THE ELECTRODE MATERIALS ON THE BASIS OF Fe$_2$O$_3$ FOR OBTAINING A CHEMICAL SOURCE OF A CURRENT

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ABSTRACT

In the article, the results of research of electrochemical system on a basis of iron and iron oxide (Fe$_2$O$_3$), which can be used for obtaining of a chemical source of a current (CSC) are reported. Use of the given system does not assume application of expensive and ecologically harmful active substances.

Possibility of obtaining of a chemical source of a current with use of galvanic pair of iron and oxide of iron (III) (Fe$_2$O$_3$) is shown. The values of electromotive force (EMF) and of a short-circuit current (SCC) in a chain of the CSC are defined. Electromotive force of a source of a current it is investigated in a water solution of chlorides and iron sulphates, at a room temperature, in absence of external loading. Thus maximum value of EMF was 900-950 mV, SCC - 40-50 mA.

Key words: Chemical source of a current, Electromotive force, Galvanic system.

INTRODUCTION

In the present article, the essentially new electrochemical method of transformation of chemical energy to electric, i.e. obtaining of a chemical source of a current (CSC) is offered. Now CSC is used in all the areas of technics and a national economy. The chemical sources of a current continue to play the big role in the various branches of a science and technics. In some areas, for example, in the portable radio-electronic equipment and communication equipment, they occupy absolutely special position as in these cases have to itself no substitutes[1,2]. It is impossible to imagine a life of the modern society, which is not

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using the chemical sources of a current. The CSC is a device in which chemical energy directly turns to the electric. A basis of the CSC work is oxidation-reduction reactions to electrodes. In the course of interaction the oxidizer being reduced attaches the electrons, and the reducer being oxidized gives electrons[3-5].

EXPERIMENTAL

The researches were spent in a glass electrolyzer without division of electrode spaces with volume of 100 mL, in a hydrochloric solution, which containing ions of Fe (II), Fe (III). An iron electrode was used as a cathodic material. For an anode material the chemically pure powder of hematite α-Fe_2O_3, made of the cylinder was used. For this purpose, Fe_2O_3 was carefully crushed to a homogeneous condition. In the centre of the hollow cylinder having numerous apertures with diameters 1 mm, a graphite electrode have placed. Then an empty part of the cylinder was filled with powder of Fe_2O_3. The given electrode carried out function of an active positive electrode (pole) of a galvanic cell.

In Figure 1, the scheme of the experimental installation consisting of electrodes of iron and Fe_2O_3 at which working solution were presented Fe (II) and Fe (III) ions are shown.
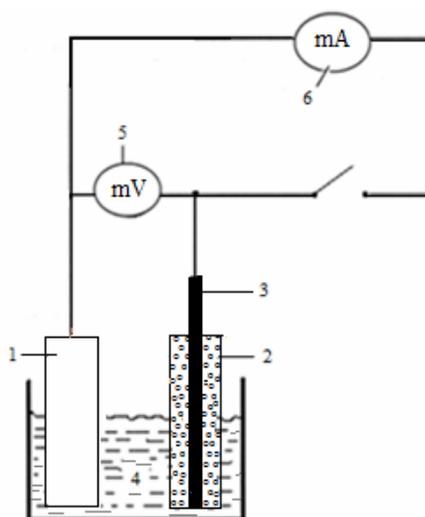
Fig. 1: Installation for research of processes of formation of an electric current in system of galvanic pair Fe-Fe$_2$O$_3$

1- Iron electrode, 2- An electrode from powder of oxide (III) (Fe$_2$O$_3$), 3- Graphite, 4- A solution, 5- Millivoltmeter, 6- Milliamperemeter

RESULTS AND DISCUSSION

Influence of the various parametres on formation EMF and SCC, in galvanic system Fe - Fe_2O_3 in the chloride solutions containing ions Fe (II) and Fe (III) is considered. It is possible to present this system as follows:

$$Fe \mid Fe\ (II),\ Fe\ (III) \mid Fe_2O_3$$

At iron immersing in a solution of the hydrochloric acid, containing bivalent and trivalent iron ions on an electrode surface the following balance is established:

$$Fe + 2e \leftrightarrow Fe^{2+} \qquad E^0 = -0.44\ V \qquad\qquad\qquad ...(1)$$

$$Fe + 3e \leftrightarrow Fe^{3+} \qquad E^0 = -0.04\ V \qquad\qquad\qquad ...(2)$$

$$Fe^{3+} + e \leftrightarrow Fe^{2+} \qquad E^0 = +0.77\ V \qquad\qquad\qquad ...(3)$$

At the same time on electrode Fe_2O_3 the following balance is established:

$$3Fe_2O_3 + 2H^+ + 2e \rightarrow 2Fe_3O_4 + H_2O \qquad E^0 = 0.58\ V \qquad ...(4)$$

$$2Fe_2O_3 + 4H^+ + 2e \rightarrow Fe_3O_4 + Fe^{2+} + 2H_2O \qquad E^0 = 0.71\ V \qquad ...(5)$$

$$\alpha\ Fe_2O_3 + 6H^+ + 2e \rightarrow 2Fe^{2+} + 3H_2O \qquad E^0 = 0.74\ V \qquad ...(6)$$

In figure 2, dependence of change of value of EMF and SCC, from time on formed in galvanic pair Fe-Fe_2O_3 is shown. Thus it is visible, that eventually the EMF and SCC values gradually decreased. The results on influence of concentration of $FeCl_3$ on process of the EMF and SCC formation were here too resulted.
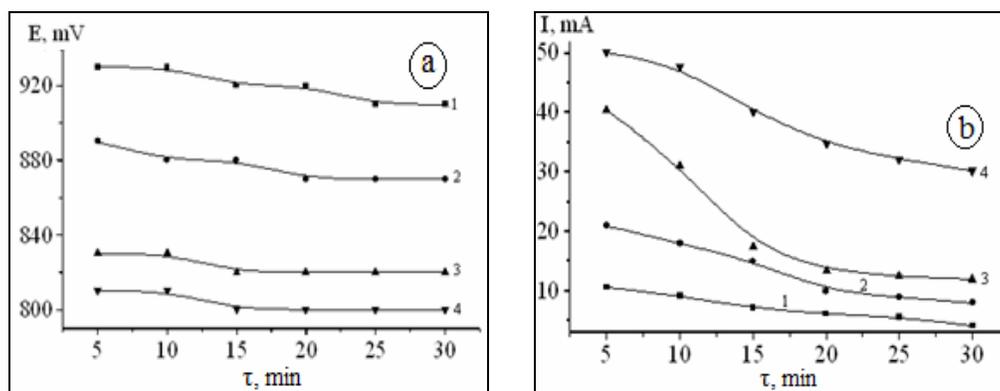
Fig. 2: Dependence of the EMF (a) и SCC (b) values from time in the galvanic pair of the system Fe-Fe_2O_3 $FeCl_3$, g/L: 1-10; 2-30; 3-50; 4-70

In Figure 2a, it is shown, that with increase of concentration of ions $FeCl_3$ with 10 g/L to 70 g/L at duration of experiment of 5 minutes the EMF value decreased from 930 mV to 810 mV. In turn, a value of SCC- increased from 10 mA to 50 mA.

In Table 1, the results of researches of influence of $FeCl_2$ concentration from 1 to 20 g/L in the presence of 10 g/L $FeCI_3$ on EMF and SCC are resulted. Thus with increase of concentration $FeCl_2$ is observed that the value of EMF is decreased and the value of SCC is increased.

Table 1: Dependence of influence of $FeCl_2$ concentration to EMF and SCC in the galvanic pair $Fe-Fe_2O_3$

$FeCl_2$ (g/L)	1	5	10	15	20
E (mV)	950	930	910	900	900
I (mA)	7.2	13.1	15.2	25.1	25.2
Note – $FeCl_3$ - 10 g/L, HCl- 0 g/L, τ = 15 min, t = 25°C					

In the given galvanic pair at short circuit of external chain iron passed in a solution on the following reaction:

$$Fe-2\,e \rightarrow Fe^{2+} \qquad\qquad \dots(7)$$

The formed bivalent ions of iron reacting with chloride ions formed $FeCl_2$:

$$Fe^{2+} + 2Cl^- \rightarrow FeCl_2 \qquad\qquad \dots(8)$$

With increase in concentration of hydrochloric acid in galvanic pair the value of SCC was increased, and EMF value was decreased. The results of researches showed, that the maximum EMF value was reached at HCl concentration - 1 g/L and was 910 mV, and of SCC - at HCl concentration - 20 g/L - 18 mA (Table 2).

Table 2: Dependence of influence of concentration of hydrochloric acid on EMF and SCC in the galvanic pair $Fe-Fe_2O_3$

HCl (g/L)	1	5	10	15	20
E (mV)	910	900	900	890	880
I (mA)	13.1	12.2	11.1	15.2	18.0
Note – $FeCl_2$ - 10 g/L, $FeCl_3$ – 10 g/L, τ = 15 min, t = 25°C					

The increase of area of electrode Fe_2O_3 reduced value of EMF while value of SCC increased (Table 3). The increase of the area of an electrode in 6 times, led to increase of SCC more than twice.

Table 3: Dependence of influence of the electrode area Fe_2O_3 on EMF and SCC formation in the galvanic pair $Fe-Fe_2O_3$

S (Fe_2O_3), cm^2	1	2	3	4	5	6
E (mV)	900	900	890	870	850	850
I (mA)	12.5	15.3	17.5	29.1	31.0	32.5

Note – $FeCl_2$ - 10 g/L, $FeCl_3$ - 10 g/L, t = 25°C

In Table 4, dependence of EMF and SCC change from time in galvanic pair $Fe-Fe_2O_3$ is shown.

Table 4: Dependence of EMF and SCC from duration of time (τ, hr) in galvanic pair of system $Fe-Fe_2O_3$

τ (h)	1	2	3	4	5	6	7	8	9	10	11	12
E (mV)	970	950	920	850	820	760	710	660	590	500	450	320
I (mA)	25.1	20.2	11.3	8.0	7.2	6.5	5.2	4.0	3.2	2.2	1.5	0.5

Note - $FeCl_2$ – 10 g/L, $FeCl_3$ – 10 g/L, t = 25°C

Apparently from Table 4, with increase in duration from 1 hour till 12 hr, decrease of EMF and SCC is observed. If at duration of experiment 1 hr EMF and SCC accordingly were 970 mV and 25 mA and by 12 hrs their decrease to 320 mV and 0.5 mA accordingly was observed.

In Fig. 3, the data of MS for hematite powders are presented. Here for comparison spectra α-Fe_2O_3 in an initial condition (Fig. 3) and after 12 hr are shown. It is observed, that structure, the physical and the chemical properties of obtaining Fe_2O_3 after 12 hr of experiment practically didn't change in comparison with the initial substances, that on-visible it was connected with the insignificant change of composite, because of passing of a small amount of an electric current in an electrochemical chain.

(a)   (b)
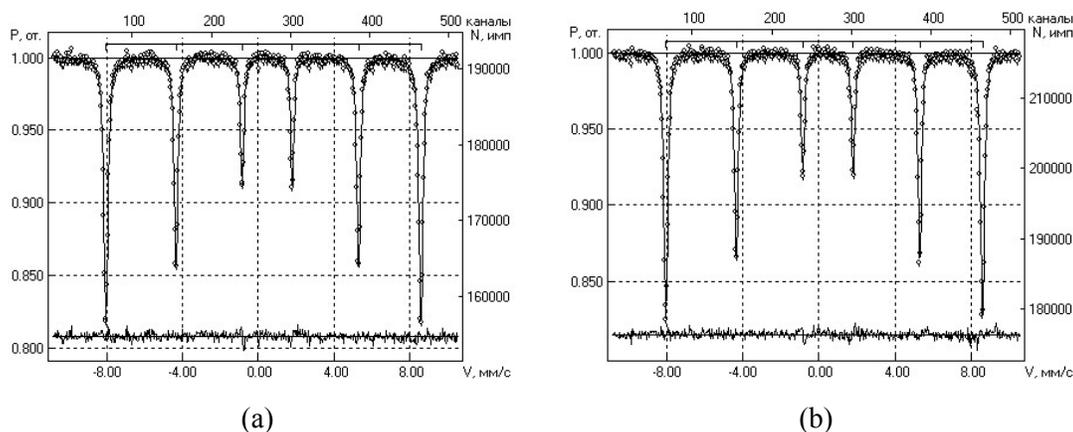
**Fig. 3: MS-spectrum for the powders of hematite: (a) pure hematite-α-Fe₂O₃,
(b) after 12 hrs of experiments-α-Fe₂O₃**

CONCLUSION

Thus, the results of research manufacturing of a source of a current with application of iron and iron compounds, had practical value. The conditions of EMF and SCC formation in galvanic pair Fe-Fe$_2$O$_3$ were defined. Thus, in the chloride solution of ions of iron (II) and (III) the maximum value of EMF was equal 970 mV, and SCC-50 mA.

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