I would like to dedicate this thesis to my family who has supported and encouraged me throughout this endeavor: Thank you for your love and support throughout my entire life and helping me to realize who I am today

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It is certified that the work contained in the thesis titled "**Structural, Mechanical and Gas Barrier Properties of Poly(ethylene terephthalate) Nanohybrids and E-waste Utilization**" by "**Dipti Saxena**" has been carried out under my supervision and that this work has not been submitted elsewhere for a degree.

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DECLARATION BY THE CANDIDATE

I, **“Dipti Saxena”,** certify that the work embodied in this thesis is my own bonafide work and carried out by me under the supervision of **“Prof. Pralay Maiti” (Supervisor)** from “July 2015 to June 2021” at the **“School of Materials Science & Technology”,** Indian Institute of Technology (BHU), Varanasi. The matter embodied in this thesis has not been submitted for the award of any other degree/diploma. I declare that I have faithfully acknowledged and given credits to the research workers wherever their works have been cited in my work in the thesis. I further declare that I have not wilfully copied any other’s work, paragraph, text, data, results, *etc*., reported in journals, books, magazines, reports, dissertations, thesis, *etc*. or available at websites and have not included them in this thesis and have not cited as my own work.

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Place: Varanasi *(Dipti Saxena)*

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABBREVIATIONS

AA	Acetaldehyde
ABS	Acrylonitrile butadiene styrene
AFM	Atomic force
BHET	Bis-(2-hydroxyethyl)-terephthalate
CAGR	Compound annual growth rate
CEC	Cation exchange capacity
C-M	Chemical mixture
CSD	Carbonated soft drinks
DCM	Dichloromethane
DMA	Dynamic mechanical analysis
DMT	Dimethyl terephthalate
DP	Degree of polymerization
DSC	Differential scanning calorimetry
EG	Ethylene glycol
EO	Ethylene oxide
FTIR	Fourier transform infrared spectroscopy
HDPE	High density polyethylene
HDT	Heat distortion temperature
LDH	Layered double hydroxide
LDPE	Linear density polyethylene
LLDPE	Linear low density polyethylene
MA	Maleic anhydride
MMT	Montmorillonite
NMR	Nuclear magnetic resonance spectroscopy
PA6	Polyamide 6
PE	Polyethylene
PEO	Poly(ethylene oxide)
PET	Poly(ethylene terephthalate)

PLA	Polylactide
P-M	Physical mixture
PMDA	Pyromellitic dianhydride
PMMA	Poly(methyl methacrylate)
POM	Polarized optical microscopy
PP	Polypropylene
PVA	Poly(vinyl alcohol)
SAXS	Small angle X-ray scattering
SEBS	Styrene (ethylene butadiene) styrene
SEM	Scanning electron microscopy
SSP	Solid state polymerization
TEM	Transmission electron microscopy
TGA	Thermo gravimetric analysis
TPA	Terephthalic acid
UTM	Universal testing machine
UTS	Ultimate tensile strength
wt. %	Weight percentage
WAXD	Wide angle X-ray diffraction
WEEE	Waste electrical and electronic equipment
XRD	X-Ray spectroscopy
µm	micrometer
mm	millimeter
nm	nanometer
T	Temperature
T_g	Glass transition temperature
T_m	Melting temperature
T_d	Degradation temperature
°C	Degree centigrade

PREFACE

Polyethylene terephthalate (PET) is a predominant polymer in the packaging industry because of its excellent properties. The need to make a light weight packaging material has driven the substitution of glass and metal packaging by polymeric materials. PET became a preferred packaging material due to its light weight, transparency, good mechanical strength, low permeability and recyclability. However, this extensively used packaging material gives a limited shelf life of the packaged goods and also has several limitations due to its other suboptimal properties. Hence, there is a constant need to further improve the mechanical strength, thermal stability and gas barrier properties of PET.

The PET is an environmentally safe material due to its high recyclability. However, there are numerous other polymeric materials which are produced as E-waste and have a vast potential to be reused for producing materials having improved properties. ABS is present in large portion of electronic equipment and contributes in a significant part of electronic waste (E-waste). This widely present ABS in E-waste gives opportunity to reuse and reutilize it.

Here in this work PET nanohybrids have been prepared using three different nanoclays namely NK75, nanotalc and Cloisite 30B. The preparation, structure and characterizations of different properties have been done in detailed manner. The nanohybrids have been prepared by solvent casting route having different clay concentrations. The dispersion and interactions of nanoclays with the PET matrix have been studied and the nanoclays have been found to be homogeneously dispersed in the PET matrix. Prepared PET nanohybrids have been tested for their thermal stability, mechanical properties, hardness, gas barrier properties as well as their structural advancement upon stretching. The different micromechanical models have been used to precisely predict the mechanical and gas barrier properties of nanohybrids. The structural changes upon stretching and effect of presence of nanoclays in PET matrix have been studied.

Further, the utilization of E-waste have been done by extracting waste poly(acrylonitrile butadiene styrene) (ABS) and using it in making polymer blend with polyethylene having improved properties. The blends have been prepared with different concentrations of maleic anhydride (MA) by melt compounding. The chemical blends have been characterized to have improved mechanical properties and found to be suitable for possible practical purposes.

This thesis has been divided in seven chapters. The first chapter is Introduction and literature review which gives the understanding about nanohybrids, problem of E-waste and its utilization along with detailed literature survey. The second chapter presents the different experimental techniques used for the characterization. The third chapter "Structural, mechanical and gas barrier properties of poly(ethylene terephthalate) nanohybrid using nanotalc" (work published in *Journal of Applied Polymer Science, (2020): 137(27), 48607*) presents the PET nanohybrids and their characterizations having nanotalc as filler. The fourth chapter "Effect of addition of NK75 nanoclay on properties of PET/clay nanohybrid" (work published in *Journal of Polymer Research, (2020): 27(2), 1-9*) discusses the preparation and characterization of the PET nanohybrids using NK75 nanoclay. The fifth chapter, "Enhancement in properties of PET/clay nanohybrids using 30B nanoclay" (work published in *SN Applied Sciences, (2019): 1(11), 1-11*) gives the preparation and characterization of PET/30B nanohybrids. The sixth chapter, Utilization of E-waste by single-step reactive extrusion (work published in *Polymer, (2021): 221, 123626*) presents the utilization of ABS extracted from E-waste to prepare a polymer blend having improved properties. The last chapter presents the major conclusions drawn from this work and suggestions for the future work in this field. The reference work is given at the end.