Acrylate Photopolymers in Additive Manufacturing: A Dive into Thermal Stability and Curing Kinetics

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Additive manufacturing (AM) of plastics stands as a forefront technology in the 21st century, offering exceptional design flexibility and finding applications across diverse industries. Photopolymers, particularly UV-light activated polymers, claimed a significant market share in AM materials in 2021, highlighting their importance. Acrylates, fundamental monomers in photopolymers, enabling rapid processing, intricate geometries with high resolutions, and a broad material spectrum, making them a focal point in various AM technologies. However, these advancements introduce temperature-dependent curing and decomposition behavior of acrylates as significant process-related challenges.

This research delves into a comprehensive analysis of the curing behavior and thermal stability of acrylic photopolymers concerning varying UV-intensities and isothermal temperatures. The study employed thermogravimetric analysis (TGA) with in-situ Fourier-transform infrared spectroscopy (FTIR), and differential scanning calorimetry (DSC) with UV light source (UV-DSC) to scrutinize thermal stability and curing behavior. Characteristic gases evolving at elevated temperatures are identified and their relevance to the curing process is discussed. Calorimetric results showcased that higher UV-intensities significantly augmented the reaction rate, reaching maximum rates before 50% conversion. Isothermal temperatures exhibited a discernible effect on the reaction enthalpy related to both the reaction speed and extent, revealing an accelerating impact up to 90°C. Additionally, the study identified 2-propenoic acid, 2-propenyl ester as a temperature-sensitive and volatile component influencing the curing process. These findings serve as a foundational reference for future investigations, particularly in the comparison of various kinetic curing models.