Rheology of Dielectric Suspensions Based on Modified Dual-Doped Titanium Oxide in Electric Field

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Papers on electrorheological effect in suspensions with dispersed phase in form of inorganic powders with a developed specific surface show that the polarization appearing in such suspensions in the electric field and determining the interaction force of the particles of dispersed phase should be mainly "slow" (Maxwell-Wagner). It is due to the difference of the electric parameters on the interface of filler particle-dispersion medium and is linked to the structural defects of the particles themselves. Known heterogeneous and polyphase materials showing this type of polarization consist of either several phases, i.e. amorphous and crystalline, or have dislocations, cracks and etc.

We have earlier shown [1], that the increase of ER-effect can be achieved by a purposed distortion of crystal lattice parameters of titanium oxide, broadly used as ERS filler, by means of doping it with aluminum atoms. In the result of experiments the increase of surface charges quantity has been obtained and the occurring structural interaction of the filler particles due to it, which is fixated by the increase of viscosity at ERF shear under the external constant electric field.

The aim of this work is to strengthen the modification effect of titanium oxide structure by means of dual doping by aluminum and phosphorus atoms. As the titanium component titanium tetraisopropoxide was used and as a template - dodecylamine, at a molar ratio TiO_2: template equal to 1: 1. The template was removed by washing with water and calcination of the samples at 700 °C for 3 hours, then the modified titanium oxide samples were used for the preparation of suspensions containing 5 and 20 wt. % of the filler in mineral oil.

Electrorheological activity of suspensions was studied by rotational viscometry by means of coaxial-cylindrical cell modified to apply the electric field. The leakage currents were recorded using a micro-ammeter. The dielectric properties of the suspensions were examined using immittance meter E7-20.

The experimental data obtained suggest that the dual modification of titanium oxide with aluminum and phosphorus allows to achieve high levels of ER activity of suspensions thereon. Thus, the shear stress value increased in comparison with the values without influence of the electric field in the 30 and 170 times for 5 and 20 % suspensions, respectively, at an electric field intensity of 4 kV/mm. These values are several times greater than the data previously obtained in experiments when doping titanium oxide only by aluminum atoms.

Participation of both alloying components in the polarization processes occurring on the surface of the modified titanium oxide is confirmed by its dielectric spectrum. Thus, dependence of the imaginary part of the complex effective dielectric constant on the frequency identified two peaks in the frequency range of 1-3 and 20-30 kHz, corresponding to a number of different types of inclusions in the sample. Blur peaks indicative of several polarization processes occurring with different rates at the media interface.

Thus, the prospect of a dual-doping of titanium oxide to obtain effective electrorheological fillers and creation of new smart materials on their basis suitable for usage in modern smart-devices and technologies was shown.

[1] Korobko E., Novikova Z., Sermyazhko E., Murashkevich A., Eshenko L. Time stability studies of electrorheological response of dispersions with different types of charge carriers. *Journal of intelligent material systems and structures*. – 2015. – VOL. 26, NO. 14. P. 1782–1788.