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ELECTROCHEMICAL TRANSFORMATION OF THERMAL ENERGY OF THE SUN AND GEOTHERMAL WATERS TO THE ELECTRIC ENERGY

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ABSTRACT

In the present work the dependences of oxiditive-reducing potential from concentration of ions of iron, from temperature for the first time are established. It is shown, that in the presence of a difference of temperatures between electrode spaces, applying graphite electrodes, it is possible to create conditions for formation of the EMF. It is found, that the increase of concentration ions of iron (III) and concentration of sulfuric acid and temperature in thermostated space of electrolyzer led to increase of EMF and SCC in an electrochemical chain.

Key words: Oxidation-reduction potential, Electromotive power (EMF), A short circuit current (SCC), Graphite electrodes, Electrolytic cell, Ions of iron.

INTRODUCTION

Now, it is difficult to present the world economic and technological development without use of the renewed energy sources. The practical use of the non-conventional energy sources is represented to one of the ways of development of the world community by principles of green economy. Tendencies of development of the renewed energy sources in the world undergo the considerable changes. Manufacture of the electric power from nonconventional sources varies in different ranges. Thus principal views of alternative energy sources include such directions as - energy of the Sun, a biomass, a wind and also energy of the geothermal waters[1]. There are examples of use of the geothermal energy of the Earth for the various purposes, including for electric power manufacture, for heating and cooling of buildings. Technologies of use of the renewed energy sources are ecologically pure and do not harm on environment[2-4]. Thereupon necessity of the working out of essentially new methods of creation of alternative energy sources, including transformations

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of thermal energy to electric is the actual problem having both theorethical, and practical value. The purpose of our work is research of process of transformation of thermal energy to electric by means of application of accessible and cheap thermoelectrodes.

EXPERIMENTAL

Method

In the course of carrying out of the experiments we established, that at immersing of two electrodes to a water solution of the electrolytes containing ions in oxidized and reduced forms and at creation of a difference of temperatures in the electrode spaces, in system there is an electromotive power (EMF) and on electrodes the oxidation-reduction potential which value is defined on Nernst equation[5,6] is established.

$$\frac{E = E^{o} + \frac{RT}{nF} \ln a_{ox}}{a_{Red}}$$

As follows from the equation, the value of the oxidation-reduction potential on a graphite electrode, at constant activity of ions in the lowest and highest oxidations will depend on solution temperature. With solution temperature rise, accordingly, the potential of a graphite electrode is displaced to a positive side, and its value undergoes changes. Thus value of EMF between two electrodes which are in solutions with different temperatures and value of a current of short circuit (SCC), first of all, depend on a difference of temperatures.

The water solutions of hydroxides, inorganic acids and their salts can be serve as electrolyte. As electrodes it is possible to use practically any electrically conductive inert materials, for example, the graphite. Electrode spaces of electrolyzer are incorporated by means of the electrolytic bridge. As the oxiditive-reducing systems in water solutions of electrolytes can serve $Fe^{2+} \leftrightarrow Fe^{3+}$, $I^{0} \leftrightarrow I^{-}$, $Cu^{+} \leftrightarrow Cu^{2+}$, $S^{0} \leftrightarrow S^{2-}$, $Se^{0} \leftrightarrow Se^{2-}$, $Ti^{3+} \leftrightarrow Ti^{4+}$, etc. Occurrence of EMF in system testifies to transformation of thermal energy to the electric.

At creation of the given conditions on a surface of a graphite electrode take place the following reactions:

- Oxidation reaction to an electrode with the more positive potential $\quad Red - ne \rightarrow Ox$

- Reduction reaction to an electrode with the less positive potential $\quad Ox + ne \rightarrow Red$

These processes promote to occurrence and current course in an electrochemical chain. It is necessary to notice, that graphite electrodes applied in case of our experiments, do not participate in the electrode reactions and, hence, them it is possible to use during long time.

The laboratory installation for transformation of thermal energy to the electric consists of two glass electrolyzer which are connected among themselves through the bottom part by the electrolytic bridge in the form of a tubule (Fig. 1). Electrolyzers are filled by solutions of electrolytes. The first electrolyzer (1) has thermostated shirt, it is attached to the thermostat, and as required in the first electrolyzer it is possible to fix any temperature within 20-90^{o}C. The first thermostatedelectrolyzer (1) in which the working electrode (4) is located, is attached through the glass bridge (10) with the vessel (9) filled with the sated solution of chloride potassium. In a vessel (9) it is placed the reference silver chloride cell concerning which measured the values of the potentials established on a graphite electrode (4). Theglassbridge (10) isfilledbyaninvestigatedsolution.

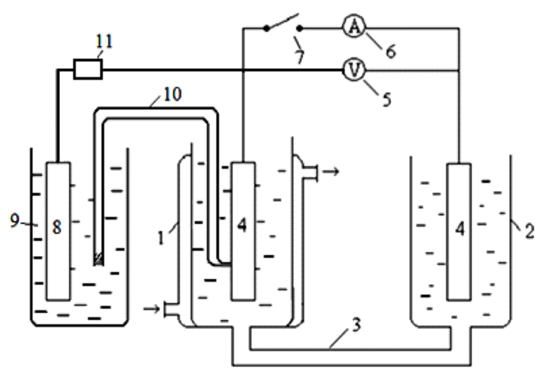


Fig. 1: The principal scheme of installation for carrying out of the researches on transformation of thermal energy to electric

1- thermostatedelectrolyzer; 2- non-thermostatedelectrolyzer; 3- the bridge for connection of the electrode spaces, 4- graphite electrodes; 5 - the voltmeter for measurement of the EMF value; 6- the ampermeter for measurement of SCC value; 7- a key; 8- a reference electrode; 9- capacity with the sated solution of potassium chloride; 10- the glass bridge filled with the investigated solution; 11- potentiometer

Influence of temperature on value of the oxidative-reducing potential of a graphite electrode it was investigated. As a background electrolyte a solution of sulfuric acid with concentration 100 g/L, containing ions of three-and bivalent iron of different concentration was used.

Apparently from Fig. 2, with temperature rise of a solution value of Redox potential of a graphite electrode gradually increased. At concentration of ions of the iron (III), equal 10 g/L at 90°C the potential value was equal 743 mV, i.e. at change of temperature from 20°C to 90°C the potential value changed on 101 mV.

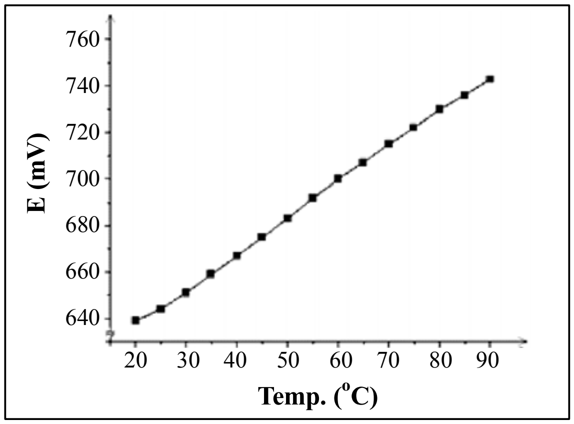
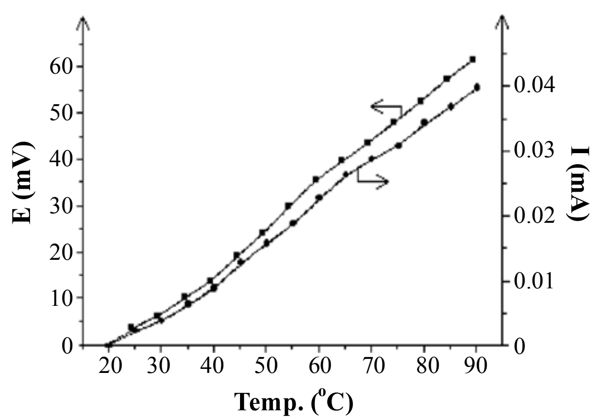


Fig. 2: Influence of temperature of a solution on value of Red ox potential of a graphite electrode: Fe (III) - 10 g/L, Fe (II) – 0.01 g/L, H_2SO_4 - 100 g/L

Also it was investigated the temperature influence between the electrode spaces on EMF and a short circuit current (SCC) formation in a solution with concentration of the sulfuric acid equal to 100 g/L and at concentration of iron sulphate (III), equal to - 50 g/L, iron sulphate (II) - 1 g/L.

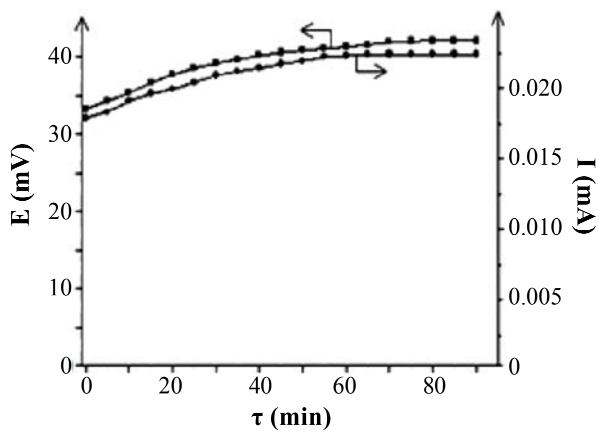


100 g/LH_2SO_4; 50 g/L$Fe_2(SO_4)_3$; 1 g/L$FeSO_4 \cdot 7H_2O$; $t_0 = 20$°C;

Fig. 3: Dependence of change of EMF (1) and SCC (2) values between graphite electrodes from temperature

It is found, that with temperature rising the values of EMF and SCC essentially increased. Apparently from Fig. 3, at the temperature difference between the electrode spaces, equal to 70^{o}C, the values of EMF and SCC, accordingly, were 61.5 mV and 0.04 mA.

It is investigated influence of duration of experience on change of values of EMF and SCC at concentration of sulfuric acid 100 g/L, and concentration of Fe (II) and Fe (III), equal to 10 g/L and 50 g/L, accordingly, at the constant temperature of a solution in the thermostatedelectrolyzer. As is shown in Fig. 4, values of EMF and SCC, are fixed within 33.3-42.1 mV and 0.018-0.023 mA, accordingly, and within 90 minutes at first slightly raised and further didn't change.



100 g/LH_2SO_4; 50 g/L$Fe_2(SO_4)_3$; 10 g/L $FeSO_4 \cdot 7H_2O$; $t_0 = 20^oC$; $t = 70^oC$

Fig. 4: Dependence of EMF (1) and SCC (2) value change between the graphite electrodes from duration of experiment

In Table 1, data on change of the values of EMF and SCC between electrodes in the sulphate solution with various concentration of salts of iron (III) are presented at temperature of thermostatedelectrolyzer spaces, equal to 90^{o}C, and it is shown, that with increase in concentration of ions Fe^{3+} the values EMF and SCC considerably increased.

Table 1: Change value of EMF and SCC depending on concentration of ions of iron (III)

$Fe_2(SO_4)_3$ (g/L)	0	1	10	30	50
E (mV)	0	8.0	19.0	50.3	61.5
I (mA)	0	0.014	0.023	0.032	0.039
Note –$FeSO_4 \cdot 7H_2O$ = 0.01 g/L; H_2SO_4 = 100 g/L; t = 90^{o}C					

It was studied influence of concentration of ions of iron (II) on values of EMF and SCC in the sulphate solution at temperature of the thermostatedelectrolyzer, equal to 90°C. It is shown, that with increase in concentration of ions Fe^{2+} values of EMF and SCC gradually reduced.

Table 2: Change of the values of EMF and SCC depending on concentration of ions of iron (II)

$FeSO_4·7H_2O$ (g/L)	0	1	10	20
E (mV)	0	61.5	53.13	48.3
I (mA)	0	0.04	0.036	0.034

Note – $Fe_2(SO_4)_3$ = 0.01 g/L; H_2SO_4 = 100 g/L; t_0 = 20°C; t = 90°C

With increase of concentration of sulfuric acid the values of EMF and SCC between electrodes gradually increased (Table 3) that is connected with increase of electrical conductivity of a solution in the investigated interval.

Table 3: Change of values of EMF and SCC depending on concentration of sulfuric acid

H_2SO_4 (g/L)	0	25	50	100	150
E (mV)	0	26.9	33.4	53.13	54.2
I (mA)	0	0.027	0.031	0.032	0.036

Note – $FeSO_4·7H_2O$ = 10 g/L; $Fe_2(SO_4)_3$ = 50 g/L; t_0 = 20°C; t = 90°C

Thus, we established for the first time dependences of the oxidative-reducing potential from concentration of ions of iron, from temperature. It is shown, that in the presence of a difference of temperatures between electrode spaces, applying graphite electrodes, it is possible to create conditions for EMF formation. It is established, that the increase in concentration of ions of iron (III) and concentration of sulfuric acid and temperature in the thermostated space of electrolyser leads to increase of EMF and SCC in an electrochemical chain. Thus the graphite electrode is not dissolved, because on its surface proceeds the oxidizing and reducing reactions with participation of the variable valency ions were proceeded.

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