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Studies on Mechanical, Thermal, Eletrical Properties and Characterisation of Recycled PET with ABS Compatibilized By Glycerol

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Abstract: *The present study includes compounding of RPET with ABS and evaluation of the properties of the blends. Recycled PET was melt mixed with ABS (10, 20, 30 wt%) using a Twin-screw extruder and Glycerol as compatibilizer (2%). The RPET/ABS blended materials were tested to find their mechanical, thermal and electrical Properties. In mechanical properties impact strength was improved and flexural strength & flexural modulus were lowered as ABS concentration increases. HDT also increased. The electrical properties were increased for 10% & 20% ABS and then decreased for 30% ABS blended with RPET. The SEM results show the ABS is found to be partlially miscible in the RPET in presence of glycerol for all compositions.*
Key Words: *RPET, ABS, Melt blending, Mechanical /Electrical properties, HDT, MFI, SEM*

I. Introduction

PET (Poly ethylene-terephthalate) is fully recyclable and may be used for manufacturing of new products in many industrial areas such as packaging for detergents, cosmetics, high-quality carpets, foils, car spares parts and fabrics. Its versatility in many industries therefore makes it irreplaceable. The Recycled PET(RPET) also has similar characteristics like PET and is enormously available as PET bottles (mineral water & soft drink packaged bottles) (1).

Acrylonitrile-Butadiene- Styrene is a hard and tough thermoplastic co-polymer. It is made by the combination of acrylonitrile, butadiene and styrene. ABS is amorphous and therefore has no true melting point. The proportions can vary from 15 to 35% acrylonitrile, 5 to 30% butadiene and 40 to 60% styrene. ABS can be used between −20 and 80 °C (−4 and 176 °F) as its mechanical properties vary with temperature. Many plastics alloys & blends are reported based on PET and ABS (2) with maleic anhydride graft ABS compatibilizers (3, 4). The morphology-property relationships in ABS/PET on compositional effects (5) and on the influence of processing conditions (6) are reported in the literature.

Glycerol is a simple triol compound. It is a colourless, odourless and viscous liquid that is widely used in pharmaceutical formulations. Glycerol has three hydroxyl groups that are responsible for its solubility in water and its hygroscopic nature. In this study we used glycerol as compatibilizer. These post consumer PET bottles are very cheaper; so, the blends of ABS with Recycled PET will also be cheaper.
The impact strength of Recycled PET is lower. Hence it was desired to improve the impact strength of Recycled PET by blending with impact modifier like ABS. R-PET is slowly hydrolysable at normal temperature and fastly hydrolysable above 60 °C and hence bio-degradable. It is well known that ABS is photo-degradable in presence of UV light and after Photo degradable the degraded ABS fragments will be bio-degradable (7). Hence R-PET/ABS blend will be Photo/bio-degradable. In this study, the mechanical, electrical, thermal & physical properties are evaluated on Recycled PET-ABS blend materials.

II. Experimental Work

2.1 Materials

Commercially available injection mouldling grade ABS (COA/2557) has been procured from INEOS ABS (India) Ltd, QA Laboratory. And the properties of which are given in the Table 1. RPET granules are collected from a Local PET scrap grinder and the properties of which are given in the Table 2. Glycerol was obtained from Diucon Lab chemical supplier and used as compatibilizer. The properties of which are given in the Table 3.

Table 1 Properties of ABS

Polymer	MFI (gm/10min)	Density(g/cc)	Tensile Strength(Mpa)	HDT(°C)0.46 MPa
ABS	28	1.04	47	98

Table 2 Properties of RPET

Polymer	MFI (gm/10min)	Density(g/cc)	Tg (˚c)	Processing temperature (°C)
RPET	73	1.24	80	140-250

Table 3 Properties of Glycerol

Compatibilizer	Density(g/cm³)	Melting Point (°C)	Viscosity (Pa·s)	Boiling Point (°C)
Glycerol	1.26	17.8	1.412	290

2.2 Twin screw compounding

The granules were initially dried for 4hrs at 80°C. The RPET material was blended with ABS in three formulations such as 10%, 20% and 30% with compatibilizer glycerol 2%. Initially high speed mixing of RPET + Glycerol + ABS was done for 5 minutes and then using a twin screw extruder (Berstorff, FRG) with temperature range of 175 to 230^{o}C melt blending was done. The extrudate was cut in the cutter to make granules. These granules were injection moulded into tensile, flexural, impact and HDT test specimens using an injection molding machine with temperature range 175 to 260 ^{o}C. Testings were conducted as per ASTM standard (8).

2.3 Testing

Test specimens were prepared by using an injection molding m/c, SP 130 Windsor for the mechanical, electrical and thermal properties as per ASTM standards (8). The Tensile strength test was done using a UTM (Universal Testing Machine) Lloyd, LR l00k as per ASTM D638 Type I specimen, using 50 mm/min Test speed. The flexural strength was done as per ASTM D790, using the same UTM, with Flexure fixture. The Test speed is 2.8 mm/min. The Test specimen size 127x12.7x6.4 mm. The Izod impact test is done by using Ats Faar m/c, Italy as per ASTM D256 Standards. MFI (Melt Flow Index) test was carried out as per ASTM D1238 standards using Lloyd (UK). The Volume and surface resistivity Tests are carried out as per ASTM D257 Standards using 110mm dia disc with thickness 3-3.2mm with a Mhometer(USA). The Arc resistance was carried out as per ASTM D495 standard with an arc resistance tester (Ceast, Italy)..

III. Results And Discussion

3.1 Mechanical properties

3.1.1 Tensile properties (ASTM D 638)

The tensile strength and elongation test results of RPET / ABS at different composition are given in Table 4. Tensile strength was decreased from 310 to 233 Kg/sq.cm (Figure 1) and elongation little increased from 2.17 to 6.01% as the composition of ABS increases. The reduction in tensile strength and elongation may be due to the poor interaction between the two polymer matrix even though both polymers are polar materials. PET is known to be hygroscopic thermoplastic material absorbing moisture easily. Thus optimum drying condition is very crucial prior to processing. Moisture content in polymer promotes degradation while processing leading to a breakdown of molecular weight which in turn affects final product properties. Hence the tensile strength was decreased.

Table 4 Tensile properties of RPET/ABS Blends

Composition(By Wt %)		Tensile Strength	Elongation at break
RPET	ABS	(Kg/sq.cm)	(%)
100	0	310	2.17
90	10	273	4.16
80	20	245	4.48
70	30	233	6.01

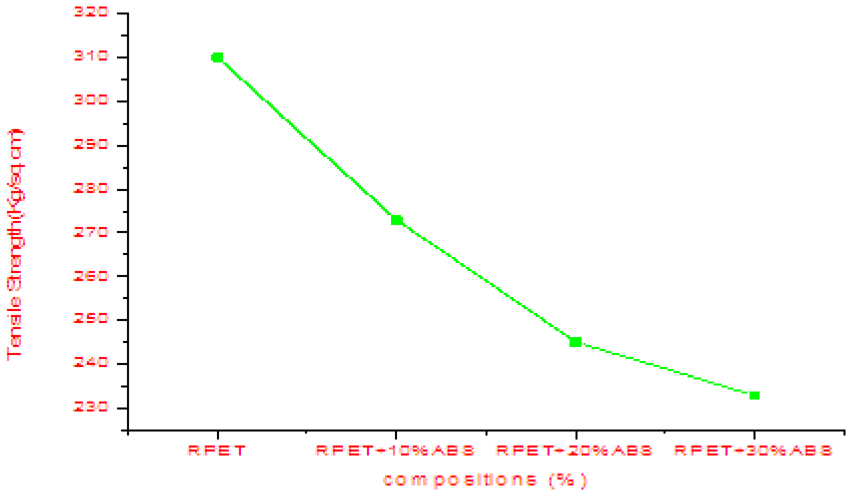

Figure 1. Tensile strength: of RPET/ABS Blends

3.1.2 Flexural properties (ASTM D 790)

The flexural strength test results of RPET/ABS blends are given in Table 5 which show that the flexural strength decreased from 602 to 445 Kg/sq.cm. There is a decreasing trend in Flexural strength. The decrease in flexural strength and modulus is due to the lower strength and modulus of ABS polymer.

Table 5. Flexural properties of RPET/ABS Blends

Composition (By Wt %)		Flexural Strength (Kg/sq.cm)	Flexural Modulus (MPa)
RPET	ABS		
100	0	602	2951
90	10	474	2638
80	20	455	2603
70	30	445	2471

3.1.3 Impact properties (ASTM D 256)

The impact strength test results of RPET/ABS blends at different concentration of ABS loadings are given in Figure 2. As per the data, it was found that impact strength of RPET/ABS blends for all composition were increased. This is due to the higher impact strength of ABS plastics due to Poly butadiene units.

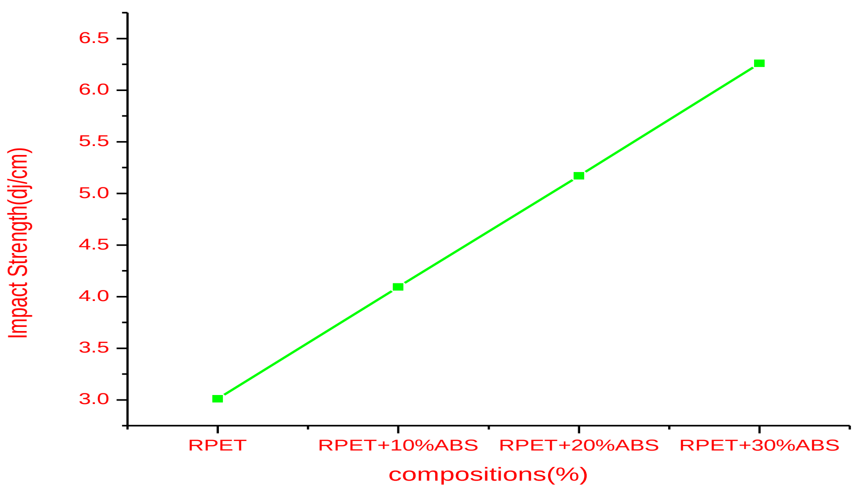

Figure 2. Impact strength of RPET/ABS Blends

3.2 Physical properties

The physical properties like density and surface hardness for RPET/ABS at different ABS loadings are depicted in Table 6. In case of density, there is only a marginal decrease in density from 1.35 to 1.23

gm/cc with addition of glycerol since the ABS has lower density than that of RPET (Table 1 &2). Similarly Hardness was also lowered.

Table 6 Density, Rockwell Hardness of RPET / ABS Blends

Composition (By Wt %)		Density (gm/cc)	Surface Hardness (R Scale)
RPET	ABS		
100	0	1.35	78
90	10	1.27	77
80	20	1.24	76
70	30	1.23	75

3.3 Thermal properties

Heat Deflection Temperature (ASTMD 648):

The heat deflection temperature of the RPET/ABS blend have been determined and tabulated and shown in the Table 7. The addition of ABS in the blend at different compositions (10%, 20% & 30%) shows that the heat deflection temperature increases in as concentration of ABS increases; because ABS has higher HDT (98 °C) value than the HDT value of RPET (62 °C) (Fig 3).

Table 7. Heat Deflection Temperature of RPET/ABS Blends

Composition (by Wt %)		Heat Deflection Test (°C)	Melt flow index
RPET	ABS		gms/10 min
100	0	62	73
90	10	74.9	62
80	20	76.7	42
70	30	79.5	32

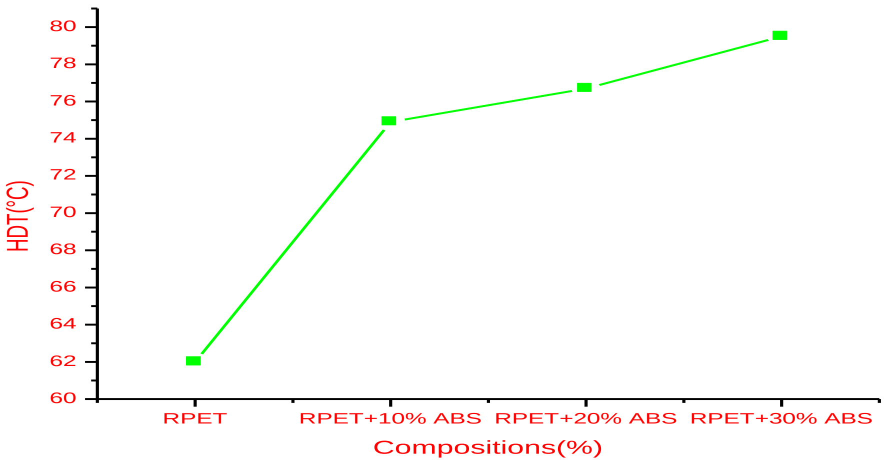

Figure3. HDT of RPET/ABS Blends

3.4 Electrical properties

The Electrical properties results of RPET/ABS composites at different ABS loadings are given in Table 8. So the Electrical properties like volume resistivity and surface resistivity (as per ASTM D257) were increasing than that of RPET and then lowering. Also the Arc resistance (as per ASTMD 495) was first increasing than that of RPET and then lowering. Upto 20%, the compatibility may be higher and then lower.

Table 8. Electrical Properties of RPET/ABS Blends

Composition (By Wt %)		Surface resistivity Ohm-cm	Volume resistivity Ohm-cm	Arc resistance Sec
RPET	ABS			
100	0	$3.86x10^{12}$	$4.94x10^{13}$	174
90	10	$5.26x10^{12}$	$6.60x10^{13}$	185
80	20	$4.82x10^{12}$	$6.18x10^{13}$	177
70	30	$3.86x10^{12}$	$2.41x10^{13}$	153

3.5 Rheological properties

3.5.1 Melt flow index (ASTM D 1238)

In case of MFI, the composition of RPET/ABS decreases MFI from 72 to 32 g/10 min. The decrease in melt flow is due to the high viscous nature of ABS. Figure 4 shows the values of melt flow index properties of RPET/ABS blends at different ABS loadings**.** RPET has lower melt viscosity and has higher MFI. AS ABS concentration increases the MFI decreases. Hence the injection pressure will be higher and the processing cost will also be higher.

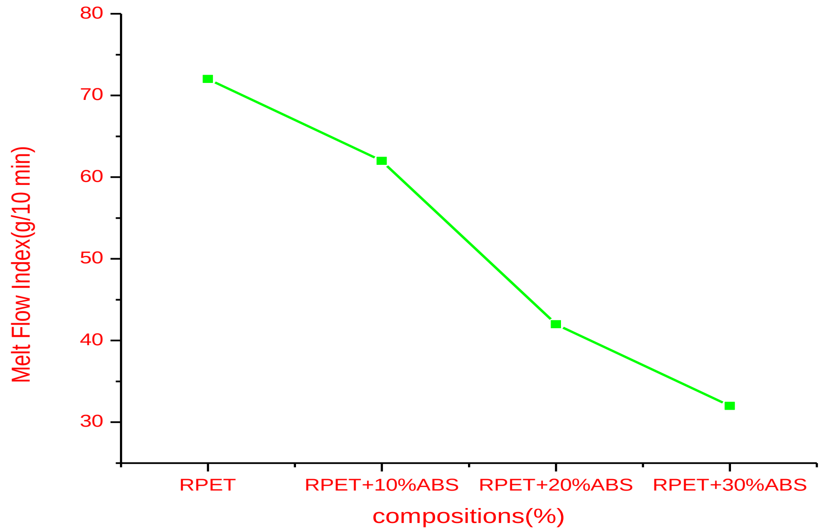

Figure 4. MFI of RPET/ABS Blends

3.6 Characterization

3.6.1 Scanning Electron Microscopy

The morphology of prepared blends were investigated using scanning electron microscope (SEM) (fig 5,6,7). SEM images of fractured surface of impact specimen revealed non- uniform mixing of ABS in RPET resin matrix due to melt blending done by using twin screw compounding extruder even though both polymers are polar. ABS is found to be partly miscible in the RPET in presence of glycerol for 20 and 30% ABS compositions. Therefore, the mechanical property impact strength was increased. Also the HDT was increased.

There are little voids in 10%ABS blended with RPET. In 20% and 30% there are more voids like structures which may be due to foaming of the moisture present in the RPET. Hence it looks like the ABS is not uniformly dispersed in RPET matrix. The compatibilization may be improved with other compatibilizers like SMA and MAn graft co-polymers (3, 4) or by drying the R PET materials for little longer time.

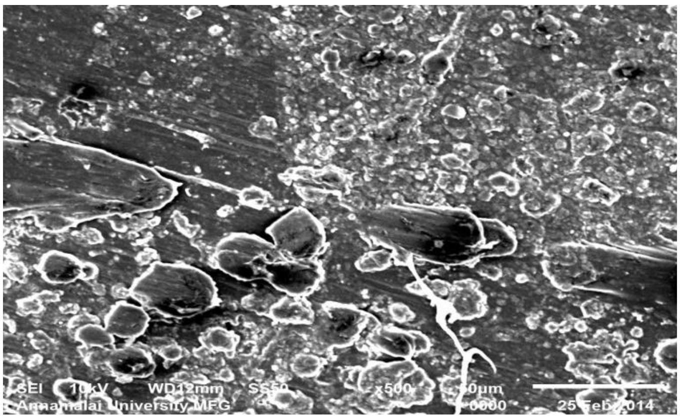

Figure 5 SEM images of RPET with 10% ABS blend

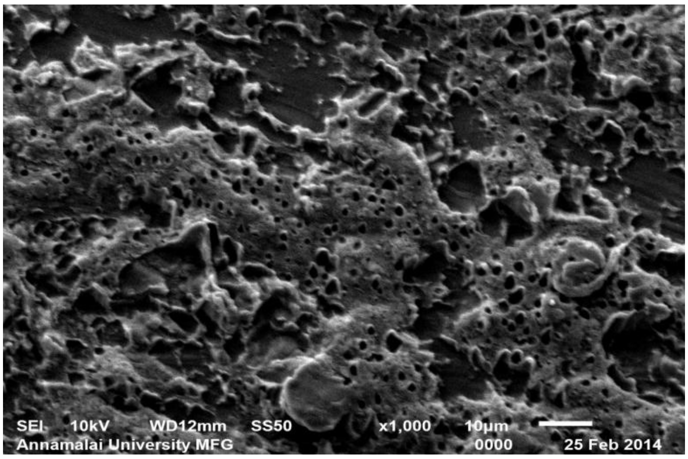

Figure 6 SEM image of RPET with 20% ABS blend

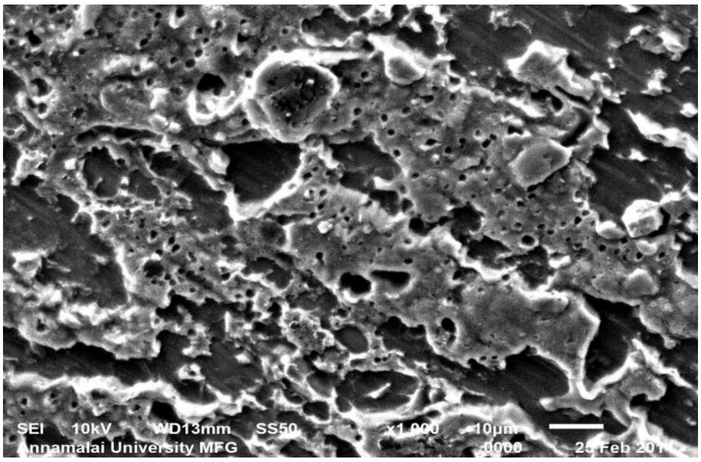

Figure 7 SEM image of RPET with 30% ABS blend

IV. Conclusion

The RPET/ABS has been successfully blended into different composition like 10%, 20%, 30%. The blends were evaluated for their mechanical, thermal and electrical properties. In mechanical properties impact property was improved but flexural strength & flexural modulus were lowered as an ABS concentration increases and HDT also increased. The tensile strength was much lowered. The electrical properties were increased for 10% & 20% ABS concentration and then decreased. The SEM results show the ABS is found to be partlially Compatible in the RPET in presence of glycerol for all compositions. The compatibility may be improved with other compatibilizers like SMA and Maleated co-polymers (3, 4). RPET/ABS blends will be Photo/bio-degradable in presence of UV light and micro –organisms and hence eco-friendly.

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