NEW FLOW METHODS FOR THE DETERMINATION OF GOLD ADSORPTION CAPACITY AND KINETICS ON ACTIVE CARBONS

A. J. Groszek, C. J. Steele**, Y. F. Jia** and K. M. Thomas***
**Microscal Ltd, 79 Southern Row, London W10 5AL, United Kingdom*
***Northern Carbon Research Laboratories, Department of Chemistry, Bedson Building, University of Newcastle upon Tyne, Newcastle upon Tyne, NE1 7RU, United Kingdom*

Introduction

Flow adsorption methods constitute an essential element in the chromatographic methods of selective adsorption and are widely applied in the separation of gaseous and liquid mixtures. Flow methods are also used for the determination of the active surface sites in catalysts, as proposed, for example, in BS Draft method 4359 [1]. The use of flow methods for determination of adsorption from solution has not received much attention compared with batch adsorption methods. A case in point is the determination of gold adsorption capacity of activated carbons[2].

Flow methods have now been successfully developed and used for the determination of gold adsorption capacity from dilute aqueous solutions and the adsorption/desorption kinetics. An extension of the methods involving injection of small aliquots of potassium aurocyanide solution permitted the evaluation of the ability of adsorbents to extract gold from very dilute solutions in short contact times.

Experimental

All reagents and solvents were supplied by Aldrich Co and had purities exceeding 99%.

Flow injection studies were carried out with a Microscal Mark 4 Flow adsorption microcalorimeter (FAMC) using a UV Spectrometer as an on-line down stream detector, as described recently [3]. Gold adsorption capacity was determined by Flow Equilibrium Analysis (FEA) using sequential adsorption/desorption cycles by injections of aqueous solutions $KAu(CN)_2$ (5 $mmoldm^{-3}$) into water. The Flow Injection Analysis(FIA) method involved injection of 20 μl of $KAu(CN)_2$ (10 $mmoldm^{-3}$) into the carrier liquid.

Both methods can be carried out at temperatures up to 120°C and pressures up to 4 bar. The adsorption can be determined simultaneously with the heats of adsorption.

Results and Discussion

The activated carbons used and some of their properties are listed in Table 1.

The gold adsorption capacities of various carbon adsorbents determined by the FEA method for irreversible and reversible adsorption processes are listed in Table 2 together with the results obtained by the AARL method. Figure 1 shows a typical sequence of adsorption/desorption cycles obtained by the FEA method for a coconut derived carbon.

The rating of the carbons by the latter method is clearly different from that obtained by the flow method for the coconut carbons. Similar trends are revealed by both methods for a series of carbons with different degrees of activation, but the differences for the more highly activated carbons are more clearly shown by the FEA method. The reason for the differences is mainly due to the fact that the AARL method determines both the irreversibly and reversibly adsorbed gold, whereas the FEA method rates the carbons on the basis of only the gold that is irreversibly adsorbed *i.e.* the gold cyanide that is strongly adsorbed from solutions having concentrations below the 50 $\mu moldm^{-3}$. It appears that as the activation increases the growth of the reversible adsorption continues, but the irreversible adsorption progresses very slowly for extents of activation exceeding 30% burn-off. It should be noted however that the rating of the carbons is very different depending on whether the reversible or irreversible adsorption is used as the criteria.

Striking differences in the rates of gold cyanide irreversible adsorption were revealed by the pulse injection FEA method for coconut and coal derived carbons. The differences appear to be much clearer than those shown by the AARL method. The rates of adsorption determined by the FIA method are sensitive to the composition of the aqueous solutions from which the adsorption takes place.

Conclusions

Two methods have been developed for the determination of the effectiveness of carbon adsorbents for the adsorption of gold compounds from aqueous solutions:

a) the FEA method for the determination of gold adsorption capacity which distinguishes between reversible and irreversible adsorption and

b) the FIA method which measures the rates at which the irreversible adsorption takes place. This method can rapidly identify the effectiveness of eluents for gold cyanide desorption at different temperatures.

References

1. B.S.I. Draft method 4359, Part 4, 12th January 1994.
2. Grigorova, B., Standard Analytical Procedures for Evaluation of Activated Carbons, AARL, Reference CA68, Johannesburg 1987.
3. Groszek, A.J. and Partyka, S., *Langmuir*, 1993, 9, 1721-1725.

Table 1
Properties of Active Carbons

Carbon Adsorbent	N_2(77K) Surface Area m^2g^{-1}	*Polar Surface m^2g^{-1}	$Hydrophobic Surface m^2g^{-1}
CS 1	1400	22	2640
CS 2	1393	24	2580
CS 3	1849	10	2945
Daw Mill Char 13% BO	500	35	846
Daw Mill Char 27% BO	630	27	1298
Daw Mill Char 43% BO	960	30	2029
Coventry Char 27% BO	900	24	1580

CS = Coconut Shell derived carbon

- determined from butanol adsorption from heptane

$ determined from butanol adsorption from water

Table 2
Adsorption Capacities of Active Carbons Determined by Flow (FEA) and Batch (AARL) Methods

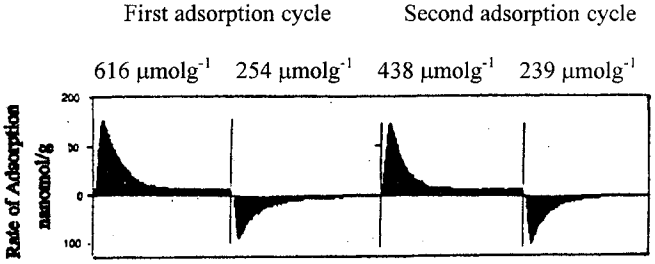
Carbon	Adsorption, $\mu molg^{-1}$*			AARL Results**	
	Total	Rever-sible	Irrever-sible	K***	R****
CS 1	404	342	62	7	66
CS 2	617	439	178	13	74
CS 3	471	333	138	14	80
Daw Mill Char 13% BO	156	93	63	14	39
Daw Mill Char 27% BO	251	193	58	19	74
Daw Mill Char 43% BO	354	216	138	23	92
Coventry Char 38% BO	389	187	202	-	90

* Index of gold Adsorption capacity using Freundlich Isotherm

** Index of adsorption rate

*** Adsorption from buffer solution

**** Adsorption from water



The difference between the amount of adsorption occurring during the first adsorption cycle and that during the second adsorption cycle is taken as the amount of irreversible adsorption

Figure 1. Adsorption/Desorption cycles of potassium Aurocyanide on CS1