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AIT Research

DEVELOPMENT OF HIGH STRENGTH NANOCOMPOSITE FOR BIODEGRADABLE STENTS

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INTRODUCTION

The use of biodegradable polymer materials are considered to be good alternatives in urology (Donohue et. al. 2018), cardiovascular (Brie et. al. 2016) and tracheal airway stenosis which provide support before it is absorbed by the body over a period of time and also in oesophageal and gastroenterology fields (Zhu et. al. 2011). However, polymer on its own do not possess all the required properties for use in high strain environment. Hence, in this study Polylactic acid (PLA) is blended with Halloysite nanotubes (HNTs) through extrusion. The influence of the screw speeds during extrusion was investigated and it was found to have a significant positive impact on the mechanical and thermal properties of the extruded PLA/HNT nanocomposite

EXPERIMENTAL DETAILS

MATERIALS

PLA was obtained from Corbion, PLA LX 175. The density of the PLA is 1.24 g/cm³. HNT was supplied by Applied Minerals; DRAGONITE-HP and has a density of 2.56 g/cm³. All materials were dried prior to use in order to remove any moisture content present.

METHODS

To determine the effect of screw speed on PLA/HNT nanocomposites, 5% and 10% of HNTs were blended into the PLA matrix through compounding at screw speeds of 40, 80 and 140 rpm. In similar condition virgin PLA was compounded for comparison. The resultant polymer melt was quench cooled onto a calendar system to produce composite films for testing. Resultant films were assessed for mechanical, thermal, chemical and surface properties.

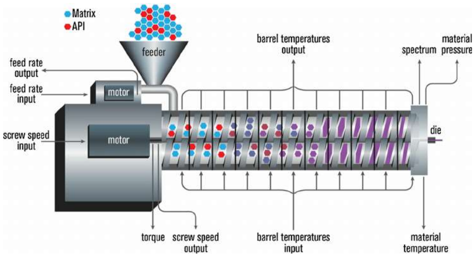


Fig 1. Twin screw extrusion (Researchgate.net)

RESULTS

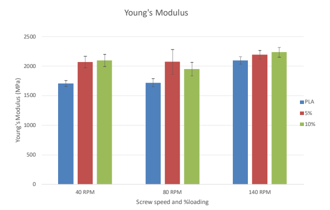


Fig 2.The increase in screw speed and the HNT loadings had significant effect (with p-value = 0.01 for both) on the increase in rigidity (Young's modulus) of the virgin PLA and the PLA/HNT nanocomposites.

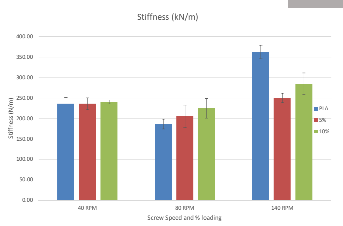


Fig 3. With p=0.01 both the screw speed and the loading of HNTs had significant increase in stiffness for virgin PLA and the 10% nanocomposites

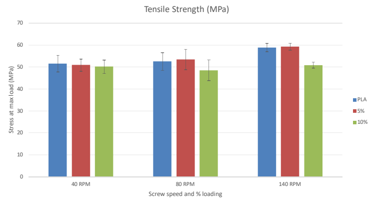


Fig 4. With p=0.045 for screw speed and p=0.01 for loadings of HNTs, both had significant effect on the tensile strength of the 5% nanocomposites.

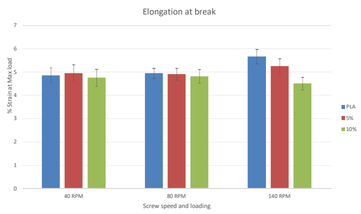


Fig. 5. With p=0.01 both the screw speed and the loading had significant effect on the elongation at break for virgin PLA and 5% nanocomposites.

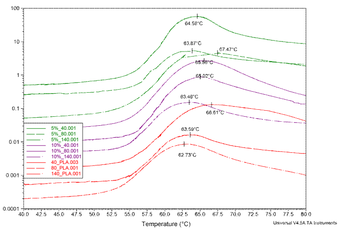


Fig 6. Tan δ curves by dynamic mechanical analysis indicates increase in Tg for 5% composite at 140 rpm

Table 1. Values corresponding to the secondary heating DSC curves indicates significant decrease in Tcc and Tm

RPM	Loading	T_g	T_{cc}	T_m
40	PLA0	60.74	128.22	159.3
40	PLA/HNT5	61.07	117.04	150.15
40	PLA/HNT10	60.67	118.36	150.5
80	PLA0	62.32	118.92	151.29
80	PLA/HNT5	62.43	118.70	150.44
80	PLA/HNT10	61.31	116.52	149.95
140	PLA0	61.21	125.68	157.37
140	PLA/HNT5	60.25	118.14	150.57
140	PLA/HNT10	60.69	116.20	149.74

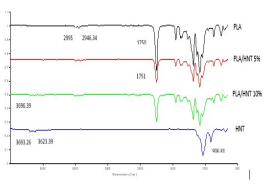


Fig 7. FTIR spectars for the PLA/HNT composites at 40 rpm screw speed.

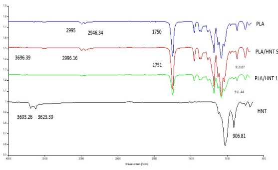


Fig 8. FTIR spectars for the PLA/HNT composites at 80 rpm screw speed.

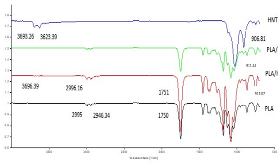


Fig. 9. FTIR spectars for the PLA/HNT composites at 140 rpm screw speed.

The peak shift of Al-OH group of HNT from 906.81 to 911.44 for 10% composites and 913.60 for 5% composites confirms better absorption for 5% composites. The absorbance peak of 5% composite is more intense as the screw speed increases.

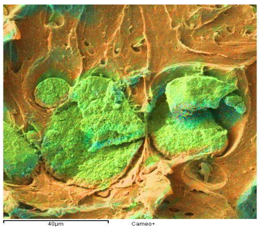


Fig. 10. Photomicrograph of PLA/HNT 10% nanocomposite shows agglomeration of HNTs

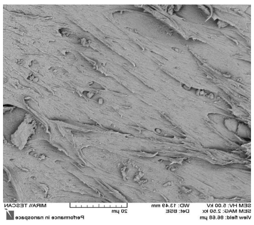
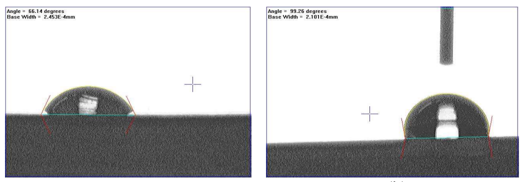


Fig. 11. Photomicrograph of PLA/HNT 5% nanocomposite at 140 rpm shows good dispersion.



(a) (b)

Fig. 12. The contact angle of the distilled water on the (a) 5% PLA/HNT nanocomposite (hydrophilic) and (b) 10% PLA/HNT nanocomposite (hydrophobic) compounded at 140 rpm screw speed.

CONCLUSION

The uniform dispersion of HNTs, increased strength, glass transition temperature and absorption peak of the nanocomposites of 5% HNTs was significant at 140 rpm when compared to 40 or 80 rpm. The improved mechanical and thermal properties of both the virgin PLA and the composites compounded at 140 rpm can be attributed to the increased melt shear at higher screw speeds which enhanced the dispersion of HNTs in the matrix.

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