3D PRINTING OF UV-CURABLE PHENOLIC RESINS COMPOSITION BY HOT LITHOGRAPHY

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This study describes the direct 3D printing of phenolic resins. Also known as Bakelite, the cured products, phenoplasts, are considered the first synthetic plastic. These resins, produced by polycondensation, have always been known for their chemical resistance, excellent flame properties and thermal stability. Therefore, they are still used today in space and aviation as well as in the automotive industry. Originally, pressure and temperature are required for processing and limited the production of phenoplasts to compression and injection molding. However, with the invention of lithography and 3D printing, new processing possibilities emerged. Previous work in this area has focused on thin-layer photoresists or parts that can only be printed using other polymers as matrix. Here we report a direct 3D printing method, without binders or matrix polymers, using hot lithography, a stereolithography-based 3D printing technology at elevated temperatures. Formulations could be presented that are stable under the selected conditions and yet reactive enough for the printing process. In addition to the onium-salt based photo acid generators (PAG), novolaks and curing agents (CA) are required to obtain a solid thermoset. Novolaks are temperature-stable, non-self-condensing phenolic resins that can only form a network with the help of a CA, usually based on formaldehyde. The most satisfactory results were achieved with a self-prepared CA. In simultaneous thermal analysis (STA) and photo-DSC we investigated the UV-induced polycondensation of the phenolic resins in a temperature range of 80–120 °C. Furthermore, the formulation shown could be 3D printed directly using hot lithography at below 100 °C and cured to a bubble-free component in a post curing step. Compared to the conventional production of novolaks by injection molding at high temperatures and pressure, a simple production of complicated components could be achieved without the complex application of injection molds.