UV Cure Kinetics of Dimethacrylate Thin and Thick Samples

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Abstract

UV curing is using UV light as the energy source to induce the polymerization of liquid monomers and oligomers to form a solid polymer. Because UV polymerization is fast and energy-saving and a UV curable system has no VOC (volatile organic compound), this new technology has developed rapidly from thin film applications to thick sample applications. In addition, since the UV cure process can be controlled spatially and temporally, it also has an important application to make gradient materials with locally optimized properties. However, most research on UV cure is based on thin film applications, and the cure kinetics of thick samples are more complex and not well understood.

In this study, we focus on the UV cure kinetics of CD540 (ethoxylated (4) Bisphenol-A dimethacrylate) thin and thick samples (2-8 mm). A photo-bleaching initiator, bis(2,4,6-trimethylbenzoyl)phenylphosphine oxide (Irgacure 819), is used in the system. UV cure kinetics are complex, especially when the sample is thick, since the light intensity is a function of depth and also a function of exposure time. In order to understand the complex cure kinetics of thick samples, we first studied the variation in the transmitted intensity and initiator concentration through the depth in thick samples. Based on the experimental measured transmitted intensity, a Matlab program was written to predict the intensity versus depth and exposure time of a thick sample. Then, the UV cure kinetics of thin samples (0.05 mm) were studied. In this part, we studied the effect of light intensity, initiator concentration, and temperature on the cure kinetics experimentally and theoretically. A model was developed based on a unimolecular termination mechanism in order to predict the cure kinetics at different conditions for thin samples. Combining the Matlab program for calculating the intensity in thick samples and the model for calculating the cure kinetics of thin samples, the cure kinetics through the depth of thick samples were predicted and compared with experimental results measured by frequency dependent dielectric sensing.

The diffusion of free radicals in a UV cure free radical cure system was studied by monitoring the cure in the dark nonirradiated region under a mask. In addition, a free radical thermal cure of an acrylic resin was characterized in order to study oxygen diffusion from the surface layers into deeper layers.