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Characterisation of Poly (Castoroil Fumerate) Polyester Resin Blends on Vinylacetate

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Abstract

The biodegradable Poly (castor oil fumarate) resin blends prepared by using castor oil, morpholin, vinyl acetate (VA) by benzoyl peroxide initiator and dimethyl aniline containing the ratio of resin blend and VA 1:1,1:0.75,1:0.5,1:0.25, as a cross linked toughened sheets CFRVA-I,CFRVA-II,CFRVA-III,CFRVA-IV. These biodegradable polyester resin blends were characterized with respect to physical, resistance to chemicals, thermal and some of the mechanical properties.

Keywords: Castor oil, Poly (castor oil fumarate), Polyester, Maleic anhydride, Benzoyl peroxide.

Introduction

Natural oil and their derivatives are used due to their availability, renewability and biodegradability [1]. Natural oils have attracted renewed attention as raw materials for the preparation of resins and polymeric materials [2]. Polymers from renewable resources have been attracting ever-increasing attention over being environmental concerns [3]. The polymers obtained from natural oils are biopolymers in the sense that they are generated from renewable natural sources; they are often biodegradable as well non-toxic [2].

In the present study biodegradable Poly (Castoroil Fumerate) Polyester Resin has been synthesized from the natural oil, castor oil. Castor oil is a triglyceride of fatty acids that contains 87-90% of ricinoleic acid (cis-12-hydroxy octadec-9-enoic acid). Ricinoleic acid is an unsaturated omega-9-fatty acid has 18-carbon on its backbone with one hydroxyl group on the 12^{th} carbon atoms and it also has a cis double bond between 9^{th} and 10^{th} carbon atoms [4].

The ester linkages, double bonds and hydroxyl groups in castor oil provide reaction sites for the preparation of many useful derivatives. The hydroxyl functionality of castor oil has been widely utilized to synthesize CFR, Castor oil fumarated resin [5]. In the present study, CFR is made to react with the cross linking agent, vinyl acetate in different molar proportions, and is cured to form rigid biodegradable poly esters.

Materials

Castor oil was obtained from Sriram industries, Madurai. Sodium acetate, Benzoyl peroxide and dimethyl aniline were received from Ranbaxy-Newdelhi, Maleic anhydride (CDH, Bombay), Morpholine (Paxmy chemicals, Chennai) and vinyl acetate (Loba chemic Pvt. Ltd. Mumbai). The chemicals were used as received.

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Methods

i) Synthesis of Poly (Castor oil Fumerate) Polyester Resin blend Vinyl acetate

The Poly (Castoroil Fumerate) Polyester Resin was prepared by heating 3 moles of castor oil with 1 mole of maleic anhydride using morpholine as the catalyst. In a typical reaction 45.8 g of castor oil, 14.7 g of maleic anhydride, and 1g of sodium acetate alon with few drops of morpholine were placed in a three necked flask with a stirrer. The reaction was carried out at 110^{o}c $\pm$ 5^{0}c for 60 minutes and then 180^{0}C $\pm$ 5^{0}C for 10 minutes under vacuum condition using rota mantle to yield yellowish transparent liquid resin, CFR Poly (Castoroil Fumerate) Polyester Resin, the prepolymer.

The prepolymer, CFR is mixed with the cross linking agent, vinyl acetate (VA) in different molar proportions in presence of benzoyl peroxide (initiator) and dimethyl aniline (accelerator) and then casted on a clean silicone oil spreaded glass plate, cured in a hot air oven at 80^{0}c for 6 hours and the polyester blends CFRVAI,CFRVAII,CFRVAIII and CFRVAIV were obtained.

ii) Analysis of Poly (Castor oil Fumerate) Polyester Resin

The Poly (Castor oil Fumerate) Polyester resin was analysed by ultraviolet spectral analysis using 0.05% n-hexane solution of the resin. A Hitachi 220 uv-visible spectrometer was used [6]. ATIR spectral analysis of the resin was done by Perklin Elmer 597 infrared spectrophotometer. Proton NMR spectral analysis of the resin was taken by using a R24 8H Hitachi-high resolution NMR spectrophotometer. The molecular weight was determined by gel permeation

chromatography using μ-styragel columns, 100A° and 500A°, uv detector and 280 nm filter. Specific gravity, iodine value, hydroxyl value and intrinsic viscosity of the resin was determined accordingly to the IS standard 840-1964 [7].

iii) Characterisation of Poly (Castor oil Fumerate) Polyester Resin blend Vinyl acetate

Tensile strength of the resin blends was determined using dumbbell specimens as per ASTM Standard D412, using an Inston universal testing machine. The gauge length was fixed as 50mm and the area of cross section was 10mm [7]. The Poly ester resin blends with vinyl acetate were subjected to differential thermal analysis (DTA)/ Thermogravimetric analysis (TGA) studies at a rate of 10K/min in air/Nitrogen using SDT Q 600 V8.3. Acid, alkali and solvent resistance were estimated according to the ASTM Standard D3137 C267. Polyester resin blend (3x1x0.1 cm) was immersed in the medium (100 ml) for a total duration of 60 days under ambient conditions. The medium was changed and fresh medium was added at an interval of one week. The loss of weight was determined using an electronic weighing balance.

Thermal properties of Poly (Castor oil Fumerate) Polyester Resin blend Vinyl acetate studied are influenced mainly by molecular weight between crosslinks. The DTA curves of poly ester sheets do not show any endothermic peak for softening but shows four exotherms for decomposition at high temperature. (CFRVAIII<CFRVAIV<CFRCAI<CFRVAII)

The TGA curves for decomposition of Poly (Castor oil Fumerate) Polyester Resin blend Vinyl acetate shows that they are invariably stable under high temperature conditions. 10% weight loss occurs only at reasonably high temperatures. The thermo gravimetric data of CFRVAI, CFRVAII, CFRVAIII and CFRVAIV given in table I, shows that they posses higher thermal stability. The 10% weight loss occurs at relatively higher temperature. They decompose in more than two stages.

The tensile properties of Poly (Castor oil Fumerate) Polyester Resin blend Vinyl acetate are given in table II. The higher tensile strength and modulus observed in CFRVA IV. The lower tensile strength is observed in CFRVA III. Accordingly CFRVAI, CFRVAII exhibits high tensile strength and modulus. The high strength and high modulus reflect the strong and hard character of these poly esters.

The percentage weight loss of Poly (Castor oil Fumerate) Polyester Resin blend Vinyl acetate were determined in 1NHCl, 1NNaOH, acetone, toluene, CCl_4, H_2O_2, saline solution, DMF, DMA etc and the results are furnished in table III. All the Resin blends are stable in H_2O_2, H_2O and saline solution and unstable in the other mediums.

Table I. Thermal data of Poly (Castor oil Fumerate) Polyester Resin blend Vinyl acetate

New polymer Films	Temperature (^{0}c) at the each stage of degradation (Weight loss %)			
	Tstart	I	II	III
CFRVAI	214.08 (96.17%)	313.75 (79.30%)	483.83 (16.50%)	629.22 (5.717%)
CFRVAII	206.77 (95.07%)	313.75 (76.57%)	476.52 (15.29%)	676.77 (3.385%)c
CFRVAIII	214.08 (95.32%)	313.75 (80.03%)	483.83 (13.96%)	676.77 (4.225%)
CFRVAIV	214.08 (95.18%)	313.75 (81.76%)	483.83 (15.20%)	676.77 (4.182%)

Table II. Mechanical properties of Poly (Castor oil Fumerate) Polyester Resin blend Vinyl acetate

Sl.No	Polyvinyl acetate sheets	Tensile strength	Modulus
1	CFRVAI	0.795	2.493
2	CFRVAII	0.780	3.443
3	CFRVAIII	0.182	3.03
4	CFRVAIV	1.694	5.38

Table III. The percentage weight loss of Poly (Castor oil Fumerate) Polyester Resin blend Vinyl acetate

Sl. No	Medium	Weight loss% CFRVAI	Weight loss% CFRVAII	Weight loss% CFRVAIII	Weight loss% CFRVAIV
1	1N HCl	17.64	7.14	12.5	22.22
2	1N NaOH	11.11	6.66	6.25	0
3	Acetone	0	0	0	0
4	Toluene	0	0	0	0
5	CCl_4	0	0	0	0
6	H_2O_2	35.29	33.33	52.63	61.53
7	H_2O	21.42	14.28	26.66	11.76
8	Saline solution	11.76	10.52	7.69	30.76
9	Dimethyl Formamide	0	0	0	0
10	Dimethyl acetamide	0	0	0	0
11	Soil burial	6	7	5	9

Conclusion

Poly (Castor oil Fumerate) Polyester Resin blend Vinyl acetate is definitely biodegradable polyester obtained from the bio renewable resource and the setting and crosslinking of the polymer depends on the concentration of the monomer. Accordingly CFRVAI, CFRVAII exhibit high tensile strength and modulus reflect the strong and hard character of these poly esters.

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