Effect of Biobased Plasticizers on Thermal, Mechanical, and Permanence Properties of Poly(vinyl chloride)

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Phthalates can be replaced by other harmless and environmentally friendly plasticizers, such as isosorbide diesters (ISB), and epoxidized sunflower oil (ESO), which has been proved an efficient stabilizer for poly (vinyl chloride) (PVC) in helping to prevent degradation during processing. Formulations based on PVC with different amounts of ISB, ESO, and di-(2-ethylhexyl) phthalate (DEHP) from 0 to 60 parts by weight per hundred parts of resin were realized. To make PVC flexible with partial amounts of the debated phthalates as plasticizers, we use a combination of DEHP, ISB, and ESO. Effects of these two biobased plasticizers, ISB and ESO, and their mixture with DEHP on thermal stability by measuring discoloration degrees and thermal gravimetric analysis, on mechanical properties such tensile strength, elongation at break, and hardness, were characterized. Plasticizer permanence properties of PVC compounds were studied. Studies showed that processibility and flexibility were improved by the addition of a plasticizer system (ISB, ESO, and DEHP). An increase in the content of ISB and/or ESO increased thermal and mechanical properties, whereas compositions with ternary compositions of ISB/ESO/DEHP (15/15/30) exhibited the best performance properties. J. VINYL ADDIT. TECHNOL., 00:000–000, 2014. © **2014 Society of Plastics Engineers**

INTRODUCTION

Poly(vinyl chloride) (PVC) polymer is a brittle, inflexible material with rather limited commercial possibilities unless stabilized with suitable additives. The processing of PVC in the raw form by using heat and pressure resulted in severe degradation of the polymer. Hydrogen chloride is produced and discolors PVC rapidly from white to yellow to brown to black. These changes were observed at processing temperatures, around 150°C [1]. There is a possibility of inhibition of the eliminated HCl by use of ester thiols to plasticize and stabilize PVC [2], or to suppress the catalytic activity of HCl by epoxides [3]. With growing interest on phthalate-free formulations, the development of alternative plasticizers has gained significant attention.

In previous studies [4–6], commercial sunflower oil was epoxidized. Epoxidation is the formation of oxirane groups by the reaction of peroxyacids (peracids) with olefinic double bonds. We examined the effect of epoxidized sunflower oil (ESO) on the thermal degradation of PVC by using dehydrochlorination rate measurement [5]. Several other reports [7, 8] on the use of epoxidized triglycerides as heat stabilizing additives for PVC claim that their effectiveness as stabilizers is related to the oxirane content and is owing to the facile reactions of the epoxide with HCl evolved at the early stages of the dehydrochlorination (which precludes auto-acceleration of the dehydrochlorination process) and with the labile chlorine atoms in the PVC (which reduces the susceptibility of the polymer to dehydrochlorination).

To date, the list of known PVC plasticizers is long. The most commonly used today are esters from petrochemicals, for example, adipates, sebacates, phosphates, citrates or butyrates, and particularly, phthalates, such diethylhexyl phthalates [di-(2-ethylhexyl) phthalate (DEHP) or dioctyl phthalate]. The effect of blends of plasticizers on mechanical and electrical properties has been the focus of many investigations. Djidjelli et al. [9] studied the effect of the phosphate plasticizer, diisodecyl phthalate, dioctyl phthalate, and their mixture on the electrical properties of PVC compounds. It was concluded that electrical properties were dependent on the type and content of plasticizer and that the use of a plasticizer blend induced a synergetic effect. Ramos-de Valle and Gilbert [10], Ramos-de Valle et al. [11], and Xu and Guo [12] investigated the PVC/plasticizer compatibility on a Brabender® plasticorder prepared by vibro-milling. They demonstrated that the plasticized PVC improved the processibility, permanence, and mechanical properties of PVC.

Over the last few years, phthalates have been increasingly critically evaluated, particularly as a result of their

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