Properties of Heat Release During Passing of Electric Current Through the Water

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Abstract – We present the peculiarities of heat release during passing of electric current through the water. It is shown that the obtained heat energy with the sum of chemical compounds formation energies exceeds essentially the spent energy. The possible nuclear transformation of atoms of the electrode is suggested.

Keywords: water, electric current, heat release

In the fields of science and technology, the electrolysers are widely used for water splitting into the hydrogen and oxygen [1, 2]. Based on these electrolytic cells, the various constructions are developed and used in technology to generate Brownian gas.

The researches in the field of hydrogen production and of the hydrogen synthesis with other elements are accompanied by the energy release and the developments of control methods of these processes, undoubtedly seem to be very promising directions in alternative energetics.

To generate the Brownian gas, the electrolytic cells of various constructions of electrodes were tested. In all cells, the increase in electrolyte temperature dependent on the construction and the material of electrodes, as well as on the electric current in electrolyte was observed. In these experiments, the water volume was 1.15 liters. As an electrolyte, the ordinary drinking water was used. The electric voltage, the electric current and the duration of current supply on electrodes have been measured. The electrodes cross section was approximately equal to 78 cm^2, and the spacing between them was equal to 13 cm. Based on these measurements, the energy release in accordance with the law of Joule ($\mathbf{Q}_{el}$) and the total heat energy ($\mathbf{Q}_T$) were calculated. The results of measurements with use of aluminum and copper electrodes are listed in Table 1. The table shows that the total heat energy is essentially greater than the spent electric energy. We also point out that the heat insulation of the cell was essentially lesser than the heat insulation of the calorimeters; therefore, the actual data of total heat energy are greater than the quantities listed in table. This difference may indicate the contribution of others sources of heat, for example, the energy of formation of chemical compounds by reacting of hydrogen ions and the hydroxyl group with the electrode material, since the elements in the form of ions and atoms chemically are more active than beinga part of molecules.

Table 1.

Electrodes	I, A	U, V	τ, sec	$\mathbf{Q}_{el}$, kJ	T_i, C^0	T_f, C^0	V, liter	$\mathbf{Q}_T$, kJ
Al(+) Al(−)	0.13	88	300	**3.43**	27.5	28.4	1.15	**4.33**
	0.18	132	300	**7.13**	24.0	25.9	1.15	**9.15**
	0.225	160	300	**10.80**	25.5	28.4	1.15	**13.96**
	0.275	195	290	**15.55**	27.4	32.2	1.15	**23.11**
	0.31	222	300	**20.65**	31.5	36.0	1.15	**21.66**

	0.14	94	300	**3.95**	26.0	27.2	1.15	**5.78**
	0.18	120	300	**6.48**	27.0	28.9	1.15	**9.15**
Al(+) Cu(–)	0.22	152	300	**10.03**	28.5	31.2	1.15	**13.00**
	0.275	191	300	**15.76**	31.0	34.8	1.15	**18.29**
	0.32	221	300	**21.22**	34.5	39.5	1.15	**24.07**

Thus, the process of passing of the electric current through the water is accompanied by the energy release in the form of heat of different nature, which can be represented in the following form:

$$E_T = \sum_{i=1}^{n} Q_i,$$

where *n* is the number of possible sources of heat, the largest of which is the heating effect of electricity, described by the law of Joule:

$$Q_1 = IU\tau.$$

Upon contact of hydrogen ions (H +) and the cathode, the attachment of an electron to the hydrogen ion takes place with the energy release equal to the energy of ionization of hydrogen atom.:

$$H^+ + e^{--} \rightarrow H + Q_2.$$
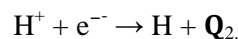
The other source of thermal energy is the process of synthesis of chemical compounds during interaction of electrolyte ions with the electrodes. In particular, the syntheses of hydrogen molecules near the cathode (Table 2):
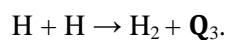
$$H + H \rightarrow H_2 + Q_3.$$

Table 2.

Compound	Standard formation heat $-\Delta E$, kJ/mole	Molar weight	Standard formation heat $-\Delta E$, kJ/g
H_2O	286.08	18.01488	15.88
HO	-38.98	17.00694	-2.29
H_2O_2	187.90	34.01388	5.52
H_2O_3	46.10	50.01288	0.92
HO_2	-20.55	33.00594	-0.62
H_2O_4	27.40	66.01188	0.42
AlH_3	11.40	30.00536	0.38
$Al(OH)_3$	1294,0	78.00236	16.59
AlO(OH)	985,0	59.98748	16.42
Al_2O_3	1676.81	101.96008	16.45
O_2	495.6	31.998	15.49
H_2	435,0	2.01588	215.79

The formation of hydride of cathode material is also possible near cathode (Table 2):

$$M^K + H \rightarrow M^K H_s + \mathbf{Q}_4,$$
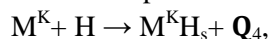
where M^K is the cathode material, and s is its valence.

Upon contact of hydroxyl ion (OH⁻) with the anode, the electron is transferred to the anode, which is accompanied by the absorption of energy equal to the affinity energy of hydroxyl group (OH) to electron:
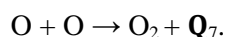
$$OH^- - e^- \rightarrow OH - \mathbf{Q}_5..$$
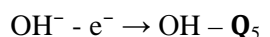
During interaction of the hydroxyl group (OH⁻) with the anode, the formation of hydroxide of anode material is also possible:

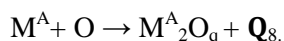$$M^A + OH \rightarrow M^A(OH)_q + \mathbf{Q}_6,$$
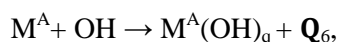
where M^A is the anode material, and q is its valence.

The synthesis of compounds is also realized near the anode, for example, the formation of oxygen molecules (Table 2):

$$O + O \rightarrow O_2 + \mathbf{Q}_7.$$

The possibility of formation of anode material oxide is not ruled out:

$$M^A + O \rightarrow M^A_2 O_q + \mathbf{Q}_8.$$

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The variety of potential compounds with the presence of hydrogen, oxygen and aluminum electrodes in the electrolytic cell is shown in Table 2 [3, 4].

The Table 2 shows that the maximal standard formation heat, normalized to one gram of material, which can be released in the region of anode, is for the compound of aluminum hydroxide $Al(OH)_3$ and one is equal to 16,59 kJ/g, while close to the cathode, the greater energy is released during formation of hydrogen molecules, since the standard formation heat for it is equal to 215,79 kJ/g.

The Table 3 presents the results of calculations of hydrogen mass and hydroxyl group supposedly liberated at the electrodes at the values of electrochemical equivalent k=0,01045 mg/C [5] for hydrogen and k=0,177 mg/C [5] for OH⁻ group. Given the data of Table 2, the amount of energy released in the formation of an appropriate amount of hydrogen molecules is calculated. Based on the estimated mass of hydroxyl group and taking into account the data of Table 2, the formation energy of the mass of possible hydroxide aluminum for this compound is calculated. The results of these calculations and the difference between the release of heat energy and the spent electric energy ($E_r - E_{el}$) at different values of measured current are listed in Table 3.

Table 3.

Electrodes	I, A	$(E_r - E_{el})$, kJ	Mass of hydrogen (g)	Formation heat of H_2, kJ	Mass of OH (g)	Formation heat of $Al(OH)_3$, kJ	Excess heat, kJ
	0.13	0.90	0.00041	0.0440	0.00688	0.2615	0.5945
Al(+) Al(−)	0.18	2.02	0.00056	0.0609	0.00952	0.3621	1.5970
	0.225	3.16	0.00071	0.0761	0.0119	0.4526	2.6313

	0.275	7.56	0.00083	0.0899	0.01406	0.5347	6.9354
	0.31	1.01	0.00097	0.1049	0.01640	0.6236	0.2815
Al(+) Cu(−)	0.14	1.83	0.00044	0.0474	0.00741	0.2816	1.5010
	0.18	2.67	0.00056	0.0609	0.00952	0.3621	2.2470
	0.22	2.97	0.00069	0.0744	0.01164	0.4425	2.4531
	0.275	2.53	0.00086	0.0930	0.01455	0.5532	1.8838
	0.32	2,85	0.00100	0.1082	0.01693	0.6437	2.0981

This Table shows that the thermal energy produced is far in excess of the consumed electric energy; therefore, the possible chemical compounds with the maximal energies of formation are chosen deliberately. And, in spite of such choice, the difference between the produced thermal energy and the sum of electric energies of the formed chemical compounds energies still remains large. This is clearly shown in Table 3. In fact, during the electrolysis process gassing occurs both in the cathode and the anode regions, latter representing the oxygen. If in the above calculations, along with the formation of aluminum hydroxide, we partly introduce also the formation of oxygen molecules, than this difference between the produced thermal energy and the sum of energy of formation of compounds and the consumed electric energy will become even more. Therefore, the presented results of investigation of electrolyte cell show the excess of heat release (ΔE) by passing an electric current through water. This result indicates the existence of little-investigated physical processes, which lead to significant heating of water by passing the electric current through it.

Fig. 1. The external appearance of aluminum electrodes after passing the electric current through the electrolyser, A is the anode, K is the cathode.

Figure 1 shows the photograph of electrodes made of aluminum, where the difference of cathode surface coloringis clearly seen. As compared with the anode, which retained practically its aluminum color, at the cathode appeared the dark gray color. Besides, the large differences of electrical resistances of surface were foundat the working parts of electrodes. The resistance of cathode surface increased on average approximately $10^7 - 10^8$ times, which clearly indicates on the formation of new chemical compounds.

In accordance with the Table 2, the possible compound at the cathode can be the aluminum hydride (AlH_3); however, it is known [4] that AlH_3 represents by itself the colorless crystalline substance. Therefore, to detect the content of the gray cathodic coating, the measurements have been carried out with

the use of a scanning electron microscope (SEM) VEGA TS 5130MM and a microanalytical system INCA Energy300.

The aim of microanalysis was to compare the elemental composition and concentrations of chemical elements on clean and electrolyzed surfaces of aluminum plate used as cathode. The characteristic X-ray spectra excited by the electron probe of microscope are shown in Fig.2, and the concentrations of chemical materials at the cathode are listed in Tables 4a and 4b before and after the process of electrolysis, respectively.
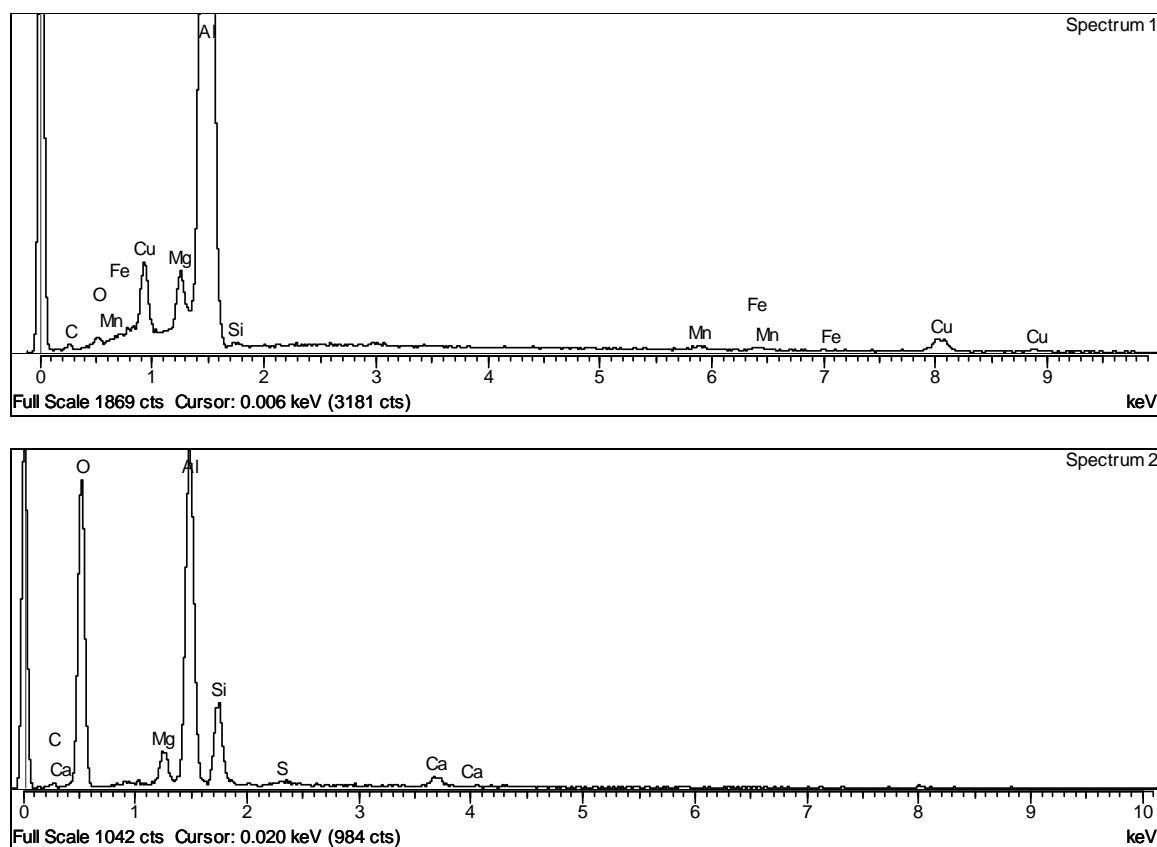

Fig. 2. The characteristic X-ray spectra of elemental composition of the material of aluminum cathode before (Spectrum 1) and after (Spectrum 2) electrolysis.

Table 4a.

Elements	O	Mg	Al	Si	Mn	Fe	Cu	Total
Concentration (wt %) Spectrum 1	0.90	1.27	92.44	0.28	0.50	0.40	4.22	100.00

Table 4b.

Elements	C	O	Mg	Al	Si	S	Ca	Total
Concentration (wt %) Spectrum 2	2.85	56.73	2.81	27.40	8.45	0.39	1.36	100.00

In Tables, the concentrations of elements are expressed in weight percents. The measurement results after electrolysis show the significant change in the surface composition of the cathode. At the cathodes surface, the most important is the large change in the amount of silicon (from 0,28 wt % to 8,45 wt %). Undoubtedly, this explains the acquired cathode dark gray shade and the sharp increase in the electric resistance of the surface. It is evident that the origination of silicon cannot be explained by chemical reactions. Consequently, we can assume that, possibly, its origination is related to the nuclear processes taking place in the cathode, where the aluminum atoms transform into the atoms of silicon. To confirm this conclusion, the radiation control of experimental installation has been carried out with use of the radiometer RUP-1. The existence of weak level γ-radiation comparable with the background level and the insignificant stream of β-particles with the level exceeding the background level by 10-15% have been revealed.

Thus, the obtained experimental results for the excess of heat release during passing of electric current through the water have been confirmed repeatedly; to explain the phenomenon, we have to make an assumption on the possible nuclear transformations in the electrolysers.

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