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Use of maleated castor oil as biomodifier in unsaturated polyester resin/fly ash composites

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ABSTRACT

Maleated castor oil (MACO) was prepared and was used as biomodifier in unsaturated polyester resin (UPE)/fly ash composites. The prepared MACO was characterized for its molecular weight and viscosity. MACO was blended with UPE in three different ratios like 5, 10 and 15 wt%. Fly ash was incorporated in the blend matrix (10 wt%) and curing was done by free radical polymerization. MACO was polymerized and crosslinked with UPE in situ during the formation of the composites. The cured matrix therefore formed an interpenetrating polymer network and the enhancement in properties was significant. Incorporation of 5 wt% MACO was most effective compared to 10 and 15 wt%, when the impact strength increased by 52% without any loss in modulus. The glass transition temperature also shifted to a higher temperature indicating strong intercomponent bonding in this set of composites.

1. Introduction

Unsaturated polyester resins (UPE) are extensively used in fiber reinforced plastic (FRP) industries. The chemical structure and the properties of these resins can be easily modified to suit the purpose. A major concern on the use of unsaturated polyester resin for the FRP applications is their brittle nature. As a result, their properties cannot reach the performance levels necessary to meet many of today's challenging application demands. Some works have been done to improve the toughness and impact resistance property of UPE-based polymeric composites by incorporating rubbers (both synthetic and natural) within the polyester resin (Ray, 2008; Salamone, 1996a,b; Maspoch and Martinez, 1998).

Now-a-days, there is a trend to incorporate chemically modified vegetable oils (renewable resources) within the UPE matrix as impact modifiers of resin. The structural versatility of vegetable oils makes them a very good candidate for biomodifier in UPE and they are often used by the researchers to enhance the properties of UPE based composites. Replacing a part of UPE resin with vegetable oil based biomodifier can also be an effective approach to reduce petroleum depletion. In a recent study, tung oil was used as biomodifier in UPE matrix which improved the impact strength, creep resistance, modulus and hardness properties significantly (Das et al., 2010). A blend of a UPE resin and functionalized vegetable oils was used to prepare biocomposites with hemp fiber as reinforcement (Mehta et al., 2004). Improvements in the properties with the incorporation of a derivatized vegetable oil were reported. In another work, bio-based UPE materials containing epoxidized methyl soyate (EMS) was investigated (Miyagawa et al., 2007). It was observed that the storage modulus and HDT (heat distortion temperature) decreased with increasing amounts of EMS.

The modification of UPE resin was also done with 4,4′-bismaleimidodiphenyl-methane (BM) (Gawdzik et al., 2001). The results obtained, showed that the addition of BM to unsaturated polyester resin improved its properties like thermomechanical properties, hardness, etc. and also accelerated the polymerization process.

Some work was done on modification of unsaturated polyester resin with hexamethylene diisocyanate (HDI) trimer (Huajan et al., 2009a) and toluene diisocyanate (TDI) (Huajan et al., 2009b), which offered a simple method to strengthen and toughen the UPE resins.

In the present study, maleated castor oil (MACO) was prepared and was used as biomodifier in UPE matrix. Fly ash, which is an environmentally hazardous, industrial by-product, was incorporated as filler in the UPE/MACO blend. Although fly ash filled polyester resin matrix composites show significantly high stiffness compared to the neat resin system, but due to their brittle nature, they do not perform well under dynamic loading conditions. MACO was used as biomodifier the UPE/fly ash system to reduce its brittleness, enhance its damping behavior and to replace a part of synthetic UPE

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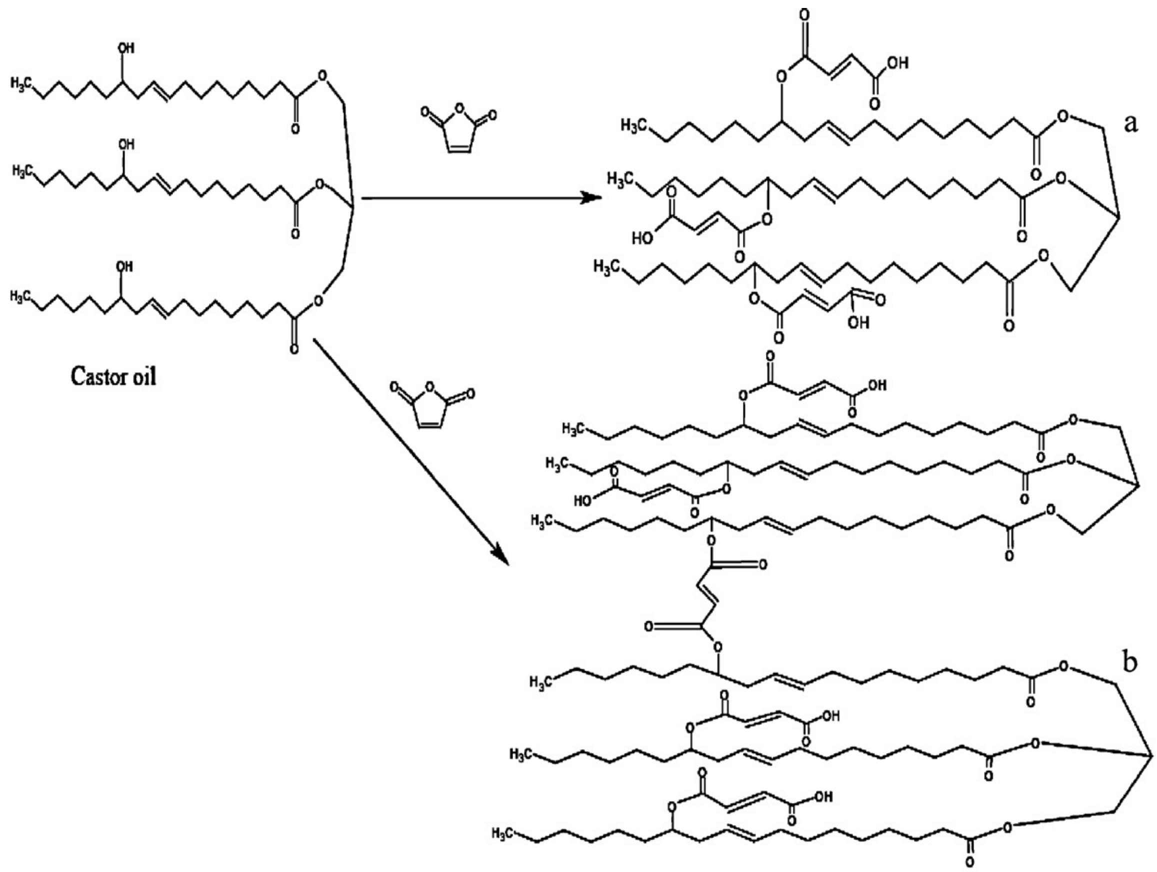

Fig. 1. Chemical reaction of MACO formation (a) monomer, (b) dimer.

resin by a renewable one. The prepared MACO was characterized by FTIR, viscosity and molecular weight. The MACO-UPE/fly ash composites were tested for their tensile properties, impact strength, dynamic mechanical properties and fracture surface analysis.

2. Materials and methods

2.1. Materials

Castor oil (medical grade) was purchased from Indian Drug House. Maleic anhydride (Loba Chemie) was used for the preparation of MACO. UPE resin was obtained from Ruia Chemicals (Grade G P Fiberbond 333). The ASTM class 'F' fly ash (as per ASTM-C 618) was used, with a particle size distribution as follows: 42 wt% of the particles had a particle size between 104 and 152 mm, 25 wt% were between 76 and 104 mm, and the rest were below that range) was procured from Kolaghat Thermal Power Station, India. Methyl ethyl ketone peroxide (MEKP) and cobalt naphthenate, were used as initiator and accelerator, respectively. The KOH and toluene used were S.D. Chemicals products.

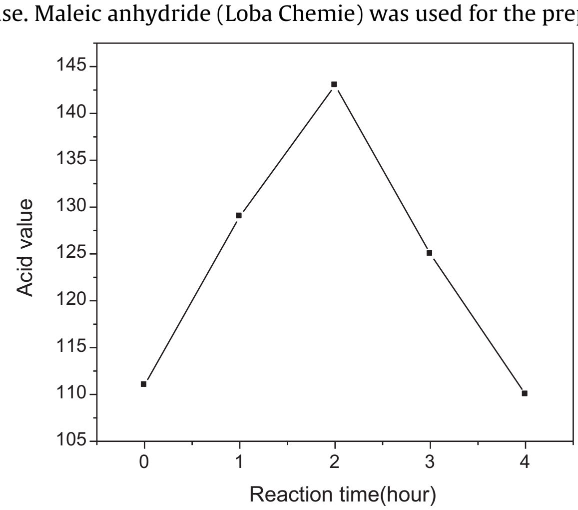

Fig. 2. Change of acid value with reaction time during MACO preparation.

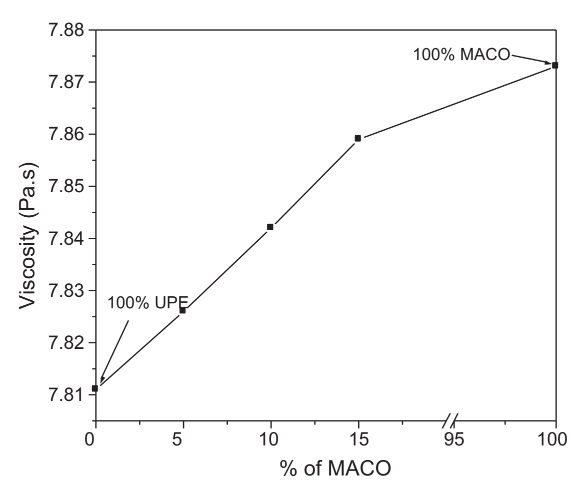

Fig. 3. Comparison of viscosity of UPE, MACO and MACO-UPE blends.