Iranian Polymer Journal (2018) 27:795–806
https://doi.org/10.1007/s13726-018-0652-3

ORIGINAL RESEARCH

Boron-containing UV-curable oligomer-based linseed oil as flame-retardant coatings: synthesis and characterization

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Received: 7 November 2017 / Accepted: 29 July 2018 / Published online: 27 August 2018

Abstract

A boron-containing UV-curable oligomer was derived from linseed oil, phenylboronic acid and glycidyl methacrylate to use in flame-retardant coating applications. The synthesized UV-curable oligomer was characterized for its structural and physicochemical properties by means of Fourier transform infrared (FTIR), ^{1}H and ^{11}B-nuclear magnetic resonance (NMR) spectroscopy techniques. The boron-containing UV-curable oligomer (BELO) was added to a conventional polyurethane acrylate (PUA) at varying concentrations ranging from 10 to 40 wt% in the presence of a photoinitiator and a reactive diluent. LOI and UL-94 tests were performed to understand the flame-retardancy behavior of the synthesized BELO oligomer, and the results revealed that the flame retardancy of UV-curable coatings enhanced as the percentage of BELO oligomer in the coating formulations increased. The glass transition temperature (T_g) and thermal stability of cured coatings were analyzed by differential scanning calorimetry and thermogravimetric analysis, respectively. The TGA analysis showed that char yield at 600 °C increased by increasing the BELO oligomer content. The mechanical properties, and stain, solvent, and chemical resistance and thermal behavior of the coatings were investigated. Incorporation of BELO into the PUA coating formulations and the comparison of the properties of BELO-incorporated PUA coatings with those of the conventional PUA coating exhibited interesting results.

Keywords Linseed oil · Epoxidation · Boron · UV-curing · Flame retardant

Introduction

Wood structural backbone is made of carbonaceous cellulose materials, and therefore, it is prone to fire accidents. Thus, it is necessary to improve the fireproof capability of wood-based material and to develop suitable flame-retardant materials which would enhance the fire-resistance properties of wood materials [1]. Fire-resistance properties can be improved by adding flame-retardant (FR) materials which have physical or chemical interactions with wood-based material. They can be incorporated into the backbone to delay the burning process of materials by enhancing the foam ignition temperature or reducing the rate of flame spread. The physically added flame-retardant additives show effective flame retardancy at higher concentrations and lead to adverse effects on coating properties, such as mechanical, chemical, solvent and thermal stability. The chemically reactive flame-retardant additives show effective flame retardancy at lower concentrations, and hence, causing less damage to the coating properties and reducing the migration of additive to the material surface, which generally occurs for physically added flame-retardant additives [2]. Nowadays, halogen- and phosphorus-containing reactive flame retardants are used to improve the fire-resistance properties [3–5]. These reactive flame retardants have various drawbacks, which are responsible for corrosive smoke and ejection of extremely carcinogenic substances like dibenzodioxins and dibenzofurans. Smoke adversely affects human health and poses pollution problems when it is released into the environment [6]. Therefore, considering the environmental and human health-related issues, the scientific community has focused on the environmentally friendly flame-retardant materials [7, 8]. Boron-containing flame retardants, such as boric acid and its analogous have been in use for a long time [9]. Organoboron flame retardants lose their water molecules, and finally, convert to boron oxide. Boron oxide

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