SCRATCH PROPERTY OF POLYURETHANE NANOCOMPOSITES STUDIED BY NANOINDENTATION

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ABSTRACT
Nanoindentation technique have been used extensively to measure the nanomechanical properties of thin films. However, the determination of the surface mechanical properties such as scratch behavior using this technique is relatively new. In this work, the scratch property of polyurethane nanocomposites was studied and proposed. A series of polyurethane(graphite oxide (GO) and polyurethane carbon nanotubes (single(walled (SWNT) and multi(walled carbon nanotubes (MWNT)) were prepared by in situ polymerization. It is believed that the preparation of polymer/GO or polymer/CNTs nanocomposites with homogeneous dispersion of nanofillers in the matrices is a crucial step to developing high(performance polymer nanocomposites. The results pronounced that with incorporation of nanofillers (GO and CNTs) the scratch depth of polyurethane matrix was dramatically reduced. With only 4wt% of GO the PU nanocomposites had greater hardness and showed better scratch resistance. In addition, the scratch penetration was less for PU(SWCNT composites than for the PU(MWCNT composites and it demonstrated as the time to achieve the maximum depth increased.

Keywords: Polyurethane Nanocomposite・Nanoindentation・Scratch Property・

INTRODUCTION

Polymers and nanocomposites have been widely used in microelectronic packaging, coatings, aerospace, automotive, food packaging and biomedical applications because of their adequate strength, lightness, versatility, ease to processing and low cost [Alaa et al 2015, Cai et al 2012, Yusoh et al 2010, Wong et al 2004]. In recent years, the developments of polymeric materials as coating materials has been gain more and more attention. However, polymer matrices are very sensitive to scratching and subjected to low scratch and wear resistance, and are unacceptable for most coating applications.

There are common efforts of improving the scratch resistance of polymeric materials. The first solution found to reduce this scratch sensitivity was to deposit a mineral coating on the surface of the polymer. This procedure experienced however little success, at least partly due to the large difference between the elastic strains domains of the substrate and coating [Demerchi et al 2005]. A second generation of coatings used polysiloxane and acrylic materials, where the scratch resistance is given by the hardness of the coat and the coatings have elastic strain domains in the range as the substrate [Demerchi et al 2005].

The new generation of protective coatings has employed nano(materials, in which an organic matrix is filled with nanosized particles of fillers or polymer nanocomposites [Demerchi et al 2005]. The idea behind this strategy is to associate the large elastic domain of an elastomeric polymer with the hardness of the filler. As nanocomposites material, polymers are combined with hard nanofillers, in order to improve the materials properties of polymer. Polymer nanocomposites offer the advantage of favorable material properties and diminish their disadvantages.

Research on nanoscale scratching can help develop mechanical scratching into a promising nanofabrication process. Thus, whether it is aiming to improve the surface scratch resistance or to engineer polymer surfaces for more efficient nanofabrication process, knowledge on scratch and wear properties at the micro to nanoscale is crucial [Wong et al 2004].

It has been suggested by various authors that the surface properties of polymers might be different from those of the bulk due to differences in molecular dynamics [Brown & Russell 1997, Kajiyama et al 1996]. Conventional wear type tests, which focus on bulk properties, might not be appropriate for assessing the surface properties of polymer nanocomposites. In recent years, the rapidly expanding field of depth(sensing nanoindentation which uses a sharp tip sliding on the surface provides a quantitative method for studying the scratch and wear properties of the surface or subsurface region of polymeric materials [Dasari et al 2007].

The advent of newly developed depth sensing devices which use a sharp tip sliding on the surface to stimulate a single asperity contact has made possible characterization techniques, such as nanoscratch, that are sensitive enough