AFM and UFM Surface Characterization of Rubber-Toughened Poly(methyl methacrylate) Samples

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ABSTRACT: The microstructure of a series of injection-molded and extruded rubber–toughened poly(methyl methacrylate) (RTPMMA) samples was investigated. Atomic force microscopy (AFM) and ultrasonic force microscopy (UFM) were used to study surface topography and local elastic properties. AFM topography measurements combined with UFM can reveal the distribution and orientation of the rubber particles in the PMMA matrix. UFM, in particular, reveals the core–shell structure of the particles as well as the presence of particles immediately under the surface, otherwise invisible. In some cases the particles appear to be covered by a thin PMMA layer, whereas in other cases they appear to have broken, thereby exposing parts of their internal structure. Generally, the particles are elongated in the skin region of the injection-molded samples. On the other hand, the particles in the surface region of the extruded samples appear to be almost spherical. The observed difference is attributed to the fountain flow phenomenon, which takes place during injection molding. © 2001 John Wiley & Sons, Inc. J Appl Polym Sci 82: 2790–2798, 2001

Key words: rubber-toughened polymer; RTPMMA; UFM; particle elongation

INTRODUCTION

There is a broad range of analytical techniques that may be used to characterize microstructures in polymeric materials. Among the physical characterization methods, two modes of scanning force microscopy (SFM), with its family of techniques including atomic force microscopy (AFM) and ultrasonic force microscopy (UFM), are rapidly gaining prominence. SFM can resolve details to the subnanometer size scale, matching or even exceeding the capabilities of more traditional microscopic techniques, as shown in Table I.[1]

Rubber-toughened acrylics are widely used for molded, formed, and extruded components. Fracture resistance of these toughened materials is largely controlled by the dispersion of the rubber particles, their internal structure, and the adhesion between the particles and the matrix. Particle size distribution is important, given that it is known that there is often an optimum "window" of particle sizes for each system. Toughening elements that agglomerate or elongate during processing may reduce the effect of their toughening on the resulting material. This is particularly true close to the surface of the sample. SFM allows us for the first time to closely characterize rubber particle size, shape, and distribution as well as internal morphology, to some extent, immediately adjacent to the surface of a molding or extrudate. The technique requires minimal sample preparation, leaving the morphology undisturbed prior to examination.

The present study involves the use of AFM and UFM for microstructural investigation of rubber-

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