# Photosensitive Resin in Stereolithography Process

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Abstract: Stereolithgraphy nowadays is one of the most common rapid prototyping techniques. Photosensitive resins are main materials in the stereolithography process to obtain parts with specific shapes and applications. In this paper, the optimization of synthesis conditions for photosensitive resins had been studied. Photosensitive resins were characterized by the DSC, TGA, and FTIR. The results show that the sample had higher thermal stability properties, with the most pronounced improvements obtained for the reinforced epoxy acrylate specimens. The relation between post-cure shrinkage and the various process parameters used in the SL also have been investigated.

Key words: stereolithography (SL); photosensitive resins; thermal stability
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Stereolithography (SL) is a widely used rapid prototyping process and has been used across a wide range of industrial sectors. The technique is based on the process of photopolymers, in which a resin, initially in liquid form, is converted to a solid polymer on exposure to ultra-violet laser radiation[1-2]. SL nowadays is one of the most common rapid prototyping techniques with 4E (Energy, Ecology, Economy and Excellent finishing of radiation curing). The main applications of the SL process are the production of visual prototypes and models used in the automobile, electric, biomedical and aerospace areas[3]. In this paper, we focus on the direct polymerization method and investigate thermal stability of sample.

## 1 Experiment

The resin was provided by epoxy resins and acrylic acid as the raw materials. After epoxy resins were heating 60℃, acrylic acid was droped into epoxy resins slowly. Keep the reaction going on at 100℃—110℃ until the PH value of the reactant falls to 4 mg/g KOH. The prepolymer is obtained.

For the post-cure process, the prepolymer was maintained in a UV chamber and a microwave oven with power of 1000W, respectively. A conventional oven was used to submit the samples to an isothermal treatment at 84℃. The exposure time was 60 s when microwave, ultraviolet chamber and conventional oven were used in the post-cure process, respectively.

## 2 Results and discussion

In order to predict more accurately the rate at which the reaction occurs as a function of temperature, the standard differential scanning calorimetry (DSC) method was used[4]. The average value obtained for the enthalpy of the reaction over several differential temperatures scans (an example of which is shown in Fig. 1a) is $\triangle H = 86.93$ J/g. The exothermic peaks are related to the cure process, i.e. the energy involved in the cross-linking reaction of resin reactive groups. The decrease in peak area at 44.5℃ on the DSC curves is indicative of the thermal postcure process efficiency. The glass transition temperature of the resin by dynamic DSC is 412℃. This temperature corresponds to other crosslinking mechanism, which is less sensitive to thermal treatment[2].

Different behavior was observed in the thermogravimetric curve for the cured resin with only one mass loss stage, as shown in Fig. 1b. Thermal degradation mainly took place above 350℃. The maximum degradation temperature and the mass loss for the cured resin were 471℃ and 80%, respectively, indicating higher

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stability for cured specimens.

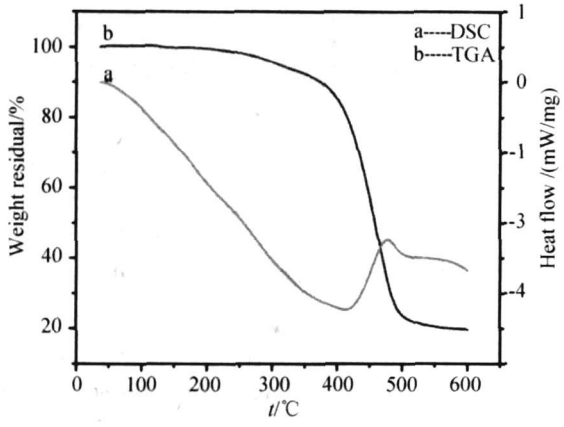


Fig. 1 DSC and TGA curves for after sodilfy sample

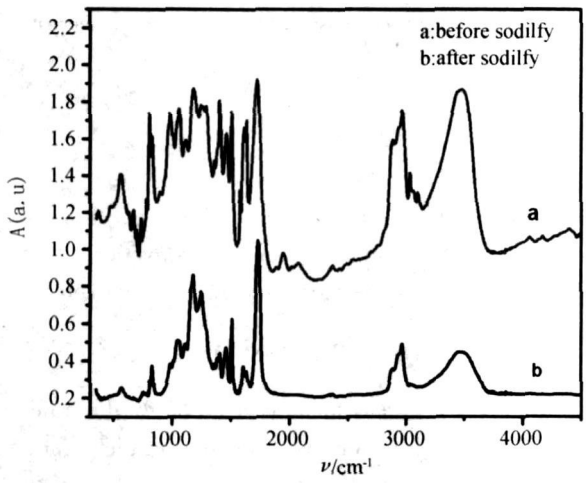


Fig. 2 FTIR spectrum of the resin

The FTIR spectra of samples are shown in Fig. 2. In the before sodilfy resin spectrum, a broad band corresponding to the hydroxyl stretching vibration at 3481 $cm^{-1}$, and a strong band due to the C-H stretching vibration at 2925 $cm^{-1}$. The band at 1725 $cm^{-1}$ corresponds to the C=O, and those at 1634 $cm^{-1}$ to the C=C. The bands at 1173 $cm^{-1}$ and 914 $cm^{-1}$ correspond to the C-O stretching vibration, and that at 760 $cm^{-1}$ to the $CH_2$ angular deformation. Such bands are inherent to epoxy and acrylic groups as well. The epoxy rings converted to ether groups during the curing process raises the band at 1250 $cm^{-1}$ and causes the disappearance of bands at 914 $cm^{-1}$ and 788 $cm^{-1}$. The band intensity corresponding to the C=C of the acrylic group also show a reduction due to reticulation process as observed in Fig. 2. The FTIR analysis showed the presence of epoxy and acrylic functional groups, as well as, aromatic and aliphatic ether groups in the resin. The aliphatic structure groups explain the value of 412℃ for the Tg[5].

## 3 Conclusions

Poly resin was synthesized by direct polymerization method. The polyimide was characterized by DSC, TGA and FTIR. The results show sample obtained a high thermal stability with the most pronounced improvements obtained for the reinforced epoxy acrylate specimens. The aliphatic structure groups explain the value of glass temperature. Polymer resin shows potential for further research in the SL.

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# 立体光造型过程中光敏树脂的研究

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摘 要: 立体光造型是一种应用广泛的快速成型技术, 光敏树脂是光固化快速成型中制造各类形状零件的重要光致凝固材料。通过实验优化了合成立体光造型用树脂聚合物工艺参数, 并用 DSC, TGA和 FTIR等测试方法对材料进行了表征。结果表明: 环氧树脂的增强使样品具有更高的热稳定性, 同时讨论了光固化过程中收缩与工艺参数之间相互关系。

关键词: 立体光造型; 光敏树脂; 热稳定性

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