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THE INVESTIGATION OF CHEMICAL ACTION OF GLIDING AND GLOW DISCHARGES BETWEEN METALLIC ELECTRODE AND AQUEOUS SOLUTION

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1. Introduction

Interaction between the gas discharge plasma and solution stimulates the oxidative chemical reactions in the liquid phase, and those can be used to solve applied problems. The choice of discharge type for purposes of practice demands to take into account its chemical efficiency and engineering applicability. Engineering fitness of the gliding discharge was proved by experiment [1]. At the same time the chemical action of this type of discharge on solution was not investigated nearly. Some investigations were carried out only for the case of the gliding discharge between two metal electrodes locuted near solution surface. However the chemical activity of the discharge can change if the solution is used as one of electrodes. In this case the active species are produced not only in the plasma volume but also directly into the solution. Therefore the goal of this work was to investigate the chemical action of gliding and glow discharges between metal electrode and solution with the comparison of their actions.

2. Experiment

The arrangement of the experiment is shown in fig. 1. An oxidative destruction of dye and oxidation of Mn^{2+} to MnO_2 in aqueous solution under the plasma action were investigated. Rectangular reaction cell of polymethylmetacrilate contained up to 400 ml of solution. The air flow to sustain gliding discharge was above of 3 l/min. The same air flow was passed through the reactor in the case of glow discharge also. The kinetic of dye destruction was controlled by optical transmittance in the absorption maximum region of dye initial solution (about of 600 nm). The experimental set included the halide-cycle incandescent lamp as radiation source, mirror grating monochromator, photocell, the amplifier and XY-recorder. Absorption spectra of initial and treated solutions were controlled by spectrophotometer. MnO_2 output was determined gravimetrically. Besides that temperature of the solution and air (at the entrance and at the exit) was measured in our experiments. Calorimetric measurements allowed to analyse of the discharge energy balance. The comparison of gliding and glow discharge was carried out at same currents. However the gliding discharge voltage was 2–2,5 times higher than that of glow discharge.

3. Results

Change of solution optical transmittance (λ = 600 nm) under glow and gliding discharges actions is shown in fig.2. Such data allowed to calculate the dye molecules concentration change. The calculations were carried out on the base of Buger-Lambert-Beer low assuming that the destruction products do not absorb in the region near 600 nm. The results of calculations are demonstrated in fig. 3. These results testify more high chemical activity of the gliding discharge at the same discharge currents. In our opinion it may be due to greater average length of the gliding discharge. In fact the measurements of the dye destruction under the stationary discharge action prove the increase of the reaction rate at higher discharge gaps. However the change of the dye absorption spectra under the plasma action show some other results. Data presented in Fig.4 show no essential difference between the gliding and glow discharge action. Records of the absorption spectra were carried out 30-40 minutes later the plasma treatment. At the same time our measurements demonsrated the existence of post-effect. Perhaps, it is the H_2O_2 accumulation in solution that causes it. We investigated post-effect influence at various doses of plasma treatment. Results of these investigations shew post-effects of two discharges action to be approximately the same. Some observed differences may be due different compositions of active particles produced at these discharges action. Besides that one has to take into consideration the difference of the discharge power at constant discharge current.

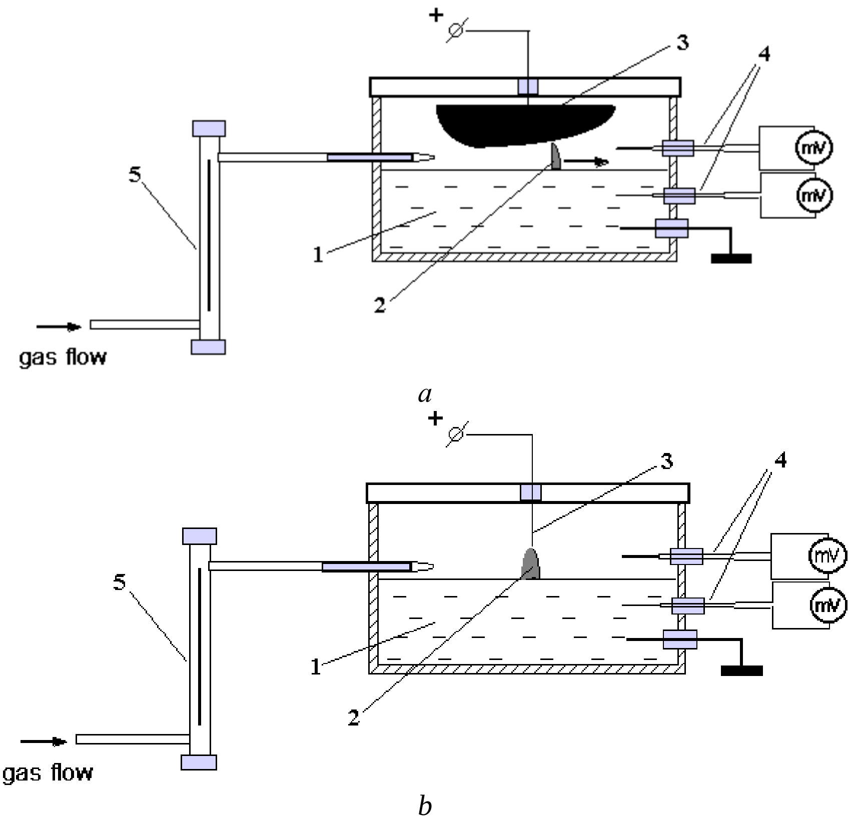

Fig. 1. Experimental sets for investigation of gliding discharge (a) and glow discharge (b):
1 – electrolyte, 2 – plasma zone, 3 – electrode, 4 – thermocouples in thin-walled glass capillaries, 5 – rotameter.

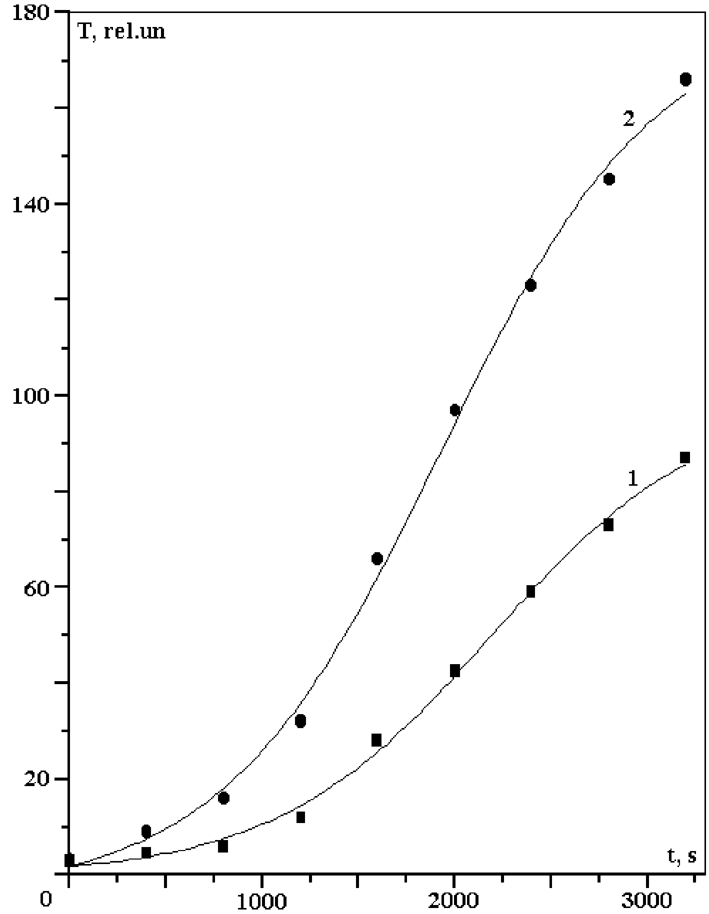

Fig. 2. Change of the dye solution optical transmittanse under plasma action:
1 – glow discharge, 2 – gliding one. Discharge current – 6 mA.

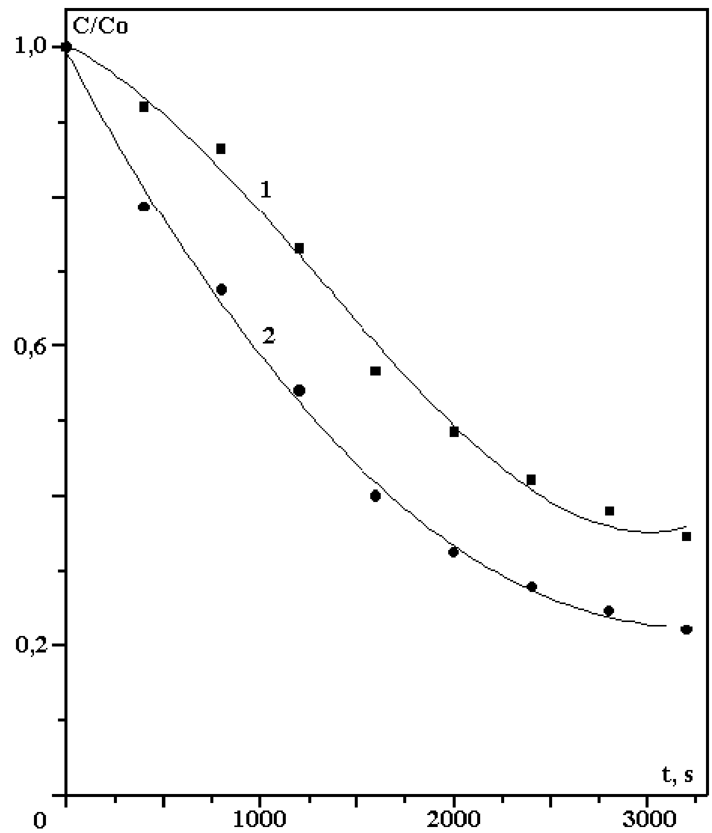

Fig.3. Dependence of dye relative contense in solution from the time of plasma treatment: 1 – glow discharge, 2 – gliding one. Discharge current – 6 mA.

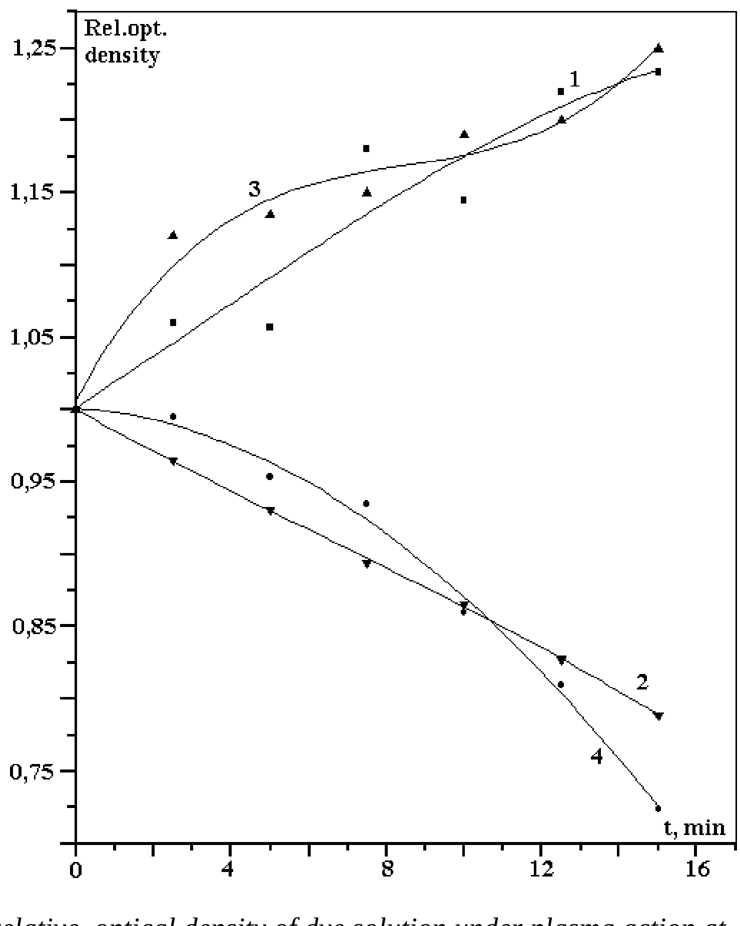

Fig. 4. Change of relative optical density of dye solution under plasma action at λ=440 nm (1, 3) and λ=600 nm (2, 4): 1, 2 – glow discharge, 3, 4 – gliding one.

The investigation of MnO_2 synthesis by the plasma treatment of $MnCl_2 \cdot 2H_2O$ solution showed the another pattern. MnO_2 outputs under the stationary and gliding arc action are presented in table 1.

Table1. MnO_2 synthesis under gliding arc and stationary arc action

Type of discharge	*I*, mA	*U*, kV	*W*, W	Current efficiency	Output Molecules/100eV
Glow	20	0,9	18	1,25	0,014
Gliding	20	2,6	52	0,66	0,0074

Table 2. Dye destruction under the plasma action

Type of discharge	*I*, mA	*U*, kV	*W*, W	Current efficiency	Output molecules/V
Glow	6	3,6	21,6	0,042	$4{,}7 \quad 10^{-4}$
Gliding	6	6,8	40,8	0,079	$4{,}6 \quad 10^{-4}$

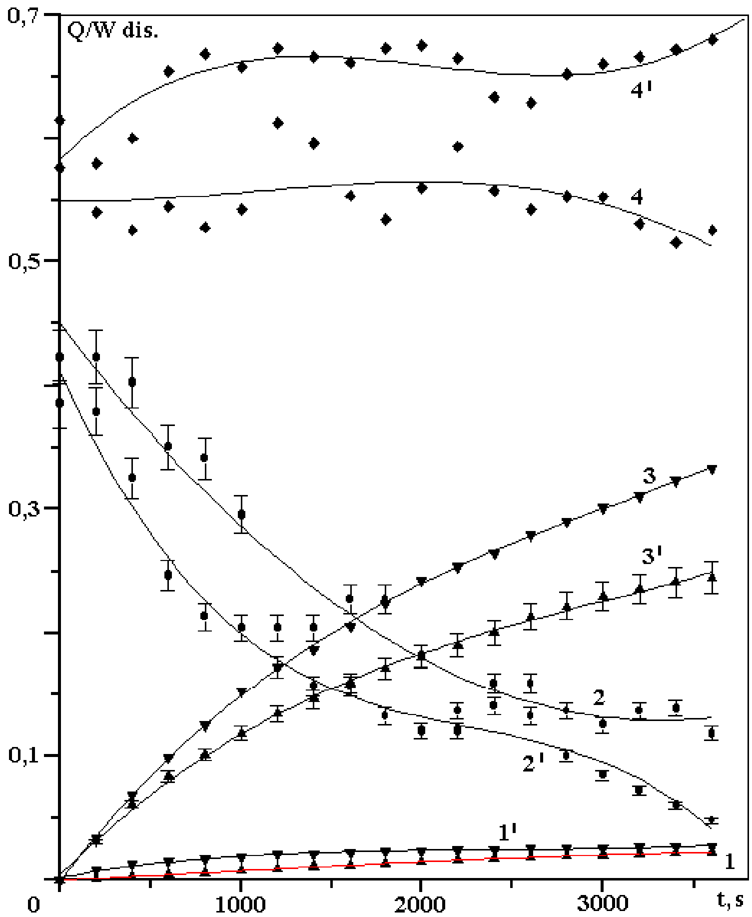

Fig. 5. Energy balance of discharge:
1 – air flow heating, 2 – solution heating, 3 – “equilibrium” heat losses, 4 – vapour jet formation.
Data with [1]-index are for the case of gliding discharge, without it-for the case of glow discharge.

The comparison of these data with that of dye destruction (table 2) shows that chemical action of any type of discharge depends considerably on the nature of processes initiated, so the choice of discharge type has to be specific only. Experimental data gave evidence there are difference not only in chemical actions of gliding and glow discharges but in their energy balances. According to our measurements the cathode potential fall under glow discharge conditions is up to 800 V near the solution surface [2]. High surface density of energy results in the formation of vapour jet in the region of the cathode spot. Energy expenditure on this process has to influence on the discharge properties. Calorimetric measurements allowed us to estimate the relation between principal channels of energy dissipation during actions of glow discharge and gliding one. Results in fig.5 shows the part of energy for vapour jet formation to be higher in the case of gliding arc.

REFERENCES

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Поступила 08.10.2001

Summary

Chemical effects induced by gliding and glow dicharges in solutions were studied. Processes of oxidative destruction of dye (monoclortriasine blue) and oxidation of Mn^{2+} to MnO_2 were taken as an example for our investigations. The gliding disharge was more effective in the case of dye destruction, but as for Mn^{2+} oxidation , the current efficiency for glow discharge was higher.