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Non-Electroneutrality in Polyethylene

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Abstract –Low density polyethylene (LDPE) samples were cleaned in different ways and electrostatic potential decay was monitored using a scanning electrostatic Kelvin voltmeter, under 1 and 60% relative humidity. Samples washed by any of the methods show variations in local potential decay kinetics and a final negative electric potential (−4.6±0.7 Volts). LDPE surfaces were also imaged by Kelvin Force (KFM) and Electric Force Microscopy (EFM) showing electric potential gradients as high as 3000 kV m^{-1}. Thus, these insulators show charge distribution heterogeneity from the nanometric to macroscopic scale and well equilibrated samples are not electroneutral.

Mechanisms for the electrization of insulators and the intervening species are attracting growing attention[1] and recent work from this laboratory showed the importance of water adsorption in insulator charge build-up and dissipation [2]. This work describes potential patterns of polyethylene (LDPE) in macro and microscopic size scale. LDPE samples were cleaned by four different methods: (1) gently washing with commercial detergent; (2) acetone in a Soxhlet extractor; (3) immersion in acid solution (HCl 0.01M) or (4) in basic solution (NaOH 0.01M), all followed by sonication. Samples were placed under N_2 atmosphere with controlled humidity within a closed aluminum box and scanned with a Kelvin electrode with 5 mm resolution, connected to an electrostatic voltmeter. Twelve measurements in each polyethylene sample, in different areas. Microscopic electric images were obtained by Electric Force Microscopy (EFM) and Kelvin Force Microscopy (KFM), derived from non-contact atomic force microscopy (AFM) and using a Pt-covered probe.

LDPE samples washed by any of the cleaning methods show a final negative electric potential at (−4.6±0.7 Volts) independent on the sign of the initial potential, as shown in Figure 1. There is no significant difference on these values depending of the relative humidity and the potential decay rates at the twelve points in each sample are not correlated, showing an electric heterogeneity in LDPE. Microscopy images (KFM and EFM) also show a potential heterogeneity, confirming the existence of local charge excesses (Figure 2). Electric potential gradients in the nanometric size range approaches 3000 kV m^{-1}, near the field for dielectric breakdown of air. The fractal dimensions calculated in lines A-B, C-D and E-F of the image (Figure 2) indicate that surface charge patterns are more complex than surface topography.

The final negative electrical potential can be explained assuming that there is a partition of hydroxide and hydronium ions between LDPE and the atmosphere, analogous to the asymmetry of the molecular charge distribution [3] on air or oil/H_3O^+ interfaces.

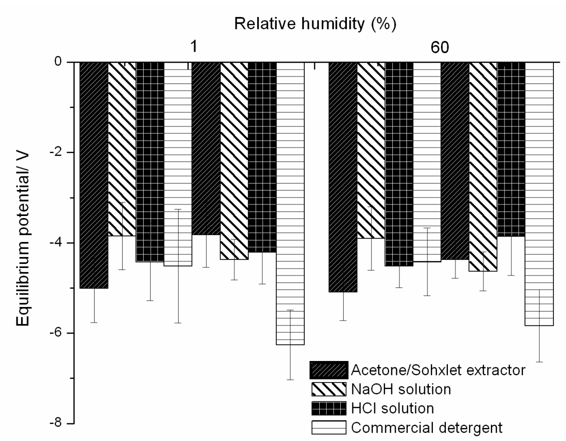

Figure 1: Final potential of LDPE samples cleaned by different procedures.

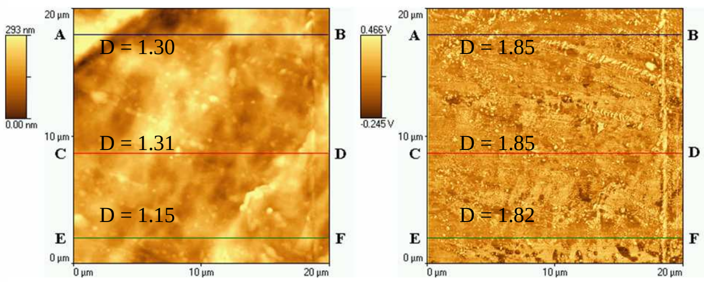

Figure 2: Topography (left) and electric force (right) images of LDPE sample washed with HCl solution obtained by EFM. D is the fractal dimension of the lines in the images.

References

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