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Impact of space charge in a polymer and a hybrid material for energy applications in the microworld

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In this work, we analyze the insulating and dielectric properties through the space charge phenomenon in polyvinyl butyral (PVB) and a hybrid material developed in our laboratory. This hybrid material is composed of iron oxide nanoparticles (Fe_2O_3) in a PVB polymer matrix. Both materials are fabricated as thin films with 15 micrometers in thickness. By Dynamic Dielectric Analysis (DDA), we obtain the complex permittivity of both materials. These tests have been done varying the frequency from 20 Hz to 2 MHz. The temperatures remain constant, going from 323 K to 423 K. Real and imaginary curves of the complex permittivity show the ability to store and dissipate electrical charges of both materials, PVB and PVB-Fe_2O_3, but it is not possible to identify the space charge in these curves. So, we computed the isochronous diagrams of the real and imaginary parts of the complex electric modulus from complex permittivity data. With the calculated complex electric modulus, it is possible to clearly identify the space charge phenomenon. Results show a reduction in space charge in the hybrid material. This reduction is caused because the dispersion of the Fe_2O_3 nanoparticles in the PVB promotes the dissipation of the electrical charges, instead of storing these ones in the polymer matrix. Additionally, the electrical manifestation of the glass transition shifts to high temperatures in the hybrid material: the glass transition temperature increases considerably from 343 K to 363 K. These results will help to perform better parameters of these polymer and hybrid materials for energy applications in the microworld.

Keywords: Space charge; dielectric; hybrid materials; magnetic nanoparticles; electric storage