Enhancing Photopolymer Performance: Exploring Phase Separation in (Meth)acrylate Systems for Additive Manufacturing

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Photopolymerization-induced phase separation presents a promising approach to enhance photopolymer performance for additive manufacturing (AM)-related applications such as biomedical engineering, tissue engineering, and digital dentistry. This phenomenon occurs in multicomponent systems with marginal incompatibilities including various monomers, oligomers, and reactive diluents at the nano to microscale levels.

The study explores a phase-separable system characterized by significant transparency changes after UV light radiation. The system comprises isobornyl Acrylate (IBOA) diluted aliphatic urethane diacrylate oligomer (UDA) and bisphenol-A-ethoxylate di-methacrylate monomers (Bis-EMA) photopolymerized by the activation of Diphenyl (2,4,6-trimethylbenzoyl) phosphinoxid (TPO) as the initiator agent.

Tensile strength, impact resistance, and thermal stability were among the qualities that were quantified before and after the system was treated to 20 wt. percent 4-Acryloylmorpholin (ACMO; Sigma-Aldrich), a highly polar reactive diluent. Optical properties such as phase separation onset, duration, and final transparency were assessed using a bespoke developed setup.

The research also explores the capabilities of atomic force microscopy (AFM) in characterizing photopolymers from fracture mechanics and microstructure-property points of view. Special focus was therefore given to the effect of sample preparation on a consistent, accurate and reliable AFM measurement. Furthermore, to obtain a homogeneous fracture surface with minimal effects of irradiation intensity throughout the component's thickness, the AM process Hot Lithography was employed. The results demonstrated the high capability of this technique in processing highly viscous formulations which is advantageous in preparing 3D-printable photopolymers with improved toughness.

Keywords: Photopolymerization, Phase Separation, (Meth)acrylate resins, Atomic Force Microscopy, Hot lithography

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