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Nanomechanical characterization of polypropylene-based materials with multifrequency atomic force microscopy (AFM)-based methods

DALIA YABLON, Exxonmobil Research and Engineering

Atomic force microscopy (AFM) is a powerful technique with broad applications to characterization of surfaces, primarily used for nanoscale quantitative topographic measurements and qualitatively distinguishing between material properties on the surface. We describe recent advances in our capabilities to quantify nanoscale mechanical measurements of surface properties using recently developed high frequency and multifrequency methods. Initial focus of this work is for polymeric materials (and specifically polypropylene based blends), where nanomechanical characterization is critical for effective understanding of structure-property relationships, especially for more complicated multi-component materials such as blends and composites. SPM techniques rely on complicated tip-sample interactions that must be effectively separated and understood if we are to ultimately identify and quantify specific materials and material properties at the nanoscale. We describe different approaches to this problem utilizing a number of AFM based techniques including force curves, bimodal imaging and contact resonance imaging. Ultimately, these techniques yield quantitative maps of conservative and dissipative tip-sample interactions that are then converted into elastic and viscous moduli maps. We describe initial applications of these methods to measure mechanical properties such as storage and loss moduli of model polypropylene containing blends including polypropylene/rubber and polypropylene/polystyrene blends. Finally, quantitative moduli values obtained by methods described above are compared to those obtained by bulk methods.