Short Note

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Short Note

Faster Curing in BMI for 3D Printing Ink

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Abstract: Bismaleimide (BMI) is a high-performance thermosetting resin widely used in the aerospace, automotive, and mechanical and electronics industries due to its chemical and mechanical stability. It also has the capability of being used as an ink in polyjets used for 3D printing evident from thinner mellamide FTIR bands and faster curing rates as observed from TGA-DSC studies.

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1. INTRODUCTION

Bismaleimide (BMI) resins are a class of high-performance thermosetting polymers with several advantageous properties that make them perfect for usage in a wide range of industrial applications, particularly those requiring aerospace components. They are very resistant to a variety of solvents, acids, and water, and they exhibit outstanding mechanical properties, low shrinkage, chemical resistance, and fire resistance. BMI coating has also been applied to stop rusting. The addition of inorganic materials, like metal oxides, can change the properties of the polymer as an inorganic-organic composite. There are several uses for organic-inorganic composites in the domains of chemistry, biology, electronics, and optics. [1–5].

BMI has been blended with titania, Ferric chloride as well as Graphene sheet. Metallization and APPJ treatment of Bismaleimide have shown better performance as corrosion protection and EMI shielding [6]. BMI monomers are molecules with two maleimide functional groups terminating them; they frequently contain several aromatic moieties to improve their curing properties. Figure 1a shows the typical structure of these compounds) [7,9]. The crystalline and structural configuration of the composite system has been reported earlier [8–12].

Additive manufacturing, also known as fast prototyping or 3D printing, is widely used in the creation of optical components, lab-on-a-chip devices, titanium scaffolds for orthopaedic implants, sophisticated biomedical devices, and aerial vehicle wing constructions. A low-cost and straightforward method for producing unique, customised components for biomedical as well as other uses is to use techniques like digital light processing (DLP) and polymer jetting. Compounds like poly(lactic acid) (PLA), acrylonitrile butadiene styrene (ABS-T), polycarbonate (PC), polydimethylsiloxane (PDMS), polyethylene terephthalate glycol (PET-G), polyurethane filaments (TPU) and polyamide (PA) [13]. BMI which is also from the family of polyamides having commendable chemical and mechanical properties is a potential ink for polyjets. Inorganic fillers added to BMI enhance the cross-linking causing improved performance (Figure 1b) [14].

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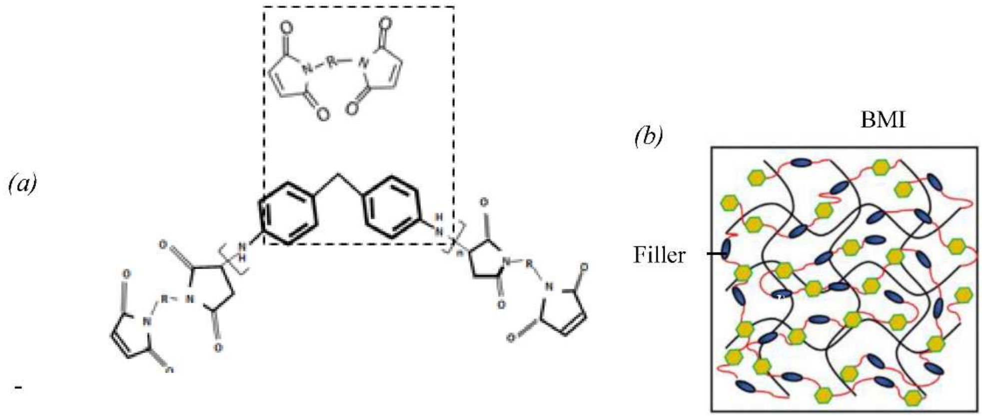

Figure 1. Basic structure of BMI [9] (self-drawn) (b)cross-linking of BMI (CC BY 4.0.) [14].

2. MATERIALS & METHODS

Homide 250 (Diamino diphenyl methane bismaleimide-diamino diphenyl methane copolymer) was used as the BMI details of which are given in ref [2,6,7,12]. The process consisted of BMI being dissolved in distilled water and stirred with PVA and stirred.

3. RESULTS & DISCUSSIONS

A faster curing rate (which has been quantified by a parameter α) is a determining factor for an efficient Polyjet ink [15]. A smaller maleimide double bond width is indicative of a faster curing rate (Figure 2a, b). A TGA-DSC plot of heat-treated BMI (Figure 2c) is shown in Figure 2d which shows weight loss and is indicative of the fact that after 370^{o}C, crystalline nature is obtained [12]. The sample before and after the study is shown as an inset. A shoulder peak at 110^{o}C and the peak at 370^{o}C indicates two curing regimes. The first one attribute to *Ene* reaction between allyl (−CH_2–HC=CH_2) and maleimide group and is endothermic in nature, whereas the second peak is due to *Diel-Alder* reaction, thermal rearrangement, cross-linking and dehydration of hydroxyl [16]. The rate of weight loss increases ten times showing a faster curing rate as required for the 3D printing ink.

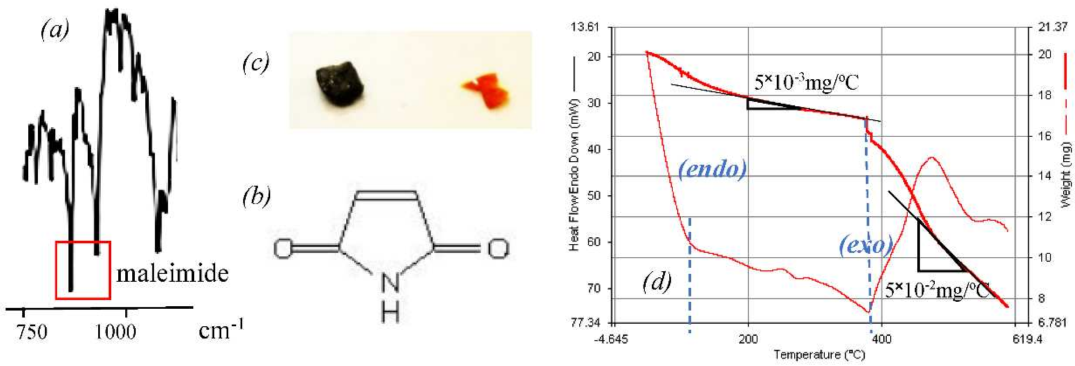

Figure 2. (a) FTIR of BMI cured at 100^{o}C showing (b) maleimide bands of low widths (c) TGA-DSC under nitrogen atmosphere of heat-treated BMI [12] .

4. CONCLUSIONS

Pristine BMI showed maleimide bands of low width indicative of faster curing rates which got confirmed from TGA-DSC studies with two different curing regimes. A higher weight loss with respect to temperature and cross-linking proved BMI to be efficient ink for Polyjet 3D printing.

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