

Thermal and mechanical properties of bio-based plasticizers mixtures on poly (vinyl chloride)

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Abstract

The use of mixtures of nontoxic and biodegradable plasticizers coming from natural resources is a good way to replace conventional phthalates plasticizers. In this study, two secondary plasticizers of epoxidized sunflower oil (ESO) and epoxidized sunflower oil methyl ester (ESOME) were synthesized and have been used with two commercially available biobased plasticizers; isosorbide diesters (ISB) and acetyl tributyl citrate (ATBC) in order to produce flexible PVC. Different mixtures of these plasticizers have been introduced in PVC formulations. Thermal, mechanical and morphological properties have been studied by using discoloration, thermogravimetric analysis (TGA), differential scanning calorimetry (DSC), dynamic mechanical thermal analysis (DMTA), tensile - strain and scanning electron microscopy (SEM). Studies have shown that PVC plasticization and stabilization were improved by addition of plasticizers blends containing ISB, ATBC, ESO and ESOME. An increase in the content of ESO or ESOME improved thermal and mechanical properties, whereas ESOME/ATBC formulations exhibited the best properties.

Keywords: PVC, epoxidized sunflower oil, epoxidized sunflower oil methyl ester, isosorbide diesters, acetyl tributyl citrate.

1. Introduction

Poly (vinyl chloride) (PVC) is very present in daily living applications due to its diverse properties and low cost^[1,2]. Its properties depend on the amount of different kinds of additives such as plasticizers^[3]. The plasticizer is a very important additive of PVC; it can improve the flexibility of PVC without changing its chemical properties^[3-6]. Phthalates are the most commonly used plasticizers in PVC with applications in food packaging, medical devices, children's toys, building materials, and other common products^[3]. Unfortunately, phthalates contaminate indoor environments, human food and are environmental contaminants. It has been reported by Bhakti et al.^[3] that several phthalates and especially diethyl hexyl phthalate (DEHP) also known as di-octyl phthalate (DOP) are suspected of having carcinogenic and toxic effects.

Recently, several alternatives exist to substitute DEHP in PVC applications^[3]. Nowadays, there is an increasing interest in the use of nature based plasticizers for PVC^[7,8]. Some studies have been done on the use of epoxidized sunflower oil (ESO) as secondary plasticizer to partially replace di-2-ethylhexyl phthalate (DEHP) in PVC formulations^[9,10]. The compatibility of plasticizers with PVC also needs to be considered^[11]. Solubility parameters are often used to predict PVC/plasticizer interactions. Decrease in the glass transition temperature (T_g) of PVC can also be studied to assess plasticization efficiency^[12].

Epoxidized sunflower oil (ESO) and epoxidized sunflower oil methyl esters (ESOME) were synthesized and then characterized by oxirane index titration and FTIR spectroscopy. The aim of the work reported here is to investigate the use

of these new products as secondary plasticizers, mixed with isosorbide diesters (ISB) and acetyl tributyl citrate (ATBC) to plasticize PVC with 60 parts of plasticizers mixtures. The plasticization of PVC with ISB, as well as with its mixtures containing ESO and DEHP, has been studied in our previous work^[13]. Although ATBC and ISB have been studied as individual plasticizers for this polymer^[13,14], ATBC, ISB and their mixtures with ESO or ESOME in PVC is the axis of the present research to evaluate thermal, mechanical and morphology characteristics of plasticized PVC. Discoloration degree of sheets, thermogravimetry analysis (TGA), dynamic mechanical thermal analysis (DMTA), differential scanning calorimetry (DSC), mechanical properties and scanning electron microscopy (SEM) were used to investigate the properties of our PVC plasticized with ATBC, ISB and their blends with ESO or ESOME.

2. Materials and Methods

2.1 Materials

PVC suspension grade resin (SE 950, K= 65.7-67.1), was kindly supplied by Shintech (Houston, USA). Plasticizers used were as follows: acetyl tributyl citrate (ATBC) (Sigma Aldrich, USA), isosorbide diesters (ISB) (ID47, Roquette Frères, France), sunflower oil (SO) with an iodine value index, I_{iod} , of 130g I₂/100g (Cevital Bejaia, Algeria), epoxidized sunflower oil (ESO) with 6.1% of oxirane oxygen (conversion = 98.2%, yield = 80.5%) and epoxidized sunflower oil methyl ester (ESOME), were prepared in our