Regular Paper

Crosslinking Reaction of Urethane Acrylate Using Castor Oil, L-lactide and Diene Rubbers

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Abstract

Starting from castor oil, we synthesized branched poly(L-lactic acid))and reacted it with isocyanate containing an acrylic moiety to synthesize urethane acrylate. A new elastomer film was then synthesized by crosslinking the poly(L-lactic acid) with various diene rubbers and irradiating with UV for 30 minutes. Films generated using castor oil were easily broken when peeled from a polytetrafluoroethylene petri dish, whereas films generated using branched poly(L-lactic acid) were obtained as free-standing films and were measured by thermogravimetric analysis. As an example of diene-based rubber, the results for natural rubber were presented. The temperature of 20% weight loss (T_{d20}) of film using castor oil was 310°C, and T_{d20} of film using branched poly (L-lactic acid) was 265°C. The obtained films using branched poly (L-lactic acid) showed elastomeric properties, because the glass transition temperature (T_g) was -20°C and the rubbery plateau region began around 20°C, as measured by dynamic mechanical analysis. The tensile strength (T_B), elongation at break (E_B), and Young's modulus (E) were determined as mechanical properties of the obtained film. Furthermore, the cross-linked films were subjected to enzymatic degradation using *porcine pancreas* lipase, and a weight loss was observed after 14 days.

Keywords: castor oil, enzymatically degradable polymer, lipase, isocyanate, acrylic monomer

1. Introduction

Polymers from petroleum resources are used in a wide range of applications as elastomers, fibers, foams, coatings, and biomedical materials exhibiting high thermal stability, high durability, and low weight. However, these polymers do not decompose in the environment due to their high chemical stability, and the recent identification of problems such as marine pollution by microplastics has attracted attention. The petroleum raw material for polymer materials is a depleted resource. Many polymer materials are subjected to thermal recycling, including heat treatment such as incineration, but these processes emit carbon dioxide, a greenhouse gas. Biodegradable polymers using plant-derived materials have thus recently been developed to reduce the burden on the environment [1-12]. Aliphatic polyesters such as polylactic acid have high degradability and transparency but compared to petroleum-derived polymer materials, polylactic acid has lower heat resistance, and is harder and more brittle, and therefore has limited uses, such as frozen food packaging. There is therefore needed to develop a flexible and strong biodegradable polymer.

Castor oil is a vegetable non-edible fat obtained from castor beans, which belong to the Euphorbiaceae family. Ricinoleic acid comprises over 85% of the fatty acids containing a hydroxy group in castor oil and is thus widely studied as a raw material for polyurethane production [13,14]. The long alkyl chains in castor oil impart flexibility and water resistance and thus polymers generated from castor oil may find novel applications compared to conventional biodegradable polyesters [15-20]. However, most

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