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Synthesis and Optimization of Epoxidized Castor Oil in the Presence of a Sulphonated Polystyrene Type Cation Exchange Resin Catalyst

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***Abstract*— Epoxidized castor oil (ECO) has synthesized with glacial acetic acid and hydrogen peroxide in the presence of a catalyst. Here hydrogen peroxide (H_2O_2) acts as an oxygen donor and glacial acetic acid acts as an active oxygen carrier. Epoxidized oils have respectable oxirane oxygen content and highly reactive oxirane rings. The formation of the oxirane ring was confirmed by Fourier Transform Infrared Spectroscopy (FTIR) analysis and Nuclear Magnetic Resonance (NMR) studies. Vegetable oil-based epoxies are sustainable, renewable and biodegradable. These Epoxidized oils can replace petroleum derived materials in numerous industrial applications.**

***Keywords*— Castor oil, Epoxidation, Catalyst**

I. Introduction

Vegetable oils like castor oil, cottonseed oil, hemp oil, linseed oil, mustard oil, palm oil, rapeseed oil and soybean oil are sustainable and renewable materials [1-2]. The unsaturation present in vegetable oils can be chemically modified to form epoxidized vegetable oils. The economic value of the vegetable oil could be increased by converting the vegetable oil into epoxidized vegetable oil. Epoxidized oil contains oxirane rings or epoxide groups [3]. The process for the synthesis of the epoxide groups is known as an epoxidation reaction. Due to the high reactivity of the oxirane ring, epoxides can also used for the synthesis of chemicals like olefinic, carbonyl compounds, alcohols, alkanolamines, glycols, compounds, etc. and polymers like polyurethanes, epoxy resin, polyesters, etc. [4]. Commonly used epoxidation methods are, (a) epoxidation by conventional method, (b) epoxidation using enzymes, (c) epoxidation using acid ion exchange resin(AIER), (d) epoxidation using metal catalyst, and (e) other systems. Epoxidation methods depending on the nature of reactants and catalysts used for epoxidation.

Nowdays castor oil (CO) is used for many industrial applications. India is the world's major exporter of castor oil; other major producers are China and Brazil. The castor oil is a versatile vegetable oil due to its unique composition in which the main component is the 12-hydroxy -9-cis-octadecenoic acid, the so-called ricinoleic acid, which represents 90 % of its fatty acid content [5]. Castor oil is a viscous, pale yellow non-volatile and non-drying oil. It has bland taste and is sometimes used as a purgative. It has a slight characteristic odour while the crude oil tastes slightly acrid with a nauseating after-taste. Compare to other vegetable oils, it has a good shelf life and it does not turn rancid unless subjected to excessive heat. Figure 1 and 2 show composition of castor oil fatty acids and epoxidation of castor oil.

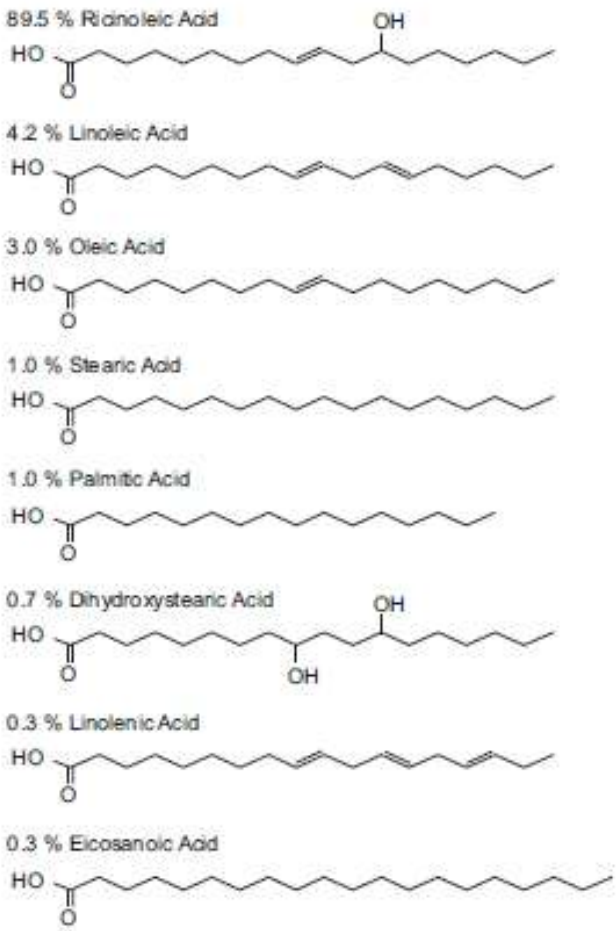

Figure 1: Composition of castor oil fatty acids

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Experimental

A. Materials

ECO synthesized by reaction of castor oil with glacial acetic acid , hydrogen peroxide(H_2O_2) and toluene using Amberite IR-120 as a catalyst [6].

B. Synthesis of epoxidized castor oil

Castor oil (91.8 g, 0.14 mol), glacial acetic acid (21.0 g, 0.35 mol), Amberlite IR-120 (23 g), and toluene (40 g) were added to a 500ml four-neck round-bottom flask equipped with a mechanical stirrer, thermometer sensor, and reflux condenser. The temperature was maintained at 55°C. To this solution, 30% hydrogen peroxide (56.7 g, 0.5mol) was added with stirring drop-wise at a rate such that the addition was completed in half an hour and the reaction was continued further for the desired time duration.. The reaction was run at 55°C for 7h. The solution was then filtered and washed with a saturated solution of $NaCO_3$, distilled water, and then dried with anhydrous sodium sulfate. Finally, the toluene was removed by distillation under vacuum to give epoxidized castor oil, which was further dried under vacuum at 80°C for 2h: yield 84%.

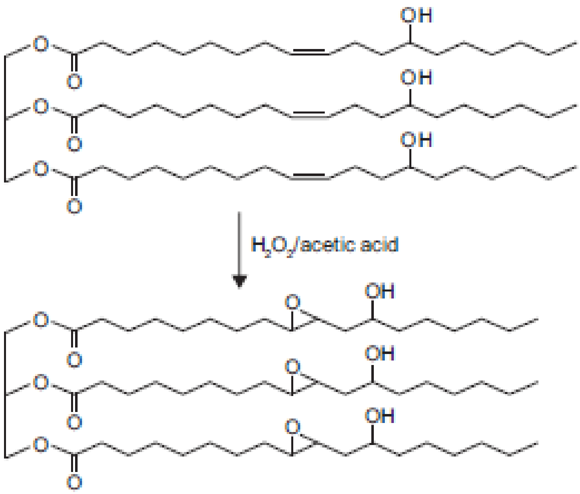

Figure 2: Epoxidation of castor oil.

Characterization

IR spectra were obtained by a Jasco International Co., Ltd.'s Model FT/IR- 4200 spectrometer by using KBr pellets. ^{1}H NMR and ^{13}C NMR characterizations were carried out with an UNITYINOVA 400/Varian spectrometer using tetramethylsilane (TMS) as an internal standard.

Results and discussion

FTIR (KBr): 3009 cm-1 (C=C), 822, 833 cm-1 (epoxide group). ^{1}H NMR (CDCI3) 5.3 ppm (2H, C=C), 2.9-3.1 (2H, epoxide group). ^{13}C NMR (CDCI3) 129.7-130.2 ppm (C=C), 54.0, 54.3 (epoxide group). Figure 3, 4 and 5 show FTIR spectra of epoxidized castor oil, ^{1}H NMR spectra of epoxidized castor oil and ^{13}C NMR spectra of epoxidized castor oil. ECO has a viscosity of 716 CPS at 25 oC and a specific gravity of 0.975.

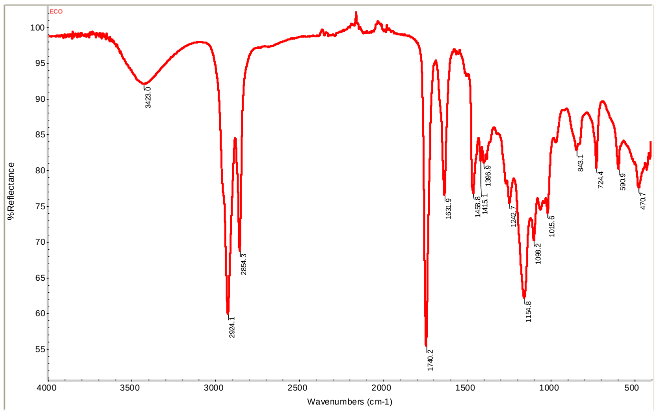

Figure 3: FTIR spectra of epoxidized castor oil

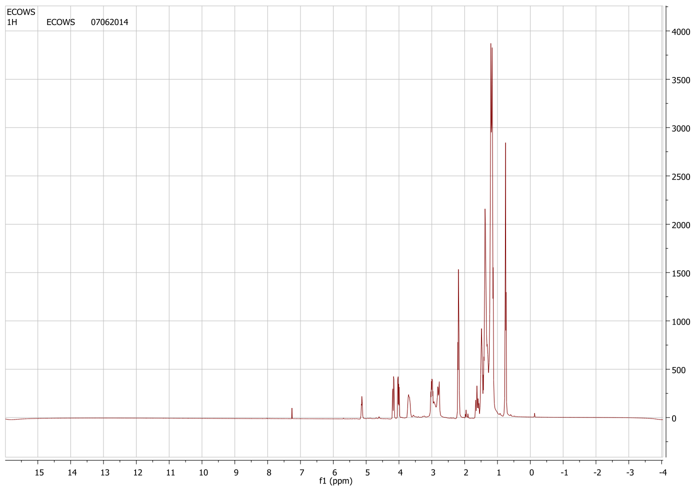

Figure 4: ^{1}H NMR spectra of epoxidized castor oil

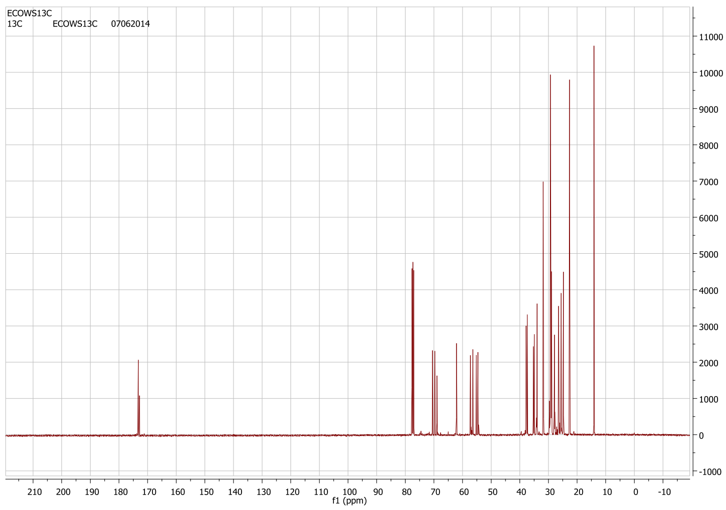

Figure 5: ^{13}C NMR spectra of epoxidized castor oil

Conclusions

Epoxidized vegetable oils which can be categorized as potential future green materials with unlimited future prospects, are fully explored to create new opportunities and applications. Significant opportunities are probable to take place in the bio-industry sector as fossil fuel reserves are limited and relatively large quantities of waste generated by industry sectors day-to-day Castor oil is an important renewable resource. ECO is used as a toughening phase to increase the toughness of diglycidylether of bisphenol-A (DGEBA) epoxy resins.

Acknowledgment

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