



# DISSOLUTION OF A COPPER ELECTRODE IN SULFURIC ACID AT POLARIZATION BY AN INDUSTRIAL ALTERNATING CURRENT

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## ABSTRACT

The electrochemical behavior of the copper electrode in sulfuric acid at polarization by an industrial alternating current was studied. It was investigated for the influence of the different parameters to the yield by current of the copper dissolution: the current density at the titanite electrode, the current density at the copper electrode, the electrolyte concentration, the electrolysis duration, and of the copper ions (II).

**Key words:** Non stationary current, Polarization, Concentration, Solution, Titanite electrode.

## INTRODUCTION

Now it is known, that application of various forms of an alternating current gives possibilities to increase of velocity of processes of anode dissolution, destruction of passivation of an electrode.

Feature of non-stationary electrolysis is possibility of obtaining of pure metals or their compounds, decrease in the expense of a reagent, creation of the wasteless and simple advantageous technological processes<sup>1,2</sup>.

Cupric sulphate is one of rather important compounds of salts of copper. Copper sulphate is used as the wet indicator, in the laboratory for dehydration of ethanol and other compounds, for production of mineral color, in the food-processing industry as food additive E 519. The most part of copper sulphate is widely applied in agriculture as sulfuric-copper fertilizer, in the insect control against harmful insects<sup>3</sup>.

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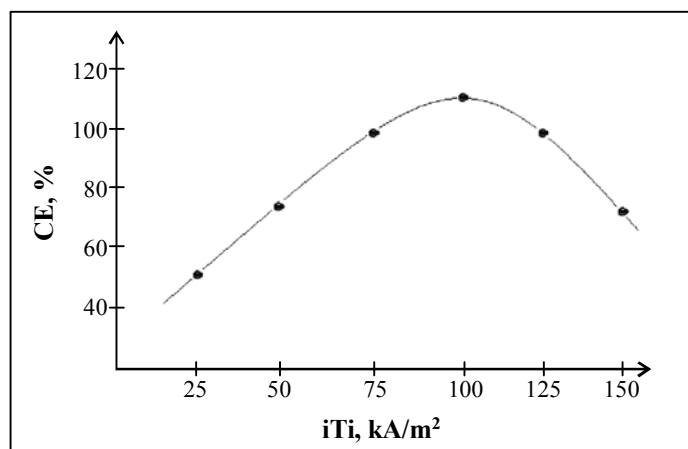
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## EXPERIMENTAL

### Method

Experiments for research of electrochemical properties of a copper electrode in a solution of sulfuric acid were spent in the thermostated glass electrolyser with capacity of 100 mL. As undivided electrodes of electrode space were used a wire of the titan (the area  $3.0 \times 10^{-6} \text{ M}^2$ ) and a copper rectangular plate with the size  $3.68 \times 10^{-4} \text{ M}^2$ . If pair of electrodes from copper and the titan to polarize by industrial alternating current with frequency of 50 Hz in solution of  $\text{H}_2\text{SO}_4$ . It is possible to observe the intensive dissolution of a copper electrode with formation of ions of copper (II).

Influence of density of a current in the titanic electrode on current efficiency (CE) of copper dissolution in a solution of sulfuric acid was investigated (Fig. 1). As is shown in figure, at increase of density of a current the current efficiency by current of dissolution of a copper electrode is increased, and after  $100 \text{ kA/m}^2$  is decreased. In the range of density of a current  $90\text{-}110 \text{ kA/m}^2$  the maximum values of current efficiency by current of dissolution of copper is observed. At increase in density of a current at the titanic electrode above  $100 \text{ kA/m}^2$ , on its surface are formed the oxidic films with the low valve properties that led to fall of the directed dissolution of a copper electrode.



$$i_{\text{Cu}} = 200 \text{ A/m}^2, [\text{H}_2\text{SO}_4] = 50 \text{ g/L}, \tau = 0,5 \text{ h}, t = 20^\circ\text{C}$$

**Fig. 1: Influence of density of a current in a titanic electrode on current efficiency of dissolution of a copper electrode at polarization by an alternating current to pair of a copper-titanic electrode**

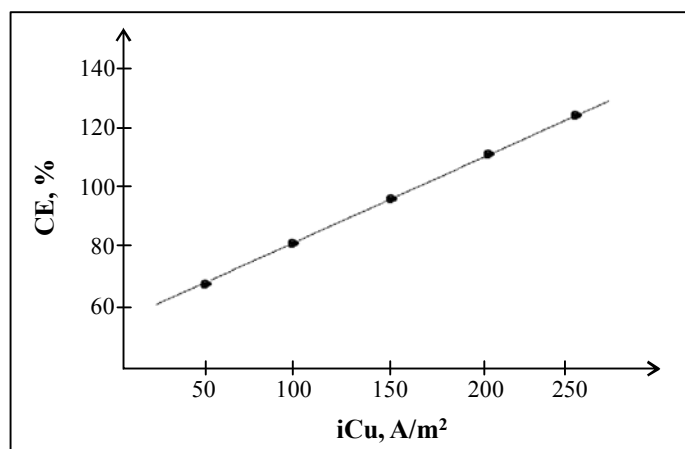
In the anode half-cycle of an alternating current copper can be dissolved with formation of one- and bivalent cations:



It is necessary to say that the ions of monovalent copper in a solution of sulfuric acid are changeable, therefore they at once pass to the bivalent. After transition to the solution the ions of copper (II) co-operate with sulphates-ions and form copper sulphate:



Influence of density of a current in a copper electrode on a yield on a current of dissolution of copper at polarization by an alternating current is investigated (Fig. 2). At increase of density of a current in the interval 50-250 kA/m<sup>2</sup> current efficiency of formation of sulphate of copper is increased.



$$i_{\text{Ti}} = 125 \text{ kA/m}^2, [\text{H}_2\text{SO}_4] = 50 \text{ g/L}, \tau = 0,5 \text{ h}, t = 20^\circ\text{C}$$

**Fig. 2: Influence of density of a current in a copper electrode on current of dissolution of a copper electrode at polarization by an alternating current**

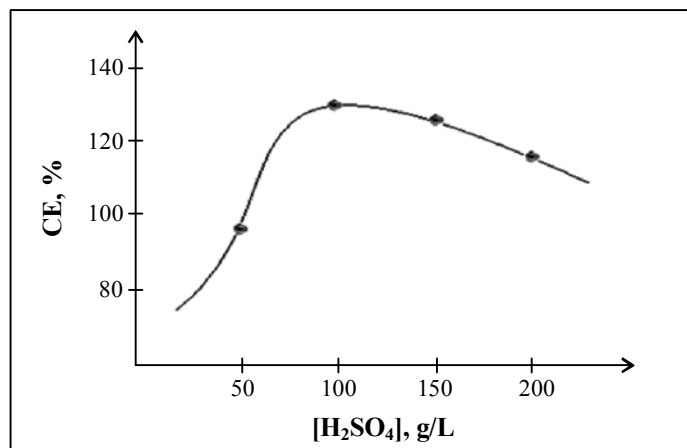
In the anode half-cycle of an alternating current of a copper electrode the reaction of chemical oxidation of copper to ions of copper (II) (2-nd-reaction) take places. The ions of Cu(II) formed in an anode half-cycle co-operated with a copper electrode and the reaction of the chemical re-proportionation proceeded :



Apparently velocity of reaction (4) at polarization by an alternating current is intensified.

Passing of reaction (4) gives possibilities to current efficiency exceeding on a current of dissolution of copper above 100 % (Fig. 2).

The sulfuric acids concentration influence on current efficiency of formation of copper sulphate at polarization by an alternating current is investigated (Fig. 3).



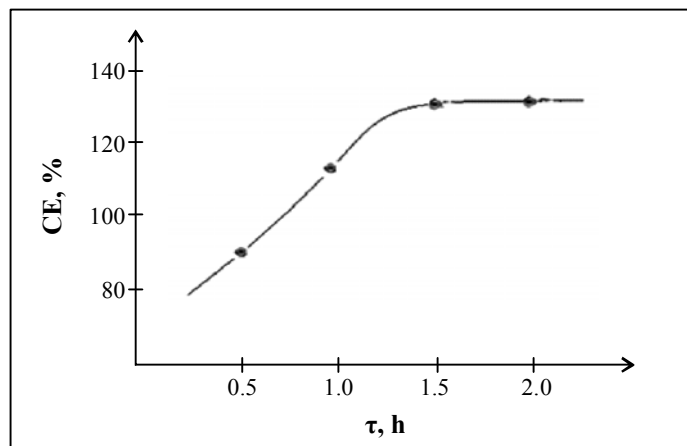
$$i_{Ti} = 125 \text{ kA/m}^2; i_{Cu} = 200 \text{ A/m}^2; \tau = 0,5 \text{ h}; t = 20^\circ\text{C}$$

**Fig. 3: Influence of concentration of sulfuric acid on current efficiency of dissolution of a copper electrode at polarization by an alternating current**

Change of concentration of acid essential influences on current efficiency. In the interval of concentration of sulfuric acid 25-100 g/L current efficiency of formation of copper sulphate increases to 100-125%, and the further increase in concentration leads to yielding decrease on a product current. These phenomena it is possible to explain by the change of semi-conductor properties of oxide, formed on a surface of a titanic electrode in an anode half-cycle.

Duration influence of electrolysis on current efficiency of formation of copper sulphate (Fig. 4) is investigated. In the interval of electrolysis duration equal to 0.25-1.25 hrs the current efficiency of copper sulphate essentially increased.

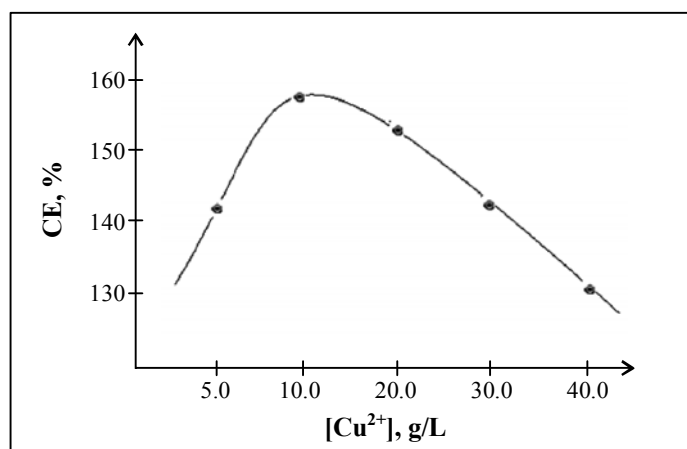
It's explained from the fact that (II) the concentration of ions of copper in due course grows in electrolyte. At this time in a copper electrode velocity of reaction of the chemical repropotion (4) is raised.



$$i_{Ti} = 125 \text{ kA/m}^2; i_{Cu} = 200 \text{ A/m}^2; [\text{H}_2\text{SO}_4] = 100 \text{ g/L}; t = 20^\circ\text{C}$$

**Fig. 4: Duration influence of electrolyse on current efficiency of dissolution of a copper electrode at polarization by an alternating current to pair of copper-titan electrodes**

As a result of calculation an yield on a current of dissolution of copper was above 100 %. In Fig. 5, influence of source (initial) concentration of ions of copper (II) on current of dissolution of copper is shown.



$$i_{Ti} = 125 \text{ kA/m}^2; i_{Cu} = 200 \text{ A/m}^2; [\text{H}_2\text{SO}_4] = 100 \text{ g/L}; \tau = 0,5 \text{ h}; t = 20^\circ\text{C}$$

**Fig. 5: Influence of initial concentration of [Cu<sup>2+</sup>] ions on yield by the current efficiency of dissolution of a copper electrode at polarization by an alternating current**

At increase of concentration of ions of copper (II) in electrolyte to 10 g/L the current efficiency of formation of sulphate of copper considerably increased, and in the interval of 10.0-40.0 g/L decreased. It is possible to explain this phenomenon by covering of a copper electrode with sulphate of copper or by the salt passivation.

### **CONCLUSION**

Thus, for the first time dissolution of a copper electrode in sulphate solution with formation of bivalent ions, sulphate of copper (II) in the pair of copper-titanic electrodes at polarization by an alternating current is shown. Influence of the different parametres on formation of sulphate of copper is investigated.

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