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RESEARCH ARTICLE

SPECTROSCOPIC STUDIES OF ENVIRONMENTALLY SUSTAINABLE POLYURETHANE COMPOSITES BASED ON CASTOR OIL

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ABSTRACT

Increasing world population demands increasing amount of chemicals, materials, polymers for daily usage. Most of the polymers and chemicals are derived from fossil resources but the major problem of using this fossil based material is undesirable environmental problem, frequent oscillation in oil price and limited fossil resources. In the present study we mainly focus on Synthesis of castor oil based soft polyurethane and its composites. In this study two fibre were selected Sisal and glass were selected. The compound was further subjected to FT-IR and XRD and the swelling coefficient and absorptivity percentage studies.

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INTRODUCTION

Bio-based materials are now receiving considerable attention in the promotion of sustainable chemistry in the production of materials by its replacement of petroleum-derived raw materials in the production of different products needed in various industries. These bio-based materials are a great alternative to fossil based materials Due to renewable feedstock use, easy degradation, easy accessible source and use of low energy for production. Plant oils contain about 15 different fatty acids. Some of them are saturated, including lauric, palmitic, stearic, arachidic, behenic, and lignoceric acids; some are unsaturated, including oleic, petroselenic, linolenic, α-linolenic, γ-linoleic, roughanic, and erucic acids; and two of them are unusual fatty acids, ricinoleic and vernolic acids. These fatty acids have chain lengths of 12 to 24 carbons, with one to three double bonds for unsaturated fatty acids. Vegetable oils are vital biorenewable resources extracted from various plants and are normally named by their biological source, such as soybean oil and palm oil. Chemically, vegetable oils consist of mainly triglycerides formed between glycerol and various fatty acids (Verhe, 2004). Most fatty acids are long straight-chain compounds with an even number of carbons and the double bonds in most of these unsaturated fatty acids possess a cis configuration. However, some fatty acid chains, like those in ricinoleic and vernolic acids, bear functional groups, hydroxyl and epoxy groups respectively (Belgacem and Gandini, 2008).

The physical state of vegetable oils depends on both the nature and the distribution of the fatty acids.

MATERIALS AND METHODS

Synthesis of castor oil based soft polyurethane: Castor oil based soft polyurethane was synthesized by using 4,4-methylene bis (cyclohexyl) isocyanate with castor oil as polyol dissolved in ethylmethyl ketone at NCO/OH mole ratio 5:2. The reaction was carried out in a three neck flask equipped with a reflux condenser at 80^0C for 45 minutes under nitrogen atmosphere. The obtained castor oil based polyurethane was stirred well in a plastic cup using a glass rod in the presence of catalyst dibutyltinlaurate and poured into a flat mould coated with silicone realizing agents to cast the neat sheet. The polymer was allowed to settle for 12hr in a flat surface without any disturbance.

Synthesis of castor oil and fibre based polyurethane: Castor oil and fibre based polyurethane was synthesized by using 4,4-methylene bis (cyclohexyl) isocyanate with castor oil as polyol dissolved in ethylmethyl ketone at NCO/OH mole ratio 5:2. The reaction was carried out in a three neck flask equipped with a reflux condenser at 80^0C for 1hr under nitrogen atmosphere. one natural fibre (sisal) and one synthetic fibre (glass) was added to the synthesized castor oil based polyurethane and then the mixture was stirred well in a plastic

cup using a glass rod in the presence of catalyst dibutyltinlaurate and poured into a flat mould coated with silicone realizing agents to cast the neat sheet. The polymer was allowed to settle for 12hr in a flat surface without any disturbance.

Determination of swelling coefficient: The polyurethane sheet and its composite were subjected to swelling experiments. The density of the polyurethane sheets and its composite were analyzed using ASTMD 0.792 standard.

Swelling coefficient Q was evaluated using the formula

$$\text{Swelling Coefficient (Q)} = \frac{\text{Weight of the solvent in swelled polymer}}{\text{Weight of the swelled polymer}} \times \frac{\text{Density of polymer}}{\text{Density of solvent}}$$

Determination of solvent absorptivity percentage (SA%)

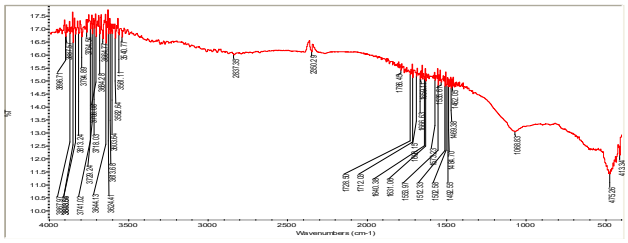
To determine the solvent absorptivity percentage each polyurethane sheet was put in 3ml of different solvents and keep it for 24hrs. after 24 hours, the excess solvent was removed by using filter paper. Then it was weighed and SA% was evaluated using the equation.

$$\text{Solvent absorptivity \%} = \frac{W2-W1}{W1} \times 100$$

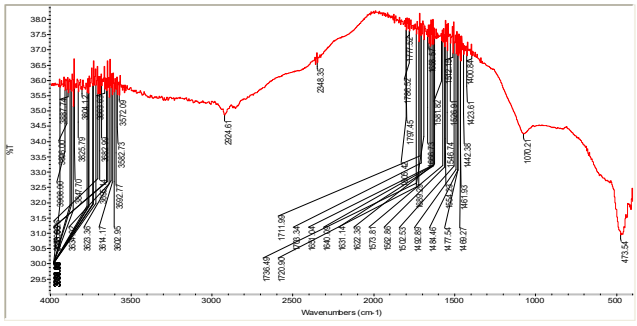
W1 = Weight of the polyurethanes composites before
W2 = Weight of the polyurethane composite after absorption of the solvent

RESULT AND DISCUSSION

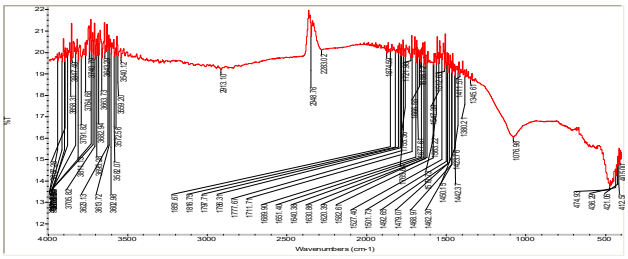
FT-IR studies of polyurethane and its composites based on castor oil: The FTIR spectra of castor oil based soft polyurethane and composites based on castor oil from fibre are depicted in figures 1 and 2. Shows peak at 3640 cm-1 which reveals the presence of -OH groups. The peaks at 2837 cm-1 indicates -CH stretching of methylene groups. The peak at 1788 cm-1 indicates -C=O stretching of unsaturated ester and the peak at 1461 reveals the presence of -CH_2 bending. This values reveals the confirmation of polyurethane linkage.



PUSR1



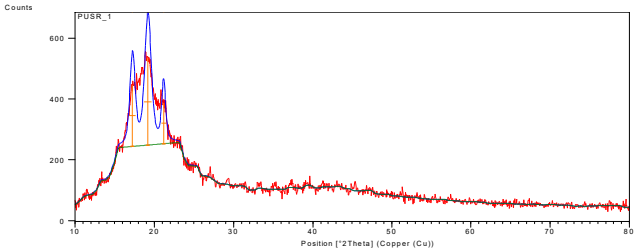
PUSR1G



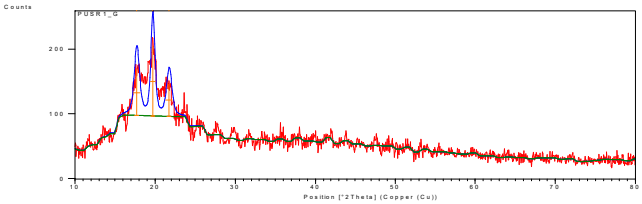
PUSR1-S

XRD STUDIES

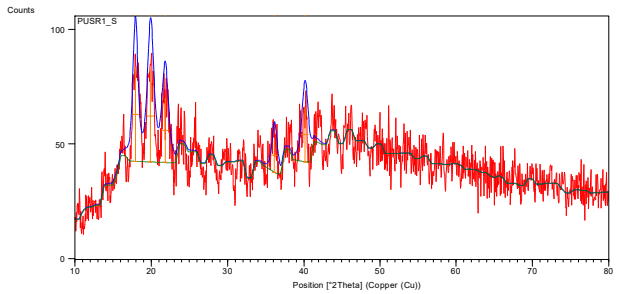
Figure 3.10, 3.11 and 3.12 shows the XRD pattern obtained for castor oil based soft polyurethane. The XRD pattern of castor oil based soft polyurethane (PUSR-1) showed peaks at 2θ corresponds to 17.247440 and 21.163410° attributed to a d-spacing of 5.14148 A˚ and 4.19815 A˚ respectively. PUSR1-G showed peaks at 2θ corresponds to 17.716380 and 21.751380° attributed to a d- spacing of 5.00643A˚ and 4.08598A˚ respectively. PUSR1-S the XRD peak at 2θ corresponds to 17.918010° with a d-spacing of 4.95054 A˚ got broadened further



PUSR1



PUSR1-G



PUSR1-S

Swelling coefficient: The swelling coefficient of the polyurethane and their composites were high in dimethyl acetamide. This clearly indicates that these polyurethane and their composites were cross-linked. These polymeric materials will only swell and doesnot dissolve in the solvents. The amount of the swelling in non-reactive solvent is used to find out the amount of crosslinking and its molecular weight between crosslinks.

Table 1. Swelling coefficient of polyurethane

Polyurethane & its composite	Swelling coefficient							
	Acetone	DMA	DMF	Ethylene glycol	EMK	Chloroform	Toluene	Glycol
PUSR1	0.83	1.146	0.78	0.17	0.57	0.68	0.59	0.17
PUSR1S	0.76	1.136	0.79	0.53	0.51	0.64	0.61	0.13
PUSR1G	0.89	1.201	0.84	0.27	0.54	0.60	0.65	0.11

Conclusion

We were able to synthesize castor oil based soft polyurethaneand it's composite. The synthesized compounds were subjected for FT-IR and XRD. These results indicated the increase in basal spacing between the polyurethane and corresponding decrease in crystallinity and ordering confirming effective castor oil based soft polyurethane fibre.

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