UV RADIATION, OZONE AND HYDROGEN PEROXIDE CREATED BY HYGH-VOLTAGE DISCHARGE IN WATER.

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Results are presented from investigations of multispark electric discharge in water excited along multielectrode metal-dielectric systems with gas supply into the interelectrode gaps. The intensity distribution of discharge radiation in the region covering the biologically active soft UV ($190 < \lambda < 430$ nm) has been determined and the absolute number of quanta in this wavelength interval has been measured [1,2]. The potentiality of the slipping surface discharge in water for its disinfection is analyzed. The energy expenditure for water cleansing is estimated to be as low as $\sim 10^{-4}$ kW h/l.

SCHEMATIC OF THE EXPERIMENT

Figure 1 shows a schematic of the experiment. A high voltage pulse applied to the electrodes produces a plasma channel between the electrodes. Provision is made for gas supply between the electrodes in order to facilitate breakdown in the interelectrode gaps (i.e., a discharge is initiated in a water—gas mixture) or only in gas without water.

The multispark discharge facility (*2*) is represented schematically in Fig. 2. A gas (air, argon, oxygen) is injected through a set of holes into water between the electrodes, producing fine gas bubbles. Discharge in each interelectrode gap is excited in the complex system, including the metal electrodes, the dielectric substrate, a gas bubble, and water. The chief advantage of the multielectrode system lies in the possibility to decrease the discharge load on each electrode (and thereby to enhance the erosion resistance of the system as a whole), which ultimately increases the system lifetime substantially.

The experiments were conducted with two high-voltage generators (G_1 and G_2) whose parameters are tabulated in Table.

Generator	High-voltage pulse amplitude (kV)	Pulse duration (μs)	Pulse energy (J)	Pulse repetition frequency (Hz)
G_1	40	0.5	0.3	≤ 100
G_2	25	5.0	2.0	≤ 100

The gas leaving the water-filled reactor flows into a cell (5) intended for determining the ozone content by the method of absorption spectroscopy. In the course of the experiments, during long-time performance of the apparatus, the production of H_2O_2 was also measured. UV radiation from the discharge was measured both in the presence and absence of water in the vessel by method of chemical actinometry [3].

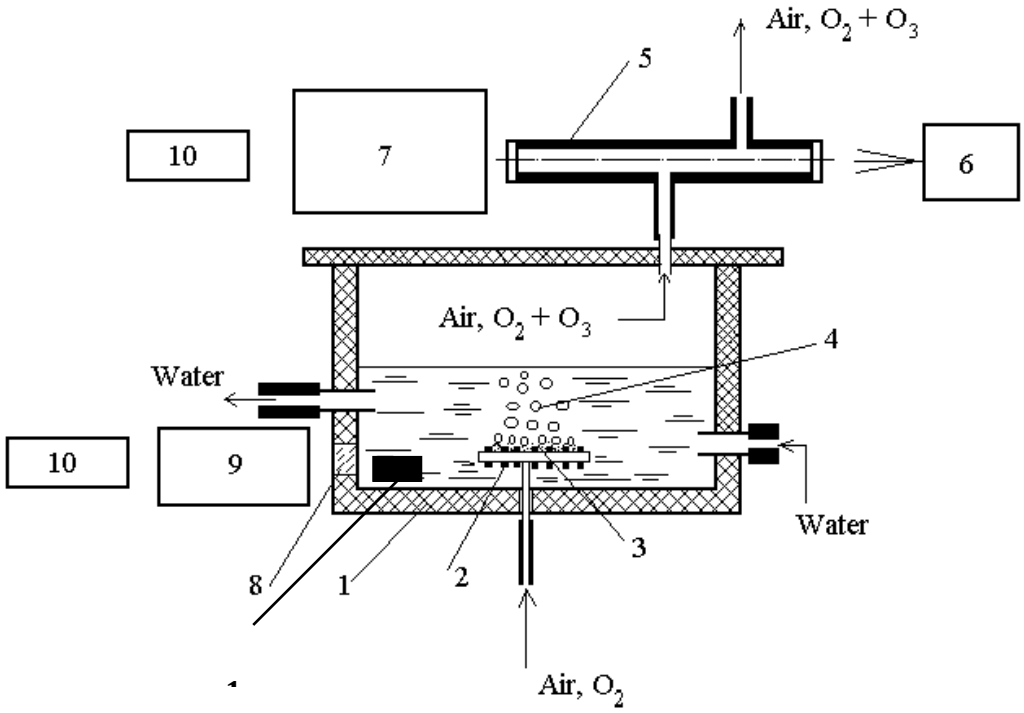

Fig.1. Experimental layout. 1-vessel filled with water; 2-multielectrode system; 3-discharge plasma; 4-gas bubbles; 5-diagnostic cell; 6-deuterium lamp; 7-MDR-3 monochromator; 8-quartz window; 9-MUM-1 monochromator; 10-photomultipliers ; 11-actinometer cell.

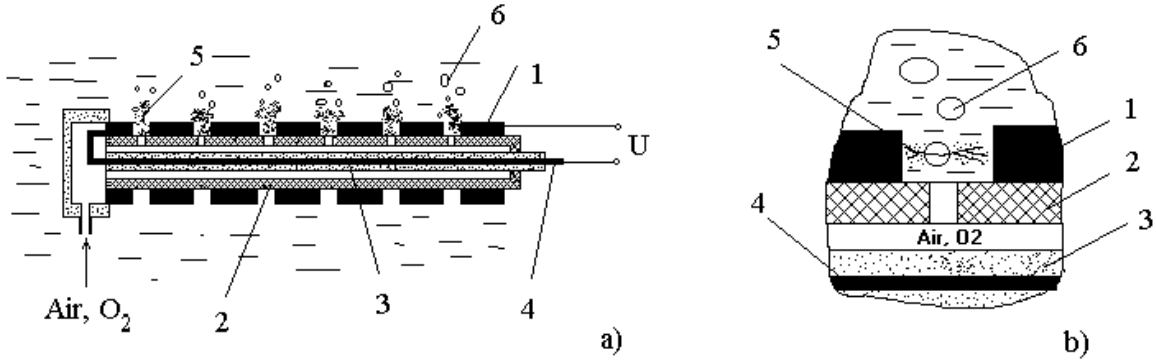

Fig.2. Multielectrode discharge facility. 1-electrodes; 2,3-dielectric tubes, 4-back current rod; 5-discharge plasma; 6-gas bubbles.

ELECTRIC DISCHARGE IN WATER AS A UV SOURCE

The discharge emission was measured in region $230 < \lambda < 300$ nm with the help of a MUM-1 monochromator (9 in Fig. 1) in combination with a FEU-142 photomultiplier,insensitive to the visible light and in region $190 < \lambda < 430$ nm,by method of chemical actinometry when vessel was filled with water and without water (discharge in gas).

As follows from measurements, when operating with the generator G_1 (low levels of the pulse energy, relatively short duration, and high voltages), observations showed the following:

- • the emission spectrum can be approximated by a Planckian with a temperature of
- $T_r \approx (4\text{-}5) * 10^3$ K;
- • the intensity of UV radiation vary only slightly, irrespective of whether the discharge is ignited in gas or in water.

When the generator G_2 was used (the regime of high pulse energies, long pulses, and relatively low voltages), the characteristic features were as follows:

- • in the emission spectrum of air discharge, we observed an intense “superthermal” emission in the short-wave region (two characteristic peaks);
- • the emission intensity of water discharge, on the average over the spectral interval under study, was more than one order of magnitude higher than that for air discharge and, compositionally, differs substantially from a Planckian spectrum.

Actinometric measurements of UV intensity in water discharge showed that, for both generator regimes (G_1 and G_2), the quantum efficiency of soft UV emission in the range $190 < \lambda < 430$ nm in the case of discharges in the water was nearly the same and equal to $\sim(2\text{--}3)10^{15}$ quanta/J.

ELECTRIC DISCHARGE IN WATER AS A SOURCE OF OZONE PRODUCTION

Measurement of O_3 concentration in gas flowing from the reactor were made by absorption spectroscopic (at $\lambda = 255{,}5$ nm) and by chemical (potassium iodide + O_3) methods with discharges in water + O_2 and in O_2.

As follows from measurements for various oxygen flow rates(from 2.5 to 5 l/min).

- • O_3 concentration increases with growing frequency generator lineary;
- • O_3 concentration decreases with growing oxygen flow rate.

When discharge was ignited in oxygen (water was pumped out from the vessel), the density of ozone produced in this discharge turned out to be nearly (within 10—20%) equal to that for a discharge ignited in the water—gas mixture.

ELECTRIC DISCHARGE IN WATER AS A SOURCE OF HYDROGEN PEROXIDE PRODUCTION

The hydrogen peroxide (H_2O_2) content in water treated by the electric discharge was measured by the iodide-molibdate method.

The measurements of hydrogen-peroxide production that were carried out with the generator G_1, in a discharge in water, with injected argon showed that a series of discharges for 6 - 7 min in 250 cm^3 of water produced H_2O_2 with a mean density of $n_{H2O2} \cong 2 \cdot 10^{-3}$mol/l $\cong 1.2 \cdot 10^{18}$ cm^{-3}.The energy cost of production of one H_2O_2 molecule in this case is $\eta_{H2O2} \leq 1.5 \cdot 10^2$ eV/mol.

With the generator G_2, the energy cost turns out to be significantly higher and equal to $\eta_{H2O2} \leq 1.4 \cdot 10^3$ eV/mol.

6. CONCLUSIONS

The main results obtained in this study can be summarized as follow:

- • it has been shown that the slipping surface discharge excited in the water—gas mixture can be used as an effective sterilizing instrument, utilizing the combined effect: ultraviolet radiation emitted from the discharge and the production of ozone and hydrogen peroxide. According to our estimates, the energy cost of water treatment will be at a level of $\xi \leq 10^{-4}$ kW h/l.
- • as has been found experimentally, in each high-voltage pulse, the slipping surface discharge ensures a high transformation coefficient of injected oxygen to ozone, conceivably, due to efficient quenching mechanisms acting during the decay phase of discharge (or due to processes occurring in the photodissocition region around the discharge channel).

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