Iranian Polymer Journal (2018) 27:405–411
https://doi.org/10.1007/s13726-018-0618-5

ORIGINAL RESEARCH

Soybean oil-based thermoset reinforced with rosin-based monomer

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Received: 9 November 2017 / Accepted: 10 March 2018 / Published online: 8 May 2018

Abstract

A full bio-based cured resin was synthesized by copolymerization of acrylated-epoxidized soybean oil (AESO) and 2-acrylamidoethyl dehydroabietic acid (DHA-HEMAA). The rigid rosin-based monomer 2-acrylamidoethyl dehydroabietic acid was first prepared from dehydroabietic acid and *N*-hydroxyethylacrylamide, which was characterized by nuclear magnetic resonance and Fourier transform infrared (FTIR) spectrometry techniques. The cured resin was then synthesized and characterized by FTIR spectroscopy, differential scanning calorimetry, dynamic thermomechanical analysis, and thermogravimetric analysis, as well as using a Kruss tensiometer and a universal testing machine. The results indicated that the resin cured with rosin-based monomer exhibited excellent thermomechanical properties. The crosslink density and thermal stability of cured samples containing DHA-HEMAA at molar ratio between 10 and 30% were higher than those of AESO/DHA-HEMAA0 sample. With increasing DHA-HEMAA content, the glass transition temperature (T_g), elongation-at-break, and tensile strength of samples increased, in the stated order, from 16 to 38 °C, from 24 to 45.8%, and from 1.7 to 6.5 MPa. Due to DHA-HEMAA with a hydrophenanthrene structure, the θ values increased with the increase of DHA-HEMAA molar ratios. The full bio-based rosin thermosetting resins may have great potentials in practical application fields, such as coating, adhesive, and packaging materials.

Keywords Bio-based cured resin · Mechanical properties · Rosin-based monomer · Thermal stability · Radical copolymerization

Introduction

Currently, polymers produced from fossil resources have been played a vital role in every sector of the manufacturing industries. While the synthetic plastics are accounted for 7% of the global oil and gas consumption, the consumption of polymers grows at an annual rate of 5% [1–3]. With the depletion of fossil resources, there is a potential global demand for renewable raw materials for the chemical industry [4–9]. Many renewable feed stocks, such as vegetable oils, cellulose, lignin, and polysaccharides, have been used extensively [10, 11]. Vegetable oils, which are the abundant low-cost renewable resources, have been regarded as the most important bio-based chemical feedstock for the production of surfactants, pressure-sensitive adhesives, biofuels, and thermosets [12–15].

Soybean oil, which contains triglyceride structure, is one of the vegetable oils that have the largest production volume and the lowest price used in the industrial production [16]. Due to its low reactivity, soybean oil generally requires further modifications with ester and double bond reactions. For instance, epoxidation of soybean oils can be obtained using the Prilezhaev reaction [17]; soybean oil-based polyols can be prepared through epoxidation/oxirane ring-opening, transesterification/amidation, hydroformylation/reduction, or thiol-ene [18–21]; and acrylation or methacrylation of soybean oils

Electronic supplementary material The online version of this article (https://doi.org/10.1007/s13726-018-0618-5) contains supplementary material, which is available to authorized users.

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