TRIMETHYLOLPROPANETRIACRYLATE LOADED NANONPORES PC FILMS WITH SELF-HEALING POTENTIAL

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ABSTRACT

Basic researches in this field focus on implementation of self-healing monomers or comonomers to film substrate as microencapsulated filling [1-3]. But such topological solutions can not always provide sufficient amount of self-healing monomers (comonomers) to healing place places. In this work, another topological solution of self-healing composite provides nanopores highly-distributed in PET film and filled with TMPTA monomer.

The aim of this work is to produce a self-healing photopolymerizable formulation incorporated to films. Trimethylolpropane triacrylate (TMPTA, acrylate monomer) as healing agent has been chosen because of its quick photopolymerization under UV radiations in presence of a photoinitiator while thermally resistant up to 300°C. In order to produce an alternative method of TMPTA distribution in polycarbonate (PC) film, a series of highly numbered nanopores has been produced using a heavy ions bombardment at a certain angle with the following chemical treatment of the nanopores. In order to fulfill the nanopores with TMPTA the films have been soaked under external pressure of 2 atmospheres in TMPTA for 4 hours. The excessive non-soaked amount of TMPTA has been removed by tissue paper and the remain of TMPTA has been fixed in nanopores by additional casting of PC solution in chloroform on both sides of the film composite and dried until protective coating formation. Preliminary results on exposure of the film, microcracked intently under UV radiation of 260 nm, have shown photopolymerization of TMPTA in the nanopores of the PC composite.

Polycarbonate PGPC 3859 was dissolved in chloroform to make 10, 15 and 20 wt% solutions respectively with intensive stirring at room temperature for 4 hours. The prepared solution was cast on a stainless steel plate. The plate was thermostated at 95-100°C for 1 hour until dry PC film formation. Films of three different thicknesses were prepared depending on the type of PC solution with 45±5, 75±5, 110±5 microns respectively. Prepared PC films of 50x50 cm were bombarded by xenon heavy ions under 1.0 GHz. Prior to use, the bombarded films were treated by 1.0 N sodium alkali solution for 1 hour, rinsed in distilled water and dried until constant weight. The finally treated PC films were immersed in liquid TMPTA equipped with two-neck flask under 2 atmospheres of nitrogen pressure for 4 hours. After exposure in TMPTA excessive amount of TMPTA from the PC film was removed by a tissue paper. Both sides of TMPTA-treated film was cast by 25wt% PC solution in chloroform. The prepared samples were thermostated at 90-100°C for 2 hours until formation of dry PC coating on both sides of the films.

Films after treatment by heavy ions as shown in Figure 1 (left) manifest a highly developed porous structure. Calculated mean size diameter of formed nanopores after additional alkali treatment is around 25 nm. All pores were loaded with liquid TMPTA monomer by immersion of the treated films in TMPTA solvent under external pressure in order to TMPTA could penetrate to pores by diffusing inside them. The excessive amount of TMPTA was removed from the surfaces of films and loaded TMPTA was enclosed by casting PC coatings on both sides of the TMPTA-loaded films. Each film was exposed under UV-radiation to provoke Darocur-initiated TMPTA polymerization. In comparison with the porous structure of blank ion-treated film, polymerized TMPTA fills pores in the film. Film morphology with TMPTA polymerized inside nanopores changes the porous structure of the film to a homogeneously monolith one without visible porosity. TMPTA is polymerized inside nanopores, forming a monolith structure with PC film as matrix.

Exposure of a composite on glass substrate with polymerized TMPTA in 20 wt% aqueous solution of sulfuric acid within 4 hours with following gentle rinsing and drying leads to dissolution of PC matrix with remaining polyTMPTA nanowires. Figure 1 (right) represents TMPTA nanowires polymerized in nanopores using PC film as imprinting matrix.

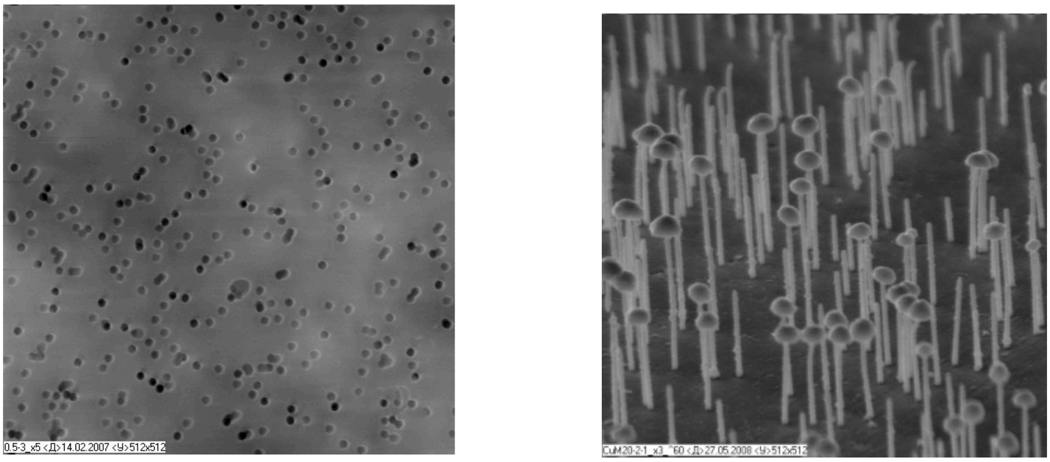

Figure 1: SEM photo of photopolymerized TMPTA inside PC film nanopores. The right picture is taken after acid treatment (dissolution) of PC substrate.

Using PC film with nanopores of 25 nm mean diameter as polymer imprinting matrix TMPTA monomer is loaded inside the nanopores. Such composites containing TMPTA loaded nanopores could be functional materials as film or coating with potentials of self-healing for microcracks and microdamages under UV treatment.

We have before described another process to get self-healing materials by encapsulation of a photo-polymerizable formulation [4]. This new route should be used for other applications.

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