodide by a KI-Impregnated Activated Carbon," Nuclear Safety (to be published)

4. Sigli, P., "Interlaboratory Tests on the Retention of Methyl Iodide by Different Adsorbents," CEC Seminar on Iodine Removal from Gaseous Effluents in the Nuclear Industry, Mol, 21.-24.9.1981, V/5283/82 (1982) 465

5. First, M.W., "CONAGT's Nuclear Carbon Roundrobin Test Program," 18th DOE Nuclear Airborne Waste Management and Air Cleaning Conference, Boston, 12.-16.8.1984

6. May, F.G. and Polson, H.J., "Methyl Iodide Penetration of Charcoal Beds: Variation with Relative Humidity and Face Velocity," AAEC/E322 (1974)