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Properties Improvement and Analysis of PLA/Cardanol/MMT Nano Clay Biodegradable Composite for Packaging Application

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Abstract—*Polylactide (PLA) a biodegradable material is derived from renewable resources. It is used as a commodity thermoplastic in packaging applications as an alternative solution to control the ecological problem of petrochemical based plastic waste accumulation. The objective of this research is to improve the brittleness and barrier properties of the PLA material the help of Cardanoland, MMT Nano clay. The proposed PLA composite is prepared by melt compounding of PLA, Cardanol, MMT Nano clay in co-rotating twin screw extruder in different weight fractions of Cardanol, MMT Nano clay and mixture of both. Followed by specimen preparation by compression moulding. ANSYS software is used to assess the performance of the PLA composite. Immersion test is used to assess apparent weight gain and length swelling.TGA is employed to investigate the liquid absorption mechanism. Tensile and flexural test are used to assess the mechanical properties. These finding will provide basis to develop the product and analysed it with optimum brittleness and barrier properties of PLA composite to maintained high quality of packaged product with biodegradable material.*

Index Terms*: Bottle, barrier properties, brittleness properties, Stress, Strain, Deformation, PLA (Polylactic Acid), and Composite of PLA / Cardanol/MMT Nano clay.*

I. INTRODUCTION

Today, bioplastics are widely used because of their sustainability, reproducibility and environmental friendliness Poly (lactic acid).

(PLA) is a typical bioplastic derived from non- petroleum phosphate based products.

Commercially, PLA can not be manufactured directly into products that require toughness and flexibility due to its brittleness. One of the most popular and practical methods to overcome this error is by blending other polymers with plasticizers.

Plasticizers are usually added to the polymer to improve processability by acting as spacers at the molecular level, so that less energy allows substantial rotation around the C-C bond. Is required for Martin and Averous examined the effects of various low molecular weight plasticizers such as Cardanol and glycerol. They found that the Cardanol plasticizer was the greatest result as revealed by the decrease in glass temperature. In contrast, glycerol was found to be the least efficient. The assessment is based on the glass transition temperature Tg shift and mechanical properties. In an attempt to improve the mechanical properties for packaging applications.

II. MATERIALS USED

Types of materials used to make some bottles:

- PLA
- Composite of PLA / Cardanol/MMT Nano clay

Cardanol acts as plasticiser or lubricant and MMT Nano clay acts as a rainforcement it also improve barrier properties in PLA / Cardanol / MMT Nano clay. Therefore, a reduction in temperature and energy mix was expected.

quality of PLA matrix and PLA / Cardanol / MMT Nano clay composites This is an excellent PLA with tiny strength of 61.0 MPa and one young modulus of 2230 MPa.

III. MATERIALS AND PROCESSIN PLA is procured from Amazon dealer Tesseract in the form of spool while Cardanol is procured from Arman Enterprises Ahemdabad Gujrat and MMT Nano clay is procured from Rajapallaya hoodi, Banglore.

The PLA spool was cut into 1 to 2 mm fine granules with the help of palletizer. Mixture batches of 0, 1.5 and 3wt% Cardanol and MMT were prepared. Next, these batches were pre-dried into a oven at $80^{O}C$ for 2 hours to remove any moisture content. After that the batches are one by one compounded into twin screw extruder with following setting:

	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5
Temp. (^{0}C)	**180**	**190**	**200**	**210**	**220**

Screw Speed: 36 RPM

the extrudate so formed is converted into pallets using palletiser. Next these pallets are used to make test specimen with the help of compression moulding machine at 210^{0}C and 100 psi for 10 minutes and then cooling. After that the specimen were shaped using contour cutter.

IV.TESTING

MECHANIC TESTING

Table 1: Tensile test results of the composites

	Densi ty (g/cm3)	Tensil e Modul us (MPa)	Tensil e strength (MPa)
PLA	1.24	2230	61
PLA+1.5%Cardanol+ 1.5% MMT	1.20	1545	56.4
	1.16	1695	52.6

V. ANALYSIS OF BOTTLE

In the present work static load analysis is performed on bottle by using ANSYS software. The model of bottle is prepared in SolidWorks software and it is imported in ANSYS software to perform analysis. Analysis is performed with different materials i.e. PLA and composite of PLA/Cardanol/MMT in to predict the suitable material for making bottle. The side portion of the bottle is taken into consideration during analysis. A set of estimated results are found out by using the analyzing software.

VI .THERMAL ANALYSIS BY TGA:-

We also investigated the thermal stability of the PLA/CD/MMT composite, and the TGA curves are shown in Fig. The thermal decomposition of neat PLA begins at about 320 C and reaches a maximum degradation rate at about 398 C, while thermal decomposition of CD begins at about 220 C and reaches a maximum degradation rate at about 340 C. All the blends reveal a single stage decomposition at 290–420 C, and a maximum degradation rate at 387–398 C, similar to that of neat PLA. For the PLA/CD/ MMT composite, the thermal decomposition starts at a lower temperature compared with that of PLA. Therefore, the addition of CD and MMT slightly influences the thermal stability of PLA, but it meets the requirements of most applications.

VII. RESULTS AND DISCUSSION

Here are some of the figures showing equivalent stress, strain and deformations at various speeds.and TGA

Result diagram.

Total Deformation:-

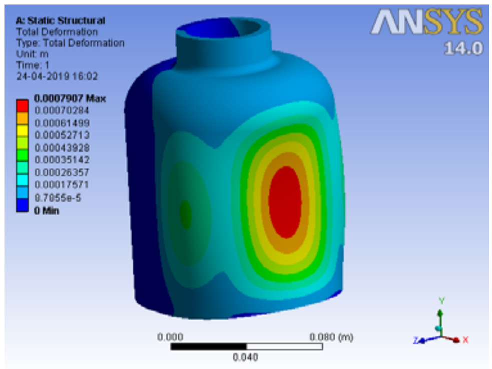


Fig 1: Total deformation of neat PLA

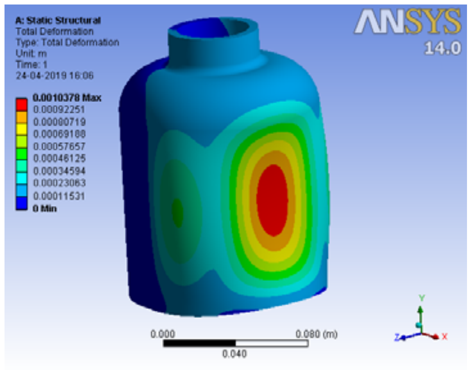


Fig 2: Total deformation of PLA+1.5%Cardanol+1.5%MMT

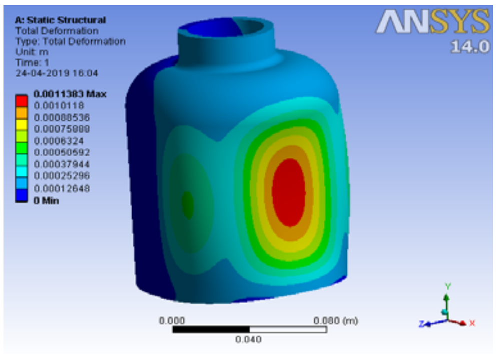


Fig 3: Total deformation of PLA+3%Cardanol+3%MMT

Principle Strain

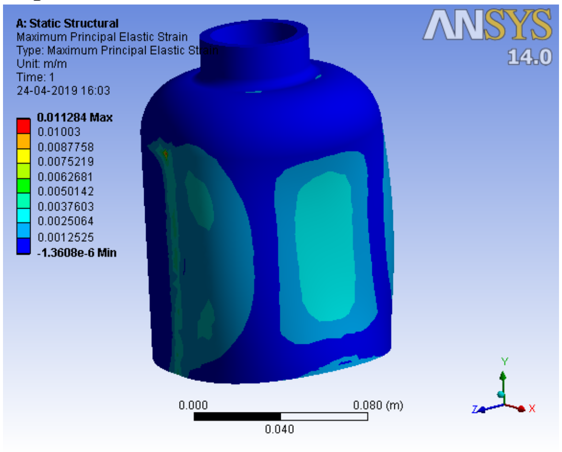


Fig 4: Principle strain of neat PLA

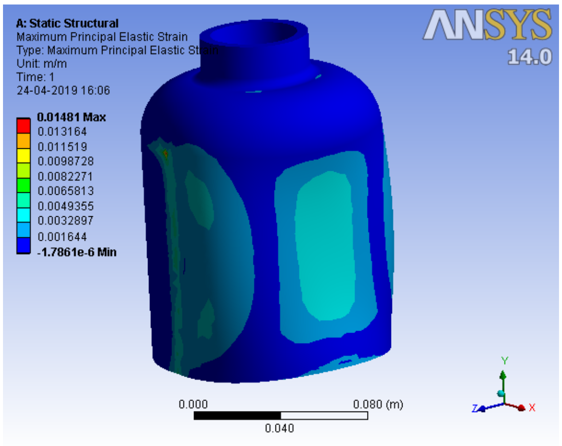


Fig 6: Principle strain of PLA+1.5%Cardanol+1.55%MMT

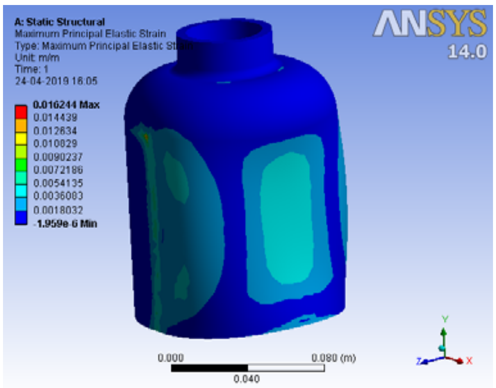


Fig 6: Principle strain of PLA+3%Cardanol+3%MMT

Principle stress

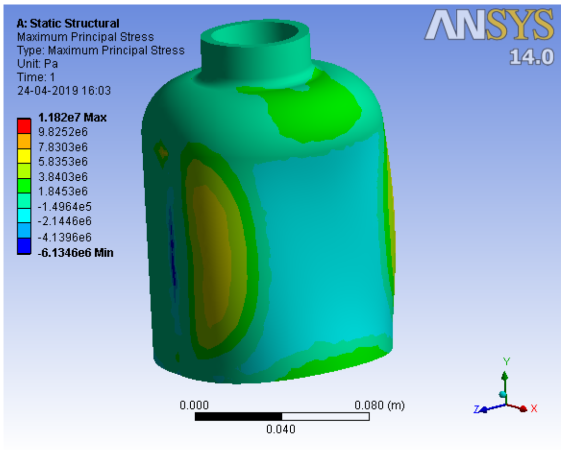


Fig 7: Principle stress of neat PLA

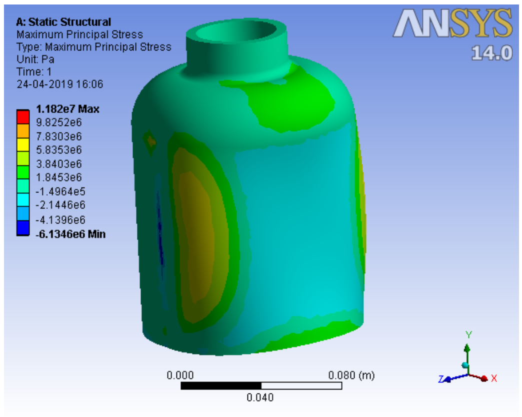


Fig 8: Principle stress of PLA+1.5%Cardanol+1.5%MMT

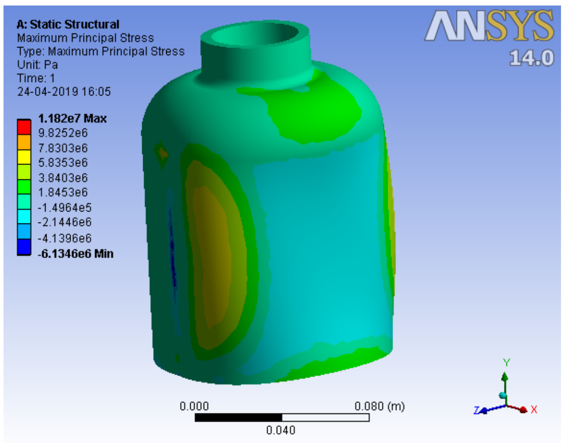
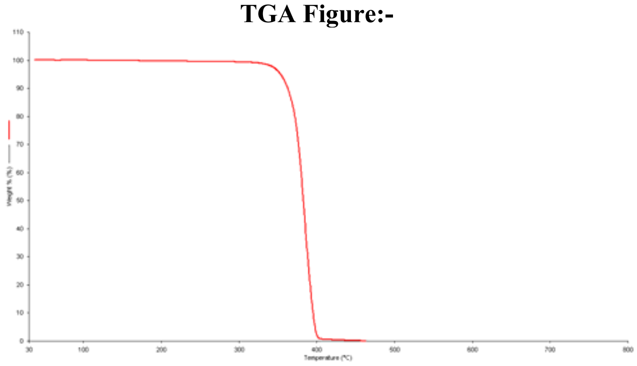
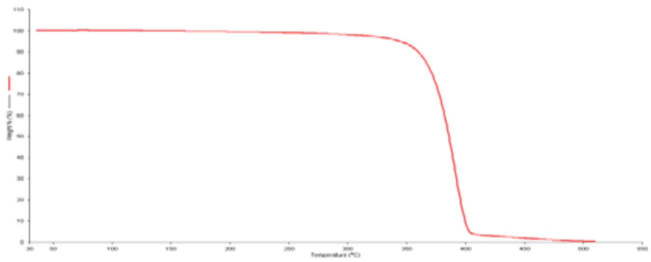


Fig 9: Principle stress of PLA+3%Cardanol+3%MMT

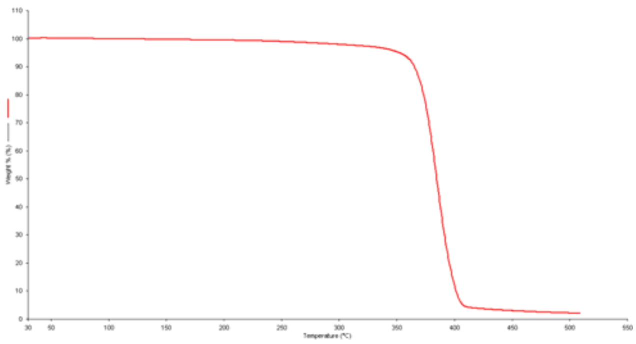
TGA Figure:-



Sample 1: neat PLA



Sample 2: PLA+1.5%Cardanol+1.5%MMT



Sample 3: PLA+3%Cardanol+3%MMT

VIII. CONCLUSION

The study showed that the developed composite showed reduced mechanical properties with increasing loading of Cardanol and loading of MMT is helping to improve the mechanical properties which is evident at larger loading rates of MMT. But Cardanol is acting as plasticizer to improve the brittleness properties of the composite and MMT is helping in improving the barrier properties of the composite by improving crystalinity and also improve thermal stability.

IX. LIMITATIONS

The analysing software i.e. ANSYS provides an approximated value for the stresses, strains and deformations developed therefore they may vary from actual result.

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