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Accelerated design and quality control of impact modifiers for plastics through atomic force microscopy (AFM) analysis

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Standard polymer resins are often too brittle or do not meet other mechanical property requirements for typical polymer applications. To achieve desired properties it is common to disperse so called "impact modifiers", which are spherical latex particles with diameters of much less than one micrometer, into the pure resin. Understanding and control of the entire process from latex particle formation to subsequent dispersion into polymer resins are necessary to accelerate the development of new materials that meet specific application requirements. In this work AFM imaging and nanoindentation techniques in combination with AFM-based spectroscopic techniques were applied to assess latex formation and dispersion. The size and size distribution of the latex particles can be measured based on AFM amplitude modulation images. AFM phase images provide information about the chemical homogeneity of individual particles. Nanoindentation may be used to estimate their elastic and viscoelastic properties. Proprietary creep and nanoscale Dynamic Mechanical Analysis (DMA) tests that we have developed were used to measure these mechanical properties. The small size of dispersed latex inclusions requires local mechanical and spectroscopic analysis techniques with high lateral and spatial resolution. We applied the CRAVE AFM method, developed at NIST, to perform mechanical analysis of individual latex inclusions and compared results with those obtained using nanoscale DMA. NanoIR, developed by Anasys Inc., and principal component confocal Raman were used for spectroscopic analysis and results from both techniques compared.