# PECULIARITIES OF ADSORPTION OF GOLD AND SILVER FROM CYANIDE SOLUTIONS

V.V.Strelko, V.V.Dudarenko

Institute for Sorption and Problems of Endoecology,
National Academy of Sciences of Ukraine, Kiev

## INTRODUCTION

First the process of the removal of gold from cyanide solutions on charcoals was patented in USA by Johnson as early in 1894 [1]. But only beginning from the 60-ths this technology was being introduced actively in hydrometallurgy of gold.

Nowadays some countries use the so called "carbon-in-pulp" technology which is based on the specific adsorption of the metal by granulated carbons directly from the cyanide pulp [2]. Although such a process is more economically preferential and easily performed in industry than the precipitation of gold on zinc powder or its removal on anion exchange resins the "carbon-in-pulp" technology was not spread thoroughly the world because of the lack of the high-strength granulated carbons and the scientifically based recommendations how to apply this technology under one or another conditions.

## RESULTS AND DISCUSSION

In this paper we present data on the comparative study of the mechanisms of adsorption of gold and silver from the cyanide multi-component solutions on charcoals and "fruit shell-and nut" carbons as well as on synthetic carbons, produced from porous copolymers and resins and differentiated as a specific type of carbon adsorbents [3, 4]. The process of the specific adsorption on the noble metals from the cyanide solutions was shown to be the reduction reaction of them in the process of their adsorption resulting in the formation of the gold and silver surface fragments in pores. This process is directly related with electrochemical properties of carbons.

On the basis of the kinetic curves and the isotherms of adsorption we have shown that "the industrial charcoals", produces from wood or anthracite, can adsorb 10-20 mg/g of gold from cyanide solutions and some 4-5 mg/g of silver. In the case of "fruit shell-and-nut" carbons this value is in the range of 40-45 mg/g, and, lastly, "synthetic" carbons, produced from styrol divinyl benzene copolymers and phenol formaldehyde resins, can adsorb as much as 45-50 mg/g of gold.

The value of adsorption of gold and silver is substantially effected by the presence of heteroatoms of nitrogen, sulfur and oxygen in graphitic lattice of carbons. In such a manner "synthetic" carbons, having up to 4 % of nitrogen or up to 1 % of sulfur, posses the largest adsorption capacity and can adsorb as much as 60-80 mg/g of gold. Larger than 1 % sulfur content (as well as oxidation of carbon in air or by other oxidizers) rapidly reduces the amount of the adsorbed gold. It has to be noted that adsorption of noble metals increases as the specific surface area of carbons rises, all other factors being the same.

Fig.1. represents the bands, formated by adsorption isotherms for all carbons. These bands clearly characterize the adsorption capacity of different carbons to adsorb gold from cyanide solutions.

Using X-ray photoelectron spectroscopy and calorimetry we proved that affinity of d-metal cyanides to the carbon surface is associated with the formation the weak-complexes with carbon surface. In the case of noble metal cyanides a high selectivity and adsorption capacity is accounted for the reduction of them on the carbon surface due to electrons, generated by carbon. In this process the cluster compounds are formed in which the oxidation number of gold and silver is 0.3. Probably groups, which form these clusters, are carbon surface and $CN^-$ anions.

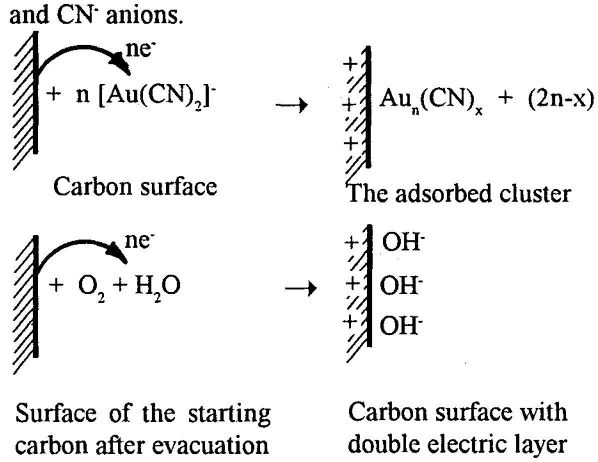


Figure 2 - Scheme of metal reduction on active carbons

It is worth to be noted that reduction of the noble metals on carbon surface is similar, as to its physico-chemical nature, to the reduction of oxygen to form double-electric layer in aqueous solutions (Fig.2).

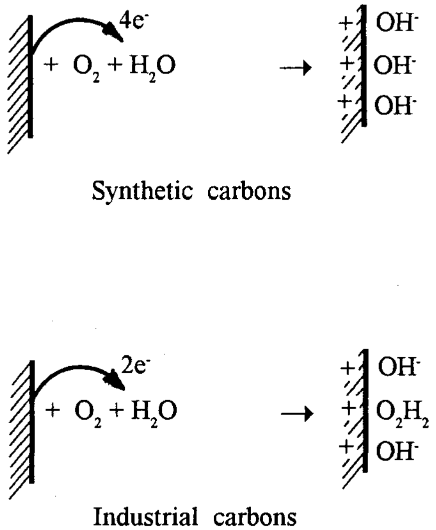


Figure 3 - Schemes of oxygene reduction on synthitic and industrial carbons

The dependencies of the stationary potential as well as capacity of carbons to adsorb gold and silver on pH value are linear. It means that they have a similar nature. Maximum value of electrochemical potential and maximum adsorption capacity was noted in acidic solutions with pH 1.5-3.0..Investigating the kinetics of formation of the electrode potentials in active carbons having a different molecular nature, we have shown that the value of difference between the stationary potential and initial one ΔE appears to be the quantitative estimation of the reducing properties of carbons. The largest value ΔE was found for the synthetic carbons and, therefore, they have the best reducing capacity to adsorb gold and silver among different carbons. To our mind it is accounted for the absence of defects in their graphitic lattice. As a result π-conjugated electrons in their structure are rather extended and, consequently, they good reducing agents. Electronic work function of synthetic carbons is less than in other carbons. From this view point the positive effect of the given amount of heteroatoms of nitrogen and sulfur is related to the so-called "correction" of the existing defects in the graphitic lattice of carbons as far as $p_z$-electrons of nitrogen and sulfur are involved in the overall π-electron conjugation (Fig.3). We were the first to show that the reduction of oxygen to form a double electric layer on synthetic carbons proceeds according to the four-electron mechanism, whereas in industrial carbons according to the two-electron mechanism.

## CONCLUSION

So, data, presented in this paper, testify the molecular structure of carbons is particular importance for adsorption of noble metals from cyanide solutions. It makes possible to direct the synthesis of active carbons with optimum properties for the needs of hydrometallurgy of gold and silver.

## REFERENCES


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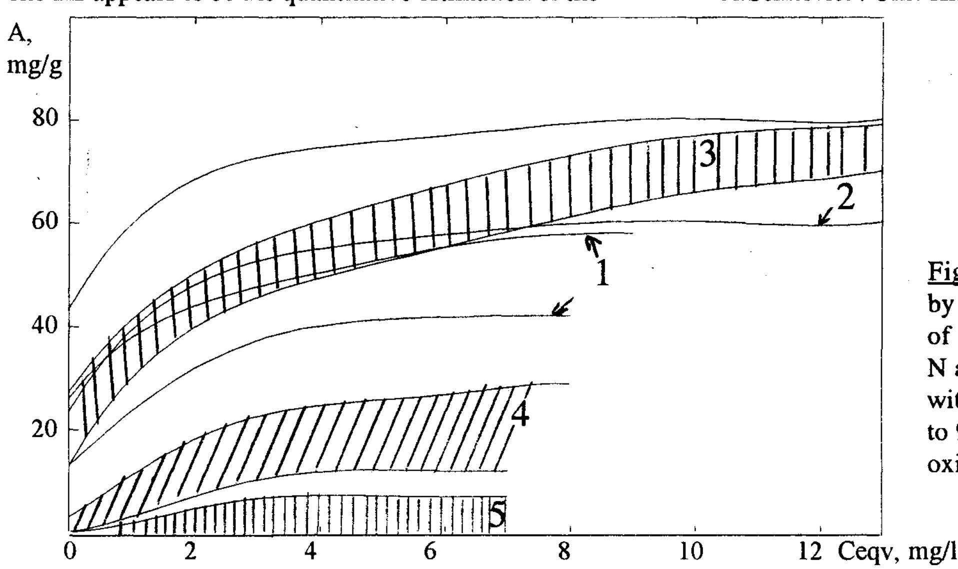


Figure 1 - Areas, formed by isotherms of adsorption of Au on carbons without N and S (1), with N (2), with 1% of S (3), from 2 to 9% S (4) and their oxidized modifications (5).