Film Formation of Nano-Sized Hard Latex (PS) in Soft Polymer Matrix (PBA): An Excimer Study

Şaziye Uğur,[1] Selin Sunay,[1] Önder Pekcan[2]
[1]*Department of Physics, Istanbul Technical University, Maslak 80626, Istanbul, Turkey*

[2]*Kadir Has University, Faculty of Arts and Science, Cibali 34230, Istanbul, Turkey*

This work reports steady state fluorescence (SSF) technique for studying film formation from pyrene (P)-labeled nano-sized polystyrene (PS) and poly(*n*-butyl acrylate) (PBA) hard/soft latex blends. Blend films were prepared from mixtures of PS and PBA in dispersion. Eight different blend films were prepared in various hard/soft latex compositions at room temperature and annealed at elevated temperatures above glass transition temperature (T_g) of polystyerene. Monomer (I_P) and excimer (I_E) intensities from P was measured after each annealing step to monitor the stages of film formation. The evolution of transparency of latex films was monitored using photon transmission intensity, I_{tr}. Film morphologies were examined by atomic force microscopy (AFM). The results showed that as the amount of hard component (PS) in the blend is decreased, a significant change occurred in both I_E/I_P and I_{tr} curves at a certain critical weight fraction (50 wt%) of PS hard latex. Two distinct film formation stages, which are named as void closure and interdiffusion were seen in (I_E/I_P) data above this fraction. However, below 50 wt% PS no film formation was observed. AFM pictures also confirmed these findings. Void closure and interdiffusion stages for (50–100) wt% range of PS were modeled and related activation energies were determined. There was no observable change in activation energies confirming that film formation behavior is not affected by varying the blend composition in this range. POLYM. COMPOS., 31:1611–1619, 2010. © 2009 Society of Plastics Engineers

INTRODUCTION

Polymer latexes are being used in a broad range of fields from adhesives, inks, paints, coatings, drug delivery systems, and films to cosmetics [1]. In many of these applications, latexes form thin polymer films on a substrate surface. Colloidal particles with glass transition temperature (T_g) above the drying temperature are named as hard latex (high-T_g) particles. On the other hand, colloidal particles with T_g below the drying temperature are called as soft latex (low-T_g) particles. Traditionally, latex film formation process has been divided into three sequential steps [2, 1]: In the first step, water evaporates and particles form a close packed array. If the particles are soft they deform to polyhedrons. Hard latex, however, stays undeformed at this stage. In the second step, annealing of soft particles causes diffusion across particle–particle boundaries which lead to a homogeneous continuous film. Annealing of hard latex system at first causes void closure [3–5]. Then, deformation of particles (coalescence) results in a honeycomb-like structure without voids. In the third step, further annealing promotes healing and interdiffusion [6, 7] processes, respectively. Finally, a continuous and mechanically strong film forms because of interdiffusion of polymer chains across particle boundaries.

In addition to the application of pure latex polymers as protective layers, polymer-polymer composites can be used for coating industry. Since dry films of single component latexes [2, 3, 8–10] have poor mechanical properties, composite latex systems involving two or more polymers with different T_g values [11, 12] can be used to get films with good mechanical and barrier properties [13, 14]. One approach to do this is the synthesis of waterborne core/shell latex particles with a high-T_g polymer core and a film-forming shell. Another technique is by physically blending two polymer latexes with different T_g values [11, 12] in which the soft latex will form a film, and become the continuous phase while the hard particles will act as filler and impart mechanical properties [13, 14]. One of the main interests in latex blends is the drive toward zero-volatile organic compounds in the organic coating industry [15]. Such latex blends would not require volatile solvent plasticizers, and therefore be less damaging to the environment. In the blend one can obtain different properties than those of the individual components, and under some circumstances might even obtain unique properties [16]. A blend of low T_g latex

Correspondence to: Şaziye Uğur; e-mail: saziye@itu.edu.tr
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