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The investigation of electroreduction of $AuCl_4^-$ in the case of gold electrosorption using activated carbon

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ABSTRACT

This paper reports a study of the kinetics of the initial stages of electroreduction of $AuCl_4^-$ in the case of gold electrosorption using activated carbon. The activated carbon was synthesized from rice husk by the chemical activation. Obtained sorption materials were characterized by Raman Spectroscopy, Transmission electron microscopy, Scanning electron microscopy and SORBTOMETR-M techniques. The kinetics of electrodeposition of gold (III) on platinum from chloride electrolytes by the cyclic voltammetry and chronoamperometry methods have been studied. Chronoamperometric measurements were performed at the potential of +0.2 V vs. Ag/AgCl with varying gold concentration and temperature. Diffusion coefficient of Au^{3+} ions determined by the cyclic voltammetry method on the basis of the Randles-Ševčik equation is in good agreement with the value determined by the chronoamperometry using the Cottrell law.

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1. Introduction

Activated carbon is a carbon-containing adsorbent having a developed porous structure and large surface area. Activated carbon can be produced from nearly any carbon-containing material by physical or chemical activation methods [1–6].

The authors of this study selected rice husk (RH) as a raw material for preparation of activated carbon, subsequently used as an adsorbent. RH is a renewable, low-cost agricultural waste, which is widely spread in south Kazakhstan. The sorption material obtained from the RH has a wide field of application. Some Kazakhstan scientists investigate RH from different regions of Kazakhstan using it mainly as an adsorbent for waste water treatment and similar purposes [7–12], production of technical silicon [13] or for the supercapacitors [14,15].

According to the literature data [16], it was claimed that the series of adsorbents based on carbonized RH (CRH) have a rather low redox potential and the stationary potential is in 0.229 V (Ag/AgCl). The measured stationary (real) potential of $[AuCl_4^-]$ in hydrochloric acid medium is equal to 0.760 V (Ag/AgCl). The potential difference between gold – oxidizing agent and sorbent – reducer is 0.531 V. For complete procedure (99.9%) of any redox reaction, a potential difference of 0.3 V is required [17]. From these data, it can be concluded that there is a real possibility for reducing Au^{3+} to a metallic state. This possibility is confirmed by electron microscopic images [16]. It follows that the sorbents of CRH possess reducing properties, due to the presence of reducing groups such as carboxyl, phenolic, hydroxyl, amine on the surface of these carbon materials [18].

Carbonized adsorbents are not only ion-exchanged [16], but also oxidation-reduction adsorbents. It follows that the process of metallic gold extraction and oxidation of reduction groups of the sorbent is electrochemical, i.e. there are cathode and anode sites. Cathode sites on which their further proceeds reduction of gold (III) are formed at the initial moment of sorption. The chemistry of Au^{3+} sorption on CRH can be represented as:

$$\text{Cathodic process}: AuCl_4^- + 3\,\bar{e} \rightarrow Au^0 + 4Cl^- \quad (1)$$

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