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ORIGINAL ARTICLE

Synthesis and characterization of interpenetrating polymer networks from transesterified castor oil based polyurethane and polystyrene

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Abstract A series of two component interpenetrating polymer networks (IPN) of modified castor oil based polyurethane (PU) and polystyrene (PS) were prepared by the sequential method. Castor oil was modified by triethanolamine by means of transesterification and designated as transesterified castor oil (TCO). The polyurethane network was prepared from transesterified castor oil (TCO) with the isophoronediisocyanates (IPDI) by using dibutyltindilaurate (DBTDL) as catalyst. Simultaneously styrene was added with benzoyl peroxide (BPO) as initiator and N,N′-Dimehtylaniline as coinitiator. Diallylphthalate was added as a crosslinking agent to form IPN and finally cast into films. To cast the film, the mixture (IPN) was poured in the glass cavity with pourable viscosity free from air bubbles. A series of two component interpenetrating polymer networks were prepared by varying % weight ratio of both polyurethane and polystyrene. These films were characterized by FT-IR, dynamic mechanical analysis (DMA), thermogravimetry analysis (TGA), morphology was measured by scanning electron microscopy (SEM). FT-IR have given the conformation of IPN formation. DMA results have shown much increase in the value of $\tan\delta$ and a decrease in the value of T_g by increasing the anount of Styrene.

1. Introduction

Interpenetrating polymer networks (IPN) can be elaborated as special class of the polymers in which there is a combination of two polymers in which one is synthesized or polymerized in the presence of other (Chen et al., 2011; Ajithkumar et al., 2000). IPN is a different way to combine two different polymers other than physical blends and copolymerization. For the synthesis of any IPN it should have three conditions (i) the two polymers are synthesized and/or crosslinked in the presence of the other, (ii) the two polymers have similar kinetics, and (iii) the two

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polymers are not dramatically phase separated (Jimenez et al., 2009).There is no involvement of covalent bonds between two polymers; hence monomer A reacts only with monomer A, while on the other hand monomer B reacts only with monomer B. The resulting material does not get dissolved in the solvents but it gets swelled (da Cunha et al., 2004). IPNs offer the possibility of combining in a network form which otherwise are non-compatible polymers with opposite properties (Pissis et al., 2002). IPN formulation is a useful method to develop a product with excellent physico-mechanical properties than the normal polyblends. IPN is also known as the polymer alloys and it is one of the fastest growing areas of research in the field of polymer blends since last two decades.

IPN can be made in many different ways. It can be defined as sequential and simultaneous IPN depending on how the polymerization has been carried out. Another kind of IPN is the latex IPN when IPN is in the form of latex; hence it also called as interpenetrating elastomeric networks (IEN) (Jaisankar et al., 2013). When film made with a network of one polymer predominantly on one surface and a network of another polymer on the other surface there is a gradient inside the film which is called gradient IPN. While among the combination of two polymers of IPN, when one is crosslinked and the another is linear or branched it is known as semi- IPN (Athawale et al., 2003).

The application of green resources in the field of polymers is the centre of attraction for many researchers; because they possess potential for substitution of petrochemical derivatives. Most of the attention has been focused on the research and development of newer materials from renewable materials (Lan et al., 2012). Among all vegetable oils, one of the most naturally and abundantly occurring oils is castor oil. Castor oil based polyols are nowadays becoming an important raw material for the polyurethane since it is environmentally friendly and cost competitive (Mutlu and Meier, 2010). In recent time IPNs synthesized from castor oil have been paid good attention in the industrial applications (Begum and Siddaramaiah, 2004). Castor oil is easily available as a dominating product from the castor seeds. Castor oil is the only naturally occurring polyol that possesses hydroxyl groups. Castor oil based polyurethane is a widely useful material as it possesses good flexibility and elasticity because of the presence of a long fatty acid chain and leads itself as a thermosetting type material due to its trifunctional nature (Zhang and Zhou, 1999; Gao and Zhang, 2001; Valero et al., 2009). There are so many literatures on modified castor oil polyurethane, but IPNs of modified castor oil polyurethane have not been paid much attention (Kumar et al., 1987; Patel and Suthar, 1989; Pandit et al., 1994; Bai et al., 1997; Siddaramaiah and Mallu, 1998; Siddaramaiah and Mallu, 1999). Only a few instances have shown the use of transesterified castor oil by glycerol and pentaerythritol for the synthesis of IPNs (Sanmathi et al., 2004; Valero et al., 2009, 2010). There is no report found regarding transesterification of castor oil with triethanolamine for IPN synthesis. So it was thought to study IPNs from triethanolamine based transesterified castor oil polyurethane. The aim of our present work is to study thermal, damping and morphological properties of IPN films. Thus the present work comprises the transesterification of castor oil by triethanolamine followed by polyurethane formation and finally IPN synthesis by adding styrene monomer.

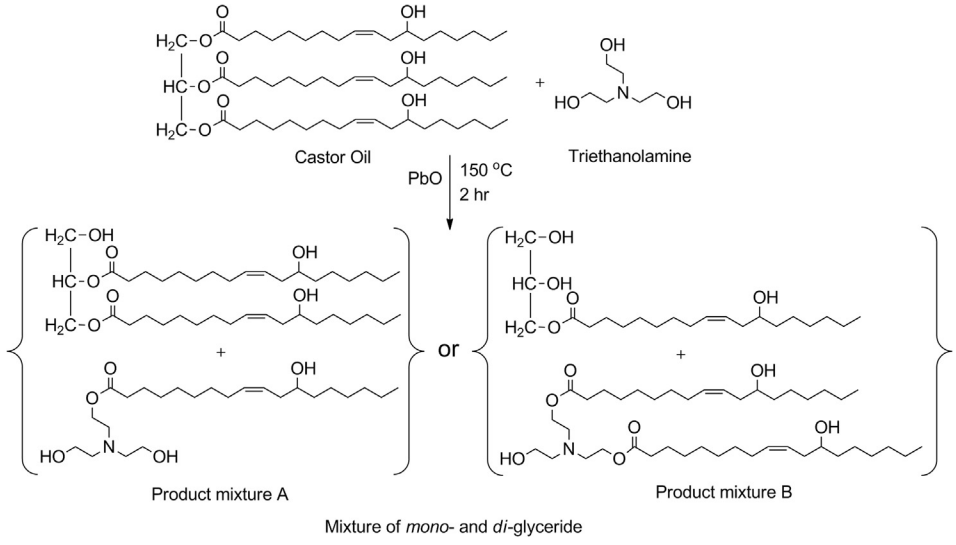
2. Experimental

2.1. General

Castor oil was purchased from local market and found to contain hydroxyl value 163, corresponding to 2.7 hydroxyl groups per mole of castor oil according to the literature method (Eren et al., 2006). Isophoronediisocyanate (IPDI) was purchased from Aldrich. Triethanolamine was purchased from SDFCL and was used without further purification. Dibutyltindilaurate (DBTDL) was purchased from HIMEDIA. Benzoyl peroxide (BPO) was obtained from SDFCL. Styrene was obtained from Samir Tech. Chem. Ltd. and was used by removing inhibitors in it. Diallyl phthalate was obtained from Sigma Aldrich.

2.2. Transesterification of castor oil

Transesterification was performed in a 500 ml three necked flask and equipped with mechanical stirrer, thermometer pocket, and water condenser. One mole of triethanolamine was mixed with 1.0 mol of castor oil. Then 0.2% lead oxide



Scheme 1 Modification of castor oil with triethanolamine by transesterification.