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Prospects for Use of Electrohydrodynamic Dispersion of Charged Meniscus and Jets in the Development and Creation of New Materials and Processes

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Experimental data on the forms and electrical characteristics of charged meniscuses and jets of water. Presented application directions electrodispersion menisci and capillary collapse jets of liquids in a variety of industries with current technology.

Keywords: Charged jet, Electrodispersion, Taylor cone.

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1. MAIN TEXT

Interest in the study of nanostructured materials is continuously increasing, due to their unusual physical properties, as well as the wide possibilities of their practical application. Traditional methods for nanoparticle formation, for example, processes based on the condensation of atoms under conditions close to equilibrium, produce crystalline particles. However, such particles tend to coagulate in contact, making it difficult to obtain based on their high-density structures, while in the structures of densely packed particles with interparticle effects lead to the appearance of new properties most interest, both in physical and practical standpoint [1].

Alternative methods of producing nanostructures based on electrodispersion melts or solutions. In these methods the nanoparticles formed by the charging and the serial (cascade) dividing the drops while the process is in a highly non-equilibrium conditions, whereby the particles are obtained in an amorphous state. By its properties, the amorphous nanoparticles significantly different from crystal, whereby the nanoparticles based on amorphous structure can be obtained with a much broader range of useful properties.

One of the most promising classes of materials are polymeric and metal- polymer nanocomposites. The latter combines the properties of nanoparticles of metals and polymers. In particular, these composites having a mixed electronic and ionic conductivity, covered in an active material of high fuel cells and lithium ion batteries. [2] Electrodispersion solutions or melts of polymers (electrospinning process) prepared highly fibrous materials for filtering gaseous and liquid media (filters Petryanov) [3], polymer fibers with metallic conductivity, high strength fiber for the manufacture of composite materials. Recently, intensively studied the possibility of using fibrous materials based on biopolymers as templates for growing artificial biological tissues. In this regard, the current task is the development of methods for continuous electrodispersion nanocomposites - a technique for the management of structural and electrical properties of materials at high performance of their receipt.

As a result of experimental studies meniscus found that in the initial state ($U = 0$) at the end of the nozzle meniscus is formed which due to the Laplace equation and the hydrostatic pressure is at rest. If the meniscus to make high DC voltage $U < U_1$, then under the influence of electrostatic induction on the meniscus surface charge will bring the highest density at the peak, there ponderomotive force and the meniscus is pulled into the cone (Fig. 1a-c). Further, when $U_1 < U < U_2$ on top of the Taylor cone formed pulsating microcones (Fig. 1d, successive frames at intervals 1/420 sec), accompanied by corona glow (Fig. 1c). Pulsation frequency ν of several hundred Hz, and it increases with increasing voltage (Fig. 1e).

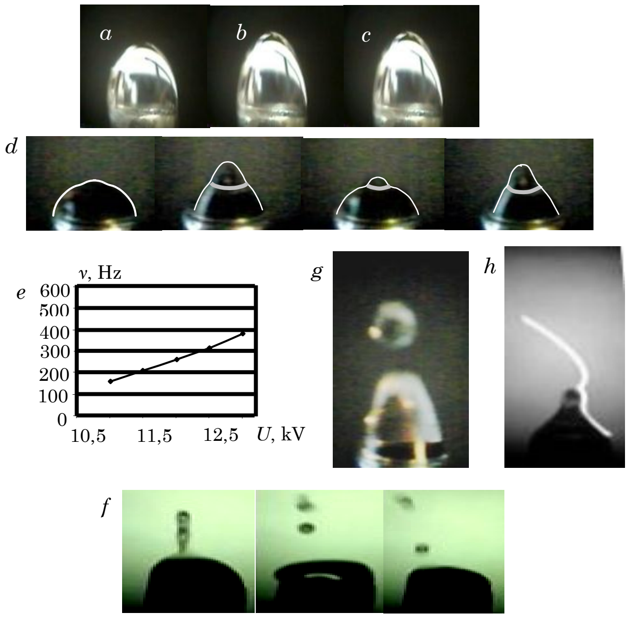

Fig. 1. – The dynamics of the meniscus of water at the tip of the copper capillary tube with an internal diameter of 1 mm depending on the applied voltage (negative polarity)

Depending on the size of the meniscus can tear off mikrojets with subsequent decay into microdroplets, and the decay of microstreams next to the meniscus drops sometimes return to the meniscus, which is caused by recharging them (Fig. 1f). This observation shows that the surface of the meniscus is surrounded by a cloud of charges of opposite sign of the polarity of the meniscus. Finally, in the $U_3 < U < U_4$ torn makrodrops or jets (Fig. 1g), the size of the order of the ra-

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dius of the capillary, when $U < U_4$ observed sample (Fig. 1h) [4-5].

In the study of the expiry of liquids with fast relaxation of charges Experimental results conveniently represented as a map mode, which shows the area of exhaust velocities in the capillary and the values of the applied voltage (Fig. 2) [6]. It can be seen that the patterns are irregular outflow jets of charged and strongly depend on the rate of discharge and the magnitude of the surface charge.

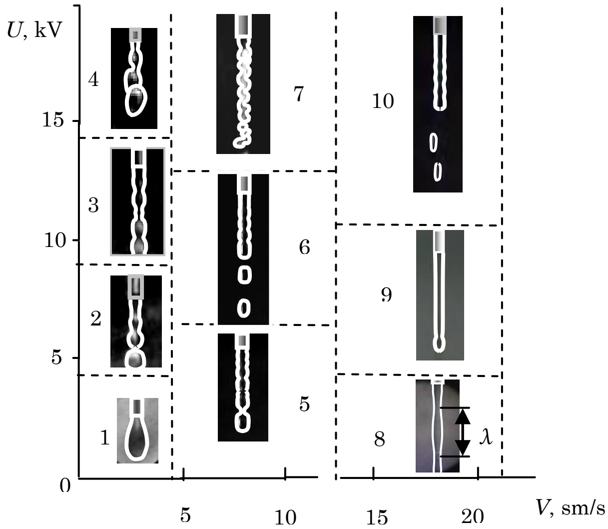

Fig. 2 – Map modes expiration charged jets: the regime drip expiration (1-4): 1 – drip issue, 2 – shift to the expiration of undulating jet, 3 – start destabilization 4 – destabilization with consolidation drops. Transients expiration (5-7): 5 – stabilization of the wave flow, 6 – destabilization, 7 – kink instability. The jet outflow (8-10): 8 – Rayleigh instability, 9 – stabilization, 10 – destabilization of the field

Fig. 3 shows an example of a high voltage stabilizing jet electric field for thin filaments micron and submicron-viscous liquids [7], such as aqueous solutions.

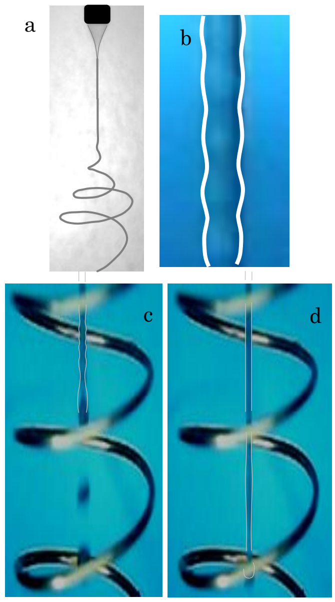

Fig. 3 – Changing the shape of the jet: a – the formation of a thin, uniform polymer fiber; twist yarns due to EHD instability; b – the development of the instability of a charged jet of water, with - without the jet decay of the field, d – the stabilization of the expiry of the water jet by an electric field with a spiral electrode [8]

RESUME

1. It is shown experimentally that the charged meniscus deformed Taylor cone at whose end is formed pulsating microcones pulsation frequency which in the case of water meniscus is several hundred hertz, and it increases with increasing voltage at the meniscus.
2. A map modes of liquid outflow from the fast relaxation of the charge of a thin capillary in terms of the rate of discharge – the applied voltage.
3. The regimes of stabilization of the jet outflow from the capillary.
4. It is concluded that electrodispersion a promising methods for obtaining nanoparticles of melts or solutions.

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