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## Joint destruction of cadmium and copper at alternating current electrolysis in sodium hydroxide solution

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### Abstract

The dependence of the metal oxidation rate on the current density and temperature of joint destruction in sodium chloride was studied. It is established that the dependence of the oxidation rate of copper is linear and generally do not differ from the dependencies established at individual oxidation of copper in the solution of sodium chloride with concentration 46.5 % wt. In contrast to the oxidation rate of copper, the oxidation rate dependence of cadmium has extreme character and the oxidation rate of cadmium at its joint oxidation of copper increased in 2-3 times indicating that the mutual influence of electrodes at the electrochemical process with alternating current. Thus, the obtained dependences can predict operating electrolysis parameters a obtain copper-cadmium oxide system of the given composition.

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### 1. Introduction

Technologies of electronic products, which are used as transparent materials, are based on the use of active oxide semiconductors and multicomponent dielectrics<sup>1,2</sup>. A special role belongs to the semiconductor of n- and p-type<sup>3</sup>. The actual problem is the mutual dosage in a wide range of the ratios of nanostructured materials having different types of conductivity to create composites of the specified composition and products on their base with unique properties. Synthesized materials are used for production of sorbents, catalysts, sensors, electrochemical and photochemical devices<sup>1,4-8</sup>.

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Currently, there is a natural interest in the methods of metal oxides synthesis and their dual systems based on the processes taking place in non-equilibrium conditions<sup>9,10</sup>. Unique opportunity to obtain double-oxide systems is the alternating current use under electrochemical synthesis. In particular, the use of alternating current of industrial frequency allows obtaining dual-oxide systems with particles in the nanometre range and uniform distribution of the components of the matrix<sup>11</sup>.

The influence of such parameters as current density, composition and concentration of an electrolyte, temperature on the rate of electrochemical process determines and provides the direction of the research. It is possible to get double systems of metal oxides with given composition only at the detailed selection of electrolysis regimes to regulate the oxidation rate of each metal separately. The aim of this work is to study the regularities of speed change of the electrochemical synthesis process the copper-cadmium oxide system on the density of the alternating current at different temperatures.

## 2. Materials and Method

Investigation of kinetics of joint electrochemical oxidation for cadmium (mark CD) and copper (mark M1) with alternating current of industrial frequency was in accordance with the method described in the<sup>12</sup> at variation of the current density from 0.5 to 3.3 A/cm<sup>2</sup> at temperatures in the range of 60 and 70 °C. Sodium hydroxide was used as an electrolyte (mark "analytical grade") with a concentration in solution 46.5 % wt. The selected electrolyte concentration is based on earlier studies on the speed of individual oxidation of cadmium and copper<sup>13,14</sup>.

The dependence of the joint oxidation rate for copper and cadmium on current density in sodium hydroxide solution with a concentration of 46.5 % wt. at temperatures of 60 and 70 °C in Fig. 1 and 2.

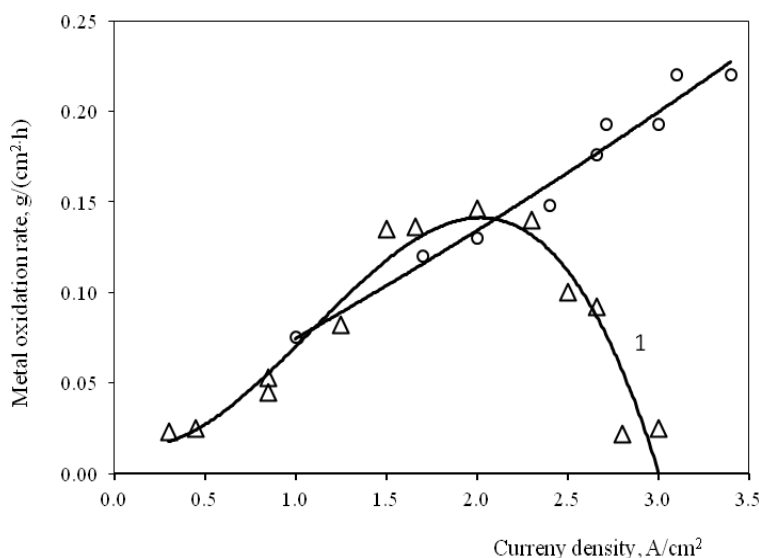


Fig.1. Dependence of oxidation rate of cadmium (1) and copper (2) on the density of the alternating current at the temperature of 60 °C

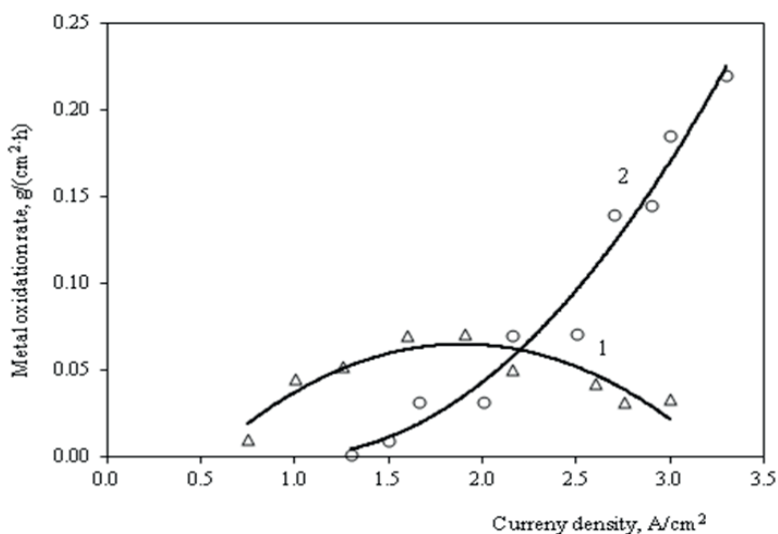


Fig.2. Dependence of oxidation rate of cadmium (1) and copper (2) on the density of alternating current at the temperature of 70 °C

### 3. Results and Discussion

The figures show the oxidation rate of copper increased in all investigated intervals of current density. In this regard, the oxidation state dependencies of copper does not generally differ from the ones determined at the individual oxidation rate of copper in a sodium chloride solution with concentration of 46.5 % wt. <sup>14</sup>. In contrast to the oxidation rate of copper, the dependence of the oxidation rate of cadmium has extreme features. The maximum speed is observed at the current density equaled to 2 A/cm<sup>2</sup>. However, the oxidation rate of cadmium at a temperature of 60 is greater above in 2.5 times, than at a temperature of 70 °C.

On the one hand, an extreme form of dependency is consistent with the previously obtained one for individual process of oxidation of cadmium <sup>13</sup>, on the other hand the oxidation rate increase of cadmium at its joint oxidation with copper (in 2-3 times) indicates the mutual influence of electrodes at the electrochemical process for alternating current <sup>11</sup>. In general, the current density of more than 2 A/cm<sup>2</sup> for oxidation rate of copper is higher than the oxidation rate of cadmium.

### 4. Conclusions

The dependences allow forecasting of the electrolysis operational to obtain the copper- cadmium oxide system of a given composition. Thus, the oxidation rate of cadmium at a temperature of 60° C is higher in 2.5 times, than the one a temperature of 70 ° C, and the maximum speed is observed at the current density equaled to 2 A/cm<sup>2</sup>. For copper, the oxidation rate increases with the increase in current density. In general, when a joint destruction of cadmium and copper in the electrolysis of alternating current in sodium hydroxide solution, the oxidation rate is increasing, which indicates that the mutual influence of electrodes at carrying out of the electrochemical process for alternating current .

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## References

1. Lokhande, B. Studies on cadmium oxide sprayed thin films deposited through non-aqueous medium. *Materials Chemistry and Physics*. 2004; **84**: 238.
2. Karunakaran, C; Dhanalakshmi, R Selectivity in photocatalysis by particulate semiconductor. *Central European Journal of Chemistry*. 2008; **7**: 134.
3. From Materials to Devices, Rodrigo Martins, Elvira Fortunato, Pedro Barquinha, Luis Pereira, Transparent Oxide Electronics: 2012, 312 p.
4. Lewis, Richard J., Sr. Hawley's condensed chemical dictionary, 13th ed., 1997, p. 189.
5. Synthesis, Properties, and Applications of Oxide Nanomaterials, John Wiley & Sons, Inc., 2007.
6. Shabanova N.A., Popov V.V., Sarkisov P.D. Chemistry and technology of nanosized oxides. M.: Academkniga; 2006.
7. Tretyakov, Y.D., Goodilin, G.A. Key trends in basic and application-oriented research on nanomaterials. *Russian chemical reviews*. 2009; **78**: 801–820.
8. Lokhande, B.J., Patil, P.S., Uplane, M.D. Studies on cadmium oxide sprayed thin films deposited through non-aqueous medium. *Materials Chemistry and Physics*. 2004; **84**: 238–242.
9. Zyryanov, V.V. (2008) Mechanochemical synthesis of complex oxides. *Russian chemical reviews*, **77**, 105–136.
10. Sitschev, A.E., Merzhanov, A.G. Self-propagating high-temperature synthesis of nanomaterials. *Russian chemical reviews*. 2004; **73**: 147–160.
11. Korobochkin, V.V., Usoltseva, N.V., Balmashnov, M.A. Nonequilibrium electrochemical synthesis of copper-aluminum oxide systems. *Fundamental research*. 2012; **11**: 143–147.
12. Korobochkin, V.V., Khanova, E.A. Determination of the amount of oxidized titanium, cadmium and copper in the electrolysis of alternating current. *Zavodskaya laboratoriya. Diagnostika materialov*. 2005; **71**: 20–23.
13. Korobochkin, V.V., Khanova, E.A. The destruction of nickel and cadmium at the alternating current electrolysis in alkaline electrolyte. *Bulletin of Tomsk Polytechnic University. Chemistry and chemical technology*. 2003; **306**: 36–41.
14. Korobochkin, V.V., Usoltseva, N.V., Gorlyshko, D.A., Balmashnov, M.A. The regularities of synthesis of nanosized copper oxide by alternating current electrolysis in alkali solution. *Bulletin of Tomsk Polytechnic University. Chemistry and chemical technology*. 2010; **317**: 13–16.