

# ADSORPTION OF PLATINUM COMPLEX COMPOUNDS BY CARBON SORBENTS.

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## Introduction

Activated carbons and other carbon materials (CM) are known to be selective sorbents for compounds of platinum group's metals (PGM). In particular palladium, ruthenium, rhodium have been found to be extracted effectively by CM from the solutions with great excess of unnooble metals [1, 2]. It is important for practical use for waste and sewage treatment, for development of inserted catalysts, for the aims of analysis and purification.

Up to now there are few data on the sorption of platinum compounds by carbon materials (CM). This paper presents the results of investigation of sorption capacity and selectivity of carbon materials with different ion-exchange properties as concern variety of complex ions of platinum.

## Experimental

The set of CM under study includes:

anion-exchange carbons and fibres (technical charcoal - BAU, activated anthracite AA, activated carbon AC-1, synthetic carbon Sibunit, activated carbon fibre CF); cation-exchange materials (oxidised activated carbon AC-O, oxidised technical charcoal - DOU, oxidised carbon fibre CF-O)  
- materials with amphoter properties (nitrogen containing synthetic carbon - SKN and its oxidised form - SKNO).

In addition, the sorption of platinum compounds by ion-exchange resins VP-1Ap (anionite) and KU-2-8 (kationite) were studied for comparison.

The chloride acidic aqueous solutions containing platinum(IV) chloride compounds with different concentration (from 0.5 mg/l to 10 g/l) were the main objects of investigations. The solutions of anionic, cationic and neutral platinum complexes ( $[\text{Pt}(\text{NH}_3)_5\text{Cl}]\text{Cl}_3$ ,  $\text{K}_2[\text{Pt}(\text{NO}_2)_4]$ ,  $[(\text{NH}_3)_2\text{Cl}_2\text{Pt}]$ ,  $(\text{NH}_4)_2[\text{PtCl}_6]$ ,  $(\text{NH}_4)_2[\text{PtCl}_4]$ ) were also used for static sorption.

0.1 g of the adsorbent's sample was added to the 10 ml of aqueous solution of platinum compounds for the static sorption experiments. Two types of systems were

studied: one-component solutions of platinum chloride complexes and the same with 10 - 500-fold excess of commonly accompanying metals' ions (copper, iron, cobalt, nickel, manganese, chromium, aluminium, zinc). The concentrations of the platinum ions in the solutions were determined after 24 hours contact time (equilibrium concentration of the ions in the solution was reached practically after 4 - 6 hours contact time). Platinum ions were determined in the form of complex with  $\text{SnCl}_2$  [3]

The columns (1.5 cm diameters, 30 cm length) were used for the investigations of the sorption processes in the dynamic conditions. The rate of passing of the solution through column was about 30 - 50 ml/h.

## Results and Discussion.

The sorption capacity of the CM concerning platinum chloride complexes was found to be relatively high. Nearly 80 - 100 mg of platinum are sorbed per 1 g of sorbent from the solution with this element concentration about 5-10 g/l. The coefficients of distribution of platinum ions for different materials are of the order of 200 - 500. Platinum ions are sorbed by CM under study and the sorption does not depend on ion-exchange characteristics of the carbons. The sorption capacity of the oxidised species (cation-exchange carbons) is about 15-30% lower than capacity of the same unoxidised materials. The capacities of SKN-type carbons and carbon fibres concerning platinum ions extraction were found to be highest among the materials under study.

The high selectivity of platinum ions sorption was found by investigations of the sorption processes for multicomponent solutions. The presence of 500-1000 fold excess of unnooble metals has practically inappreciable effect on the sorption of platinum ions as in static as in dynamic conditions. The selectivity coefficients ( $K_s$ ) calculated as ratio of platinum sorption  $a_{\text{Pt}}$  in multicomponent solution to the corresponding value  $a_{\text{lim}}$  for platinum at the same equilibrium concentration in one-component solution were found to be 0.91-1.0 for different CM. The analysis of the ash after

burning of the saturated CM after dynamic sorption from multicomponent solutions confirms that residue contains mainly platinum compounds ( Table 1).

Table 1. The relative contents of the elements in the origin solutions and on the sorbent after the passing of the 1500 ml of the solution through the column with 15 g of CM

| Element | Relative content, % |         |
|---------|---------------------|---------|
|         | solution            | sorbent |
| Pt      | 12.2                | 88.5    |
| Mn      | 14.2                | 0       |
| Fe      | 13.2                | 7.0     |
| Co      | 7.6                 | 0       |
| Ni      | 22.1                | 1.7     |
| Cu      | 30.7                | 2.8     |

The results of the sorption of complex ions of platinum with different charge by carbon materials and for comparison by some ion-exchange resins are presented at Table 2.

Table 2. Sorption of platinum complexes by CM and ion-exchange resins (m = 0,1 g; V =10 ml; t=24 h; c<sub>Pt</sub> = 40,0 mg/l).

| Sorbent | Adsorption values*, mg/g |     |     |     |     |
|---------|--------------------------|-----|-----|-----|-----|
|         | I                        | II  | III | IV  | V   |
| AA      | 0,3                      | 2,9 | 1,8 | 2,6 | 2,7 |
| Sibunit | 0,5                      | 2,0 | 1,5 | 2,9 | 2,6 |
| AC-1    | 0,3                      | 3,0 | 1,7 | 3,0 | 2,9 |
| AC-1-O  | 2,8                      | 1,2 | 2,3 | 1,2 | 1,5 |
| BAU     | 0,5                      | 3,0 | 1,5 | 2,8 | 2,9 |
| SKN     | 0,6                      | 3,1 | 2,9 | 3,2 | 3,1 |
| SKNO    | 2,5                      | 0,9 | 2,1 | 1,9 | 1,8 |
| VP-1Ap  | 0,2                      | 2,9 | 1,5 | 3,0 | 3,0 |
| KU-2-8  | 2,7                      | 0,1 | 0,2 | 0,1 | 0,1 |

\* I - [Pt (NH<sub>3</sub>)<sub>5</sub>Cl]Cl<sub>3</sub>, II - K<sub>2</sub>[Pt(NO<sub>2</sub>)<sub>4</sub>],  
 III - (NH<sub>3</sub>)<sub>2</sub>Cl<sub>2</sub>Pt, IV - (NH<sub>4</sub>)<sub>2</sub>[ PtCl<sub>6</sub>],  
 V - (NH<sub>4</sub>)<sub>2</sub>[ PtCl<sub>4</sub>]

It was found that cationic platinum compounds are effectively sorbed by cation-exchange resins KU-2-8 and cation-exchange modifications of CM (FC-0, SKNO), the sorption of these compounds by carbons with anion-exchange characteristics are relatively low. The neutral complex ion - cis-dichlorodiaminoplatinum - was practically not sorbed by cation-exchange resin, but it was sorbed effectively by the anionite VP-1Ap and all forms of CM. Anionic forms of platinum complex - nitrite and

chloride compounds of Pt(II) and Pt(IV) - were also sorbed essentially by anion-exchange resins and by all modifications of CM. However the values of sorption of such complexes were appreciatively lower at oxidised species than at unoxidized ones in the same conditions (Table). The importance of ion-exchange processes for the sorption of platinum compounds by ion-exchange resins and CM was found by the data obtained. However, the another types of interaction are also certain for these materials. The platinum compounds sorption by carbon materials seems to be complex process. Besides ion-exchange it includes specific donor-acceptor interaction of platinum ions with π-systems of carbon matrix, which could be considered as part of the ligand environment of the metal ions. Such interaction results in the partial (complex formation) or full (reduction of platinum ion to metallic state) electron transfer from the carbon to the platinum ion. It appears to be the main reason of high selectivity of the sorption of platinum compounds and compounds of another PGM ions by CM because such processes are unlikely for the complexes of un-noble metals. For the CM with oxygen- and nitrogen-containing groups at the carbon surface the complex formation with these ligands seems to be additional contribution to the sorption mechanism.

So, the good perspectives of the use of variety of carbon materials for the sorption of platinum compounds from the high mineralized solution containing great excess of accompanying metal ions was shown from the data obtained.

## References

- [1] Tarkovskaya IA, Tikhonova LP, Tomashevskaya AN, Goba VE, Antonova LS, Svarkovskaya IP. Sorption of complexes of ruthenium, rhodium and palladium by the materials based on natural coals. Russ. J. Phys. Chem. 1996; 70(8): 1463-1457.
- [2] Tikhonova LP, Tarkovskaya IA, Rosokha SV, Kulik NV, Korovin YuF, Komarov VP, Kadochnikov VA. Selective sorption of platinum metals compounds by different materials Russ.J.Applied.Chem. 1998; 71( 10): 1632-1637.
- [3] Ginzburg SI, Ezerskaya NA, Prokofyeva IV. Analytical chemistry of platinum metals Nauka:Moscow. 1972.