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Short-Circuit Mode of Dark Electric Current in Liquid

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Abstract: Dark electric current in liquid contacting with two cylindrical aluminium electrodes depends on sizes of the electrodes. Measuring the voltage on the resistor linked to the electrodes enables to determine electromotive force and internal resistance of such a source of electric current. It is found out that the electric current flowing at the load resistance equal to zero is maximal when radius of large cylindrical electrode is 6 times the radius of the inner one. Electric current in short-circuit regime reaches a value of the order of 100μA.
Keywords: Dark Electric Current, Electromotive Force, Aluminium, Water, Electric Energy, Voltage, Internal Resistance.

I. INTRODUCTION

Dark electric current flowing in the liquid conducting with two immersed asymmetrical aluminium electrodes (Gerasimov, 2020b) differs significantly from usual dark current that flows through photosensitive devices such a photomultiplier or photodiode even when no photons are entering the device (Buckingham, 1983). First of all, with no external optical and electrical influences, beside, may be, heat, this dark electric current flows unlimited time in a resistor connected to cylindrical aluminium electrodes immersed in distilled water. The second law of thermodynamics asserts that the current can occur at the temperature difference between electrodes. One should note that the system consisting of a volume of the liquid with electrodes and external environment is not equilibrium (Affard, 2002).

By combining two or more vessels with aluminium electrodes in parallel or in series, one can improve energy parameters of a source of the dark electric energy (Gerasimov & Lysenko, 2018). Electromotive force created by each one source and internal resistance depend on the volume of liquid in the cell (Geasimov, 2020a). From the point of view of dissipated energy, this would not be a best way out since geometrical parameters of each cell are far from optimal. In order to choose the geometrical sizes of electrodes one should measure the electromotive force and the internal resistance at various radii a and c of aluminium electrodes A_1 and A_2 remembering that maximum of dissipated energy takes place at the load resistance R equal to the internal one (Fig. 1).

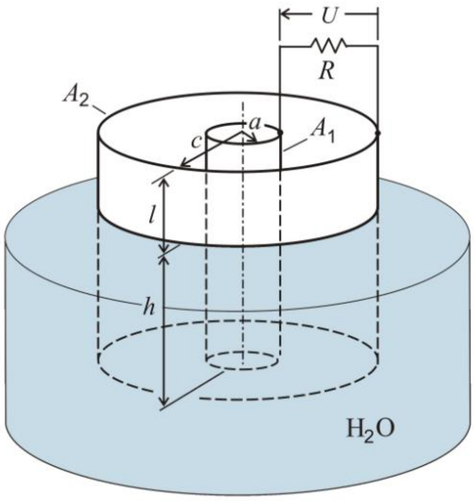

Figure 1: Two cylindrical aluminium electrodes in distilled water.

II. ELECTROMOTIVE FORCE AND INTERNAL RESISTANCE

As a first step of these simple but long-time measurements one needs to be convinced that two cylindrical aluminium electrodes immersed in the chemically clean liquid acts as a real source of the electric energy. For a usual electric source, the electromotive force E, the internal resistance r and the voltage U on the resistor R satisfy the relation

$$U = ER/(r + R),$$

that can be rewritten in a form

$$\frac{1}{U} = \left(\frac{r}{E}\right)\frac{1}{R} + \frac{1}{E}.$$

Having calculated the parameters of linear regression of 1/U versus 1/R, this makes it possible to determine the internal resistance r and the e.m.f. E for each value of radius a or c. That shown in Figure 2 demonstrates that the dependence of the voltage U on radius large electrode c is not regular. Moreover, the large value of voltage at small magnitude of c does not mean that small value of sizes of the external electrode is optimal from the energetic point of view.

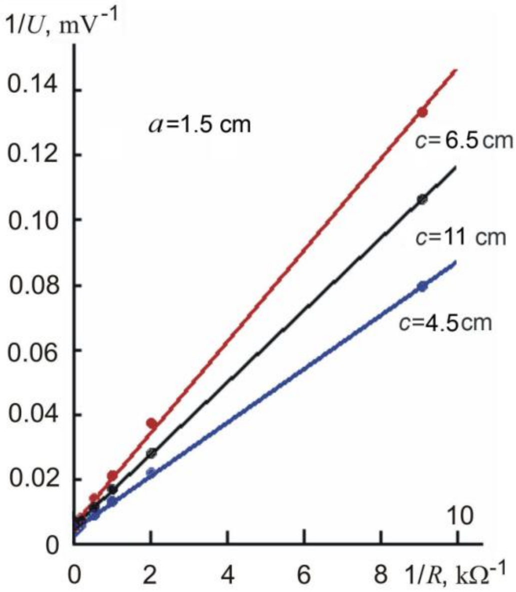

Figure 2: Voltage at various load resistance R.

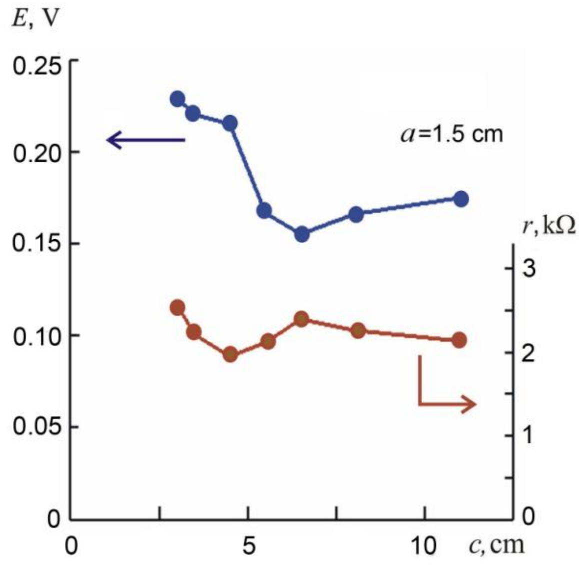

Figure 3: Electromotive force and internal resistance versus radii of the large electrode c.

Measurements were carried out for at least 7 radii of aluminium electrodes 1 mm thick and 17 cm height. Depth of immersion of the electrodes in the liquid was 12 cm. The water sample was the same throughout all the measurements. The time interval between loading the electrodes into vessel with distilled water was at least 6 hours. This is an additional argument that the system shown in Fig. 1 is source of electric energy.

Results of calculating the electromotive forces E and internal resistance r for one radius of internal electrode a=1.5 cm are shown in Fig. 3. A decrease in e.m.f. by almost one and a half times with in increase in the radius of the outer electrode by more than four times does not lead to a significant decrease in the internal resistance. This casts doubt on the chemical origin of the phenomenon. In this case, an increase in the radius of the outer electrode should have led to a noticeable decrease in the internal resistance.

III. ELECTRIC CURRENT IN SHORT-CIRCUIT MODE

Maximum of dissipated energy corresponds to the load resistance equal to internal resistance of a source of electric energy. In this case electric current in the circuit is half the current I corresponding to the so-called short-circuit mode for which R=0. It makes sense to calculate the electric current I not only for the dependence of I versus c at a fixed value of a, but also for the dependence of I on a at c=11 cm. Similar measurements were carried out and their results differ little from the above. Otherwise, the problem will not be solved.

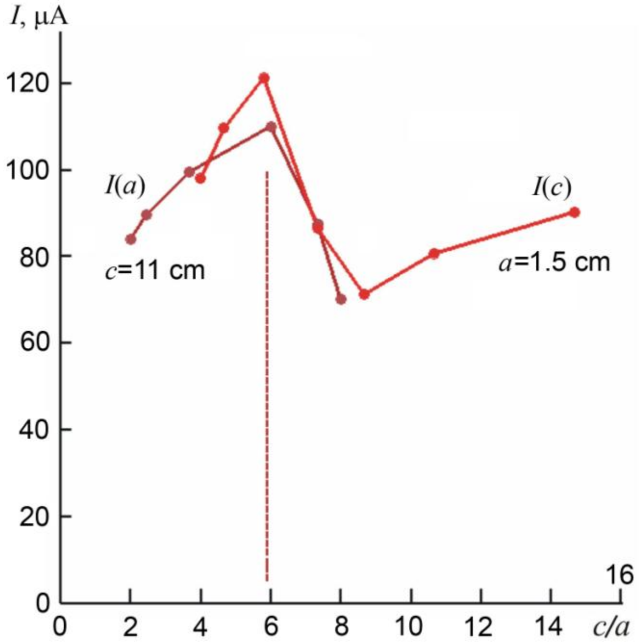

Figure 4: Electric current in short-circuit mode.

It so happened that the electric current in the short-circuit mode is maximal at radius c close to $6a$. The fact that the maximum current is observed for one value c/a for both dependencies $I(c)$ and $I(a)$ turned out to be quite unexpected. Moreover, it is seen that these dependencies are similar. In any case this is true in the range $c/a<8$. Therefore, one may insist on the existence of auto-scaling of the phenomenon: the electromotive force, internal resistance and other energetic parameters depend only on the scaling parameter c/a.

IV. CONCLUSION

Radii of electrodes corresponding maximal current in a vessel with aluminum electrodes contacting with the distilled water are obtained. So far this current is weak enough, but history knows when a seemingly weak phenomenon became the cause of significant progress in one area or another. There is every reason for this. The internal resistance values obtained in this work are many times lower than the internal resistance corresponding to the usual dark electric current (Buckingham, 1983).

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