Enabling Fast Debinding of Ceramic Vat Photopolymerization Prints with Supercritical Carbon Dioxide as a Solvent

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Thermal debinding of ceramic parts, with a possible pre-conditioning step, can require a week of time. However, it is an essential and carefully controlled processing step that is necessary to prevent part deformation and cracks caused by pressure gradients from evaporating substances. The use of ceramics in e.g., dental applications, which require unique characteristics from ceramic forming, has been challenging due to the difficulty of manufacturing parts with minor deviation in properties. Nowadays, ceramic dental restorations are mostly milled into final shape from ceramic blocks, which is cost effective, but the material waste percentage can be even 95 %. Additive manufacturing (AM) methods, such as vat photopolymerization, have become an alternative to milling providing better user safety, lower waste generation, and increasingly lower price range due to increasing popularity of AM methods.

The thermal debinding of ceramic 3D printed parts could be made more economical by extracting some of the slurry substances prior to thermal debinding, creating flow channels for gases to exit the structure. Supercritical carbon dioxide (scCO2) extraction was used for different polymeric and ceramic vat photopolymerization prints to find out which substances dissolve from the part without cracking and part deformation. The scCO2 extracted samples were characterized with mercury porosimetry, thermogravimetric analysis, optical microscopy, and the sample mass and dimensions were measured before and after the extraction test. The scCO2 extraction time, pressure, temperature, and monomer fractions in slurry recipes were varied. Various uncured monomers were successfully extracted. Extraction in conditions with high scCO2 density resulted in the most efficient mass removal in the printed samples.

Keywords: vat photopolymerization, supercritical carbon dioxide, ceramic debinding, monomers, solvent extraction