Electrostatic stability in insulating polymers

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Introduction:

The electrostatic stability in insulators is commonly researched using metals and other conductors and seldom studied using insulating polymers. And even fewer have been able to provide substantial reproducible electrostatic charges in given polymer samples. Scanning electric potential microscopy (SEPM) images illustrate the degree of electric potential of a sample, in our investigations: latex and polypropylene. In SEPM imaging, it uses a type of non-contact atomic force microscope (AFM) technique, but samples are scanned using Pt-coated nitride tips. The electron potential areas are measured by a gray-scale at each particular pixel. The image is built using the dc voltage fed to the tip, at every pixel, thus detecting electric potential gradients throughout the scanned area. The electron potential distribution across polymer films reveals the existence of domains of different charge densities, ranging from a few nanometers up to hundreds of nanometers.[1]

Procedure:

Each of the polymer SEPM images was taken at 5-µm magnification while the microscope tip situated 10 nm from the polymers surface. These positive outermost layers are highly concentrated potassium counter-ions; where as the negative cores are composed of sulfur.

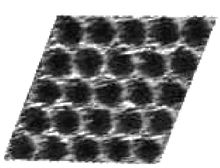


Figure 1:

SEPM image of a self-assembled poly(styrene-*co*-hydroxyethyl methacrylate) latex macrocrystal.

Figure 2:

SEPM image of a high-density polyethylene film surface

In both of these particular images (Figures 1 and 2), the electric potential differences are detected by the microscope probe between the adjacent domains in the films. These dielectric films are a mosaic of electrically charged domains, and this is only observed at the macroscopic levels.[2]

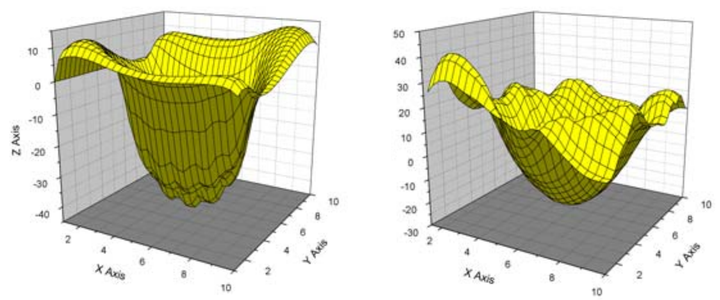
In order to obtain the grey-level for both the latex and polypropylene, Image Pro Plus 7.0 image analysis software was used. Using a simple *bitmap analysis* tool in the software, a pixel-by-pixel breakdown of the image was obtained ranging between 255 (white) to 0 (black).

The calculation of the electrostatic potentials generated by a charged surface is used by the Poisson's Equation in the C++ code.

$$V = \sum_{i=1}^{n} V = \frac{1}{4\pi\varepsilon_{\circ}} \sum_{i=1}^{n} \frac{q_i}{r_i}$$ which can reduce to:

$$V = (k_e q)(1/r)$$

Figure 3/4: The measured electric domain potential of latex (left) and polypropylene (right)



Conclusions:

The tightly cube spaced latex polymer particles show a sorted patterned SEPM as well as a distributed electric potential. Whereas the polypropylene SEPM can be noticed to be random in regards to its electric potential, and similarly its electric potential graph shows a non-uniform charge distribution. Our experiments using latex and polypropylene polymers have accepted the electrostatic charges to its surface, and has have served as an excellent model for further investigations.

References:

1,2. Braga, M.; Costa, C.A.R.; Leite, C.A.P.; Galembeck, F. *J. Phys. Chem. B*, Vol. 105, No. 15, **2001**.

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