# The influence of plasma–solution treatment on the electrokinetic properties of powder cellulose

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The change of the electrophoresis properties of powder cellulose under the action of glow and underwater diaphragm discharges is investigated.

Cellulose and its derivatives, including their powder forms, are widely industrially used.[1,2] It is important to study the modifications of its colloidal properties.[3,4] Effective methods for the treatment of the dispersions of high-molecular substances are well known.[5–7] Previously, we investigated the colloidal properties of an aqueous dispersion of powder cellulose under mechanical activation and electromagnetic action.[8,9] The aim of this work is to study the influence of electrical discharges on the properties of cellulose.

The use of low-pressure plasma for the treatment of natural and synthetic polymers is well known. However, the processes stimulated by such a plasma are non-selective. The polymer treatments in plasma–solution systems provide an attractive possibility of integrating the high chemical activity of plasma with the selectivity of processes in aqueous solutions.[10–12]

We studied two plasma–solution systems: an atmospheric-pressure glow discharge with an electrolyte cathode and a diaphragm discharge (Figure 1). The electrodes of graphite were used. The discharge current was 30–50 (glow discharge) or about 50 mA (diaphragm discharge). The voltage was about 2 kV in the case of the glow discharge and less than 1 kV in the case of the diaphragm discharge. Sulfite cellulose from the Baikal plant (the degree of polymerization is 870) was used in the experiments. Particles smaller than 30 μm were selected by sedimentation. The dispersions were prepared according to a published procedure.[8] The conductivity of the system was ensured by the use of NaCl (1 mmol $dm^{-3}$). The acidity was regulated by the addition of NaOH and HCl (pH 2.0–8.0). The dispersion was treated in a closed cell (Figure 1) by stirring for 20 min. The measurement of the colloidal particles mobility electrophoresis was made using standard micro electrophoresis.[8] The influence of the treatment conditions and medium acidity on the mobility of cellulose particles is illustrated in Figure 2. The results for the initial (non-treated) sample are in accordance with published data.[13,14] The plasma treatment leads to an increase of the mobility. The effect of the glow discharge is greater. The dependence of the particle mobility on the acidity of solution shows that the positions of the mobility maximum (pH 6.5) and that of the isoelectrical point (pH 2.5) are the same for all samples. In our opinion, the plasma treatment increased the surface concentration of the RCOOH groups under the action of OH radicals produced in the solution.[15,16] The result of this process is an increase in the surface charge and the following growth of opposite ion number in the diffusion sheet and an increase in the particle mobility. The difference between the effects of the glow discharge and diaphragm discharge may be connected with the existence of a sound wave in the case of the diaphragm discharge.[16,17] The action of a sound wave produced in the diaphragm discharge results in the destruction of graphite and copper samples immersed in solution.[16]

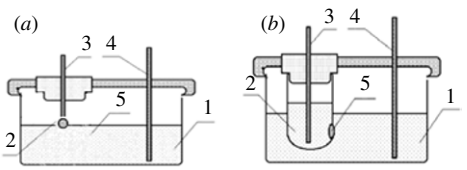


**Figure 1** Plasma-solution cells. (*a*) Glow discharge cell: (1), (5) solution; (2) discharge zone; (3) potential electrode; (4) earthed electrode. (*b*) Diaphragm discharge cell: (1) solution; (2) ampoule with solution; (3), (4) electrodes; (5) diaphragm.

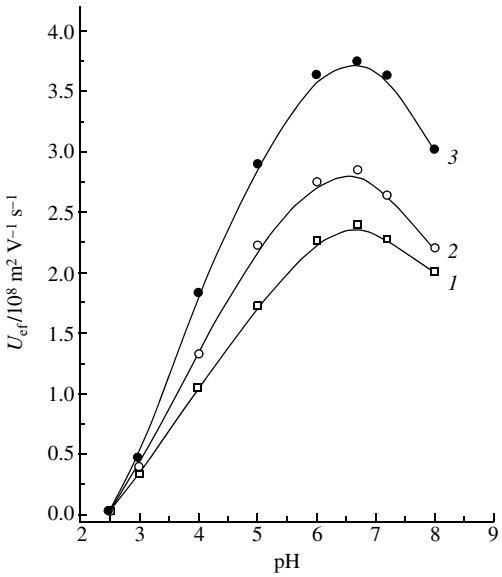


**Figure 2** The change of the powder cellulose EPM under the plasma–solution systems action: (*1*) initial sample, (*2*) sample treated by a diaphragm discharge and (*3*) sample treated by a glow discharge.

The plasma action resulted in a post-effect (Figure 3, curves 2–4). The nature of the post-effect is unclear. The initial active species are very short lived. The only stable active particle is hydrogen peroxide.

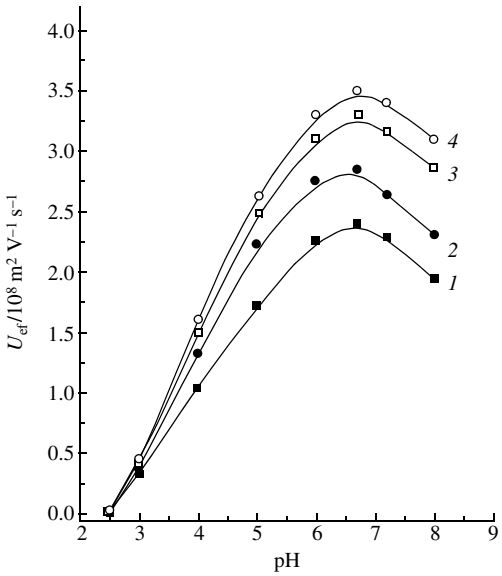


**Figure 3** The change of the powder cellulose EPM under the diaphragm discharge treatment: (*1*) initial sample, (*2*) immediately after the treatment, (*3*) 24 h after the treatment and (*4*) 72 h after the treatment.

**Table 1** The influence of $H_2O_2$ (5 mmol dm$^{-3}$) on the electrophoretic mobility of cellulose at pH 6.4–6.8.

| Experimental conditions | Exposure time after the addition of $H_2O_2$/h | $T$/°C | pH | $U_{ef}$/10$^8$ m$^2$ V$^{-1}$ s$^{-1}$ |
|---|---|---|---|---|
| Initial dispersion (A) | — | — | 6.54 | 2.40 |
| A + $H_2O_2$ | 0 | — | 6.48 | 1.54 |
| | 24 (light) | 25 | 6.52 | 1.93 |
| | 48 (light) | 25 | 6.61 | 2.38 |
| | 24 (dark) | 2 | 6.67 | 1.51 |
| | 24 (light) | 25 | 6.73 | 2.18 |
| | 48 (light) | 25 | 6.65 | 2.41 |

In order to check the possibility of the post-effect under the action of $H_2O$, we investigated its influence on the electrophoretic mobility of cellulose (Table 1). Thus, the addition of hydrogen peroxide value formed under the glow discharge action resulted in a decrease in the mobility of cellulose. The destruction of $H_2O_2$ under the action of heat and light leads to initial values.

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