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Editorial corner – a personal view

Nanoindentation: an emerging technique for polymer surface mechanical characterization

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Polymer surfaces are the phase boundaries that reside between the bulk polymer and the outer environments. For many applications they have to be modified using physical or chemical processes to achieve the desired functional properties. Examples are biomedical, automobile, microelectronic or packaging applications. While the driving force of surface modification is generally the functional properties, good surface and global mechanical properties are necessary in most applications. Surface analytical methodologies have already been well established, but mechanical characterization of polymeric surfaces is still a subject of debate.

The so-called depth sensing indentation or nanoindentation is a well established instrumental technique to assess Young's Modulus and hardness, of hard inorganic engineering materials, but its usage is rather questionable for thin and low compliant materials like soft polymers and polymeric films. The analysis of nanoindentation data is often based on the Oliver and Pharr approach which displays limitations in describing viscoelastic and viscoplastic behavior of polymers, and uneven yielding behavior under multiaxial stress systems. Experiments also depends on a number of parameters like the shape of the indenter tip, the strain history of the sample or adhesion phenomena between tip and surface, surface preparation and pre-conditioning of the sample. Besides, properties of polymeric materials also depend on many intrinsic factors which range from monomeric level to macroscopic level, such as monomer sequence, tacticity, short-chain branching, long-chain branching, molecular weight, molecular weight distribution, degree of chain orientation, degree of crystallization, and the states of the crystal-amorphous interfaces which may promote, for instance, strain hardening. Despite the mentioned limitations, comparative studies of polymers have been recently reported which encourage the use of this technique to assess surface modified polymers.

Further research on the nanoscale mechanical response of polymers should be focused on the development of new analysis procedures assisted by mathematical modeling and numerical simulation capable of determining absolute quantitative constitutive equations representative of the actual mechanical behavior of polymers. When this goal has been met, nanoindentation will become a powerful tool to optimize the surface polymer tailoring.

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