A comprehensive study to optimize binder compositions to be used in ceramic vat photopolymerization

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Successful ceramic vat photopolymerization (VP) relies on the precise optimization of binder formulations to achieve optimal properties in printed components. Most resins used in VP are binary systems comprising two monomers/macromers with varying functionalities. Copolymerization, especially concerning the chemical structure of monomers/macromers, has been insufficiently studied in VP.

Addressing this gap, this research systematically evaluates three difunctional monomers (DDDA, HDDA, ethoxylated HDDA (HDDA+)), three difunctional macromers (PEG400DA, PEG200DA, PEG200DMA), and three multifunctional monomers (TMPTA, ethoxylated TMPTA (TMPTA+), ethoxylated PETTA (PETTA+)). 18 distinct combinations (R1-R18) were prepared from difunctional monomers/macromers with multifunctional monomers at a 50:50 ratio and tested to assess their suitability based on the specified properties, emphasizing crucial properties, such as low viscosity, low critical energy for photocuring initiation, minimal shrinkage, and robust mechanical characteristics, which are all essential for successful printing processes. This study aims to comprehensively examine the effect of linker chain of diacrylate monomers (DDDA- vs. HDDA-containing resins), the impact of ethoxylation of diacrylate monomers (HDDA- vs. HDDA+-containing resins), the influence of linker chain of macromers (PEG400DA- vs. PEG200DA-containing resins), and the effect of functional groups (PEG200DA- vs. PEG200DMA-containing resins). Furthermore, the impact of ethoxylation of triacrylates (TMPTA- vs. TMPTA+-containing resins) and the effect of functionality (PETTA+- vs. TMPTA+- and TMPTA-containing resins) were explored.

The findings of this research not only contribute to a deeper understanding of the intricate relationships within binder formulations but also offer practical implications for the careful selection of binders tailored to the specific requirements of ceramic VP processes. The results identified R5 (HDDA:TMPTA+) and R14 (PEG200DA:TMPTA+) as promising candidates for optimized binders in ceramic VP. R5 and R14 demonstrated the following values, respectively: low viscosity (16.62 and 35.3 mPa.s), moderate critical energy (56.81 and 36.17 mJ/cm2), moderate volume shrinkage (9,1 and 4,99%), and superior compressive strength (64.31 and 115.35 MPa).