Structural, Mechanical and Gas Barrier Properties of Poly(ethylene terephthalate) Nanohybrids and E-waste Utilization

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By

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Chapter 7

Conclusions and Scope for future work

Chapter 7

7.1 Conclusions

In this thesis, properties enhancement of PET have been explored by preparing its nanohybrids using nanoclays. Effect of nanoclay inclusion on thermal, mechanical, structural and gas barrier properties was studied in detail. As the PET, known for its numerous important applications, is largely recycled globally, utilization of a less utilized polymer (ABS) largely present in E-waste has been explored.

In ***Chapter 3*** the PET nanohybrids have been prepared using nanotalc and the solvent casting route is explored for the preparation technique. The dispersion of nanotalc in the PET matrix has been found to be homogeneous. The nanohybrids have showed improved thermal stability and increased T_g up to 8°C. The nanotalc has imparted improved mechanical properties with increment in Young's modulus up to 28% for 4wt% and 43% for 8 wt% nanotalc inclusion and very slight compromise in toughness. The Young's modulus was predicted very closely using Halpin Tsai and Hui Shia models. The microhardness was also enhanced up to 2.8% as determined by Vicker hardness tests. The microhardness values predicted by MROM model showed good agreement with the experimental data. The storage modulus was found to be increased in nanohybrid up to 45 and 50% for 4 and 8 wt% of nanotalc concentrations respectively. The effect of stretching in nanohybrids containing nanotalc has been studied and found that the presence of nanotalc has imparted orientational ordering in the PET polymer chains as the blob size increased from 9 in stretched PET to 13 in stretched P-T nanohybrid. The oxygen gas permeability was reduced up to 64% in P-T nanohybrid. The permeability values have been predicted very closely using different theoretical models.

In ***Chapter 4*** the PET nanohybrids have been prepared using NK75 nanoclay via solvent casting route. The nanoclay was found to be dispersed homogeneously in the PET matrix and increased level of intercalation was determined by XRD studies as intergallery spacing was increased from 2 nm to 3.7 nm. The strong interaction between PET matrix and NK75 was confirmed via considerable shifting in FTIR absorption band. The thermal properties of nanohybrid were improved and T_g was found 8°C higher in P-NK. The inclusion of NK75 resulted in 66% improvement in Young's modulus yet retained the toughness to a sufficient extent. The experimental values were predicted precisely using Halpin-Tsai model. The microhardness was improved up to 16% and the experimental data was predicted closely using MROM model. The storage modulus was enhanced up to 20% for 4wt% and 64% for 8wt% NK75 concentrations. The stretched nanohybrids showed enhancement in correlation length as the correlation length increased up to 12 in P-NK against 9 in pristine PET and induced orientational ordering in stretched nanohybrid. The oxygen permeability was reduced 38% for 4 wt% NK75 content and was predicted precisely by various theoretical models.

In ***Chapter 5*** the PET nanohybrids were prepared via solvent casting route using 30B nanoclay. The nanoclay was found to be homogeneously dispersed and high magnification TEM images showed existence of intercalation in P-B nanohybrid. The interactions of nanoclay and PET matrix were confirmed by shifting in carbonyl (C=O) peak as determined by FTIR analysis. Thermal properties were analyzed and nanohybrids were found to have identical T_g as pristine PET. The Young's modulus has increased 93% for 8 wt% of clay concentration with compromised toughness values. The experimental Young's modulus was predicted precisely using Halpin Tsai and Hui Shia models. An increment of 16% in microhardness was achieved as determined by Vicker hardness test. The MROM model predicted the experimental hardness values very precisely. Analysis of stress distribution in presence of nanoparticles of different shapes has been observed using ANSYS software and stress distribution in and around differently shaped nanoparticles was studied. The stretching of nanohybrid induced orientational ordering as determined by increased correlation length from 9 (pure PET) to 19 (P-B nanohybrid).

In ***Chapter 6*** the utilization of ABS with an existing and widely used polymer has been explored. The reactive extrusion of ABS (extracted from waste electronic equipments) has been done with the LDPE polymer with MA. MA content was optimized at 5% for reactive extrusion to attain the most desirable properties. The resulting chemical blend was found to have one-phase structure. The blend showed ~45% indicative crosslinking density as determined by gel content. The chemical blends were thermally stable whereas there was slight decrement in degradation temperature. The chemical blends showed improvement in Young's modulus of 246% and 29% increment in tensile strength. The flexural properties were improved as flexural modulus and flexural stress were enhanced by 160% and 80% respectively. The heat distortion temperature was determined to have an increment of 27% as compared to pure LDPE.

7.1 Scope for future work:

- Explore new nanofillers for further enhancement of PET properties.
- Explore new preparation techniques for PET hybrids.
- Utilization of ABS with other polymers in diverse ways.
- Utilization of other polymers present in E-waste.