PET as a plastic substrate for the flexible optoelectronic applications

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In this paper, different techniques are used for characterization the structural, thermal and optical properties of the polyethylene terephthalate (PET) substrate. The PET substrate was characterized by X-ray diffraction (XRD), energy dispersive X-ray (EDX), differential scanning calorimetry (DSC), thermogravimetric analysis (TGA), atomic force microscopy (AFM) and UV spectrophotometer, respectively. X-ray diffraction patterns confirm the proper phase formation of the material. The high transmission in the visible range makes this PET substrate suitable and useful such as optoelectronic and other thin film applications.

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1. Introduction

Polyethylene terephthalate (PET) is an excellent commercial thermoplastic polymer resin of the polyester family. PET can be semi-rigid to rigid, depending on its thickness, and is very lightweight. PET can be aluminized by evaporating a thin film of metal onto it to reduce its permeability and to make it reflective and opaque (MPET). PET substrate has attracted interest in a wide array of fields because of its low cost, good thermal stability, surface inertness, good spin ability and excellent moisture resistance [1, 2]. PET was given serious consideration as flexible display film materials in various display technologies such as organic light emitting displays and resistive touch-screens. The most important reasons are that they exhibit satisfactory optical properties with optical transmission higher than 85% in the visible range and also they are mechanically flexible under bending or buckling conditions [3]. During service conditions, the PET display substrate, which serves as the interface between the user and the machine, can be susceptible to repetitive scratching, intensive in the case of inexperienced users. Particular applications such as electronic touch drawing pads, where a ball-pen is used in order to make contact with the screen, must exhibit high mechanical. It is therefore apparent that the substrate properties of such films need to be fully understood in order to minimize deficiencies during manufacturing and in service [4-6].

In this study, different experimental methods were used to investigate the structural, thermal and optical properties of PET substrate.

2. Experimental detail

In this experiment, a 250 μm thick PET from Penfibre Sdn. Bhd. (Film Division) was used. The PET substrates were first cleaned by full immersion in Decon 90 for 10 minutes to remove contamination. After the cleaning process, all of the substrates were rinsed with deionized water (DIW) to remove the Decon 90 residue. The samples were then dipped in isopropyl alcohol (IPA) and agitated with moderate ultrasonic power for 10 minutes. The samples were again dipped in DIW and then dried off with nitrogen (N_2) gas after the ultrasonic cleaning. The PET substrate thickness was measured by optical reflectometer (Model: Filmetric F20). The optical transmittance of the PET substrate was measured by UV Spectrophotometer (Model: U-2000 HITACHI). HR-XRD (PANalytical X'pert Pro MRD) with CuKα1 radiation source (λ= 0.154 nm) was used to determine the crystalline quality of the samples. The compositions of the PET substrate were estimated with energy dispersive X-ray analysis (EDX) (Model JSM – 6460 LV). The surface morphology of the PET substrates was studied by AFM (model: Ultra Objective). Differential scanning calorimeter (DSC 822e METTLER TOLEDO) and thermogravimetry analyser (TGA) techniques were used for the investigation of thermal properties of PET substrate.

3. Results and discussion

3.1 Thermal properties

The PET substrates were investigated by DSC under dry nitrogen at a heating and cooling rate of 5 ºC per minute from 20 to 250 ºC. The thermo-scan profiles were sketched in Fig. 1 for PET substrate.

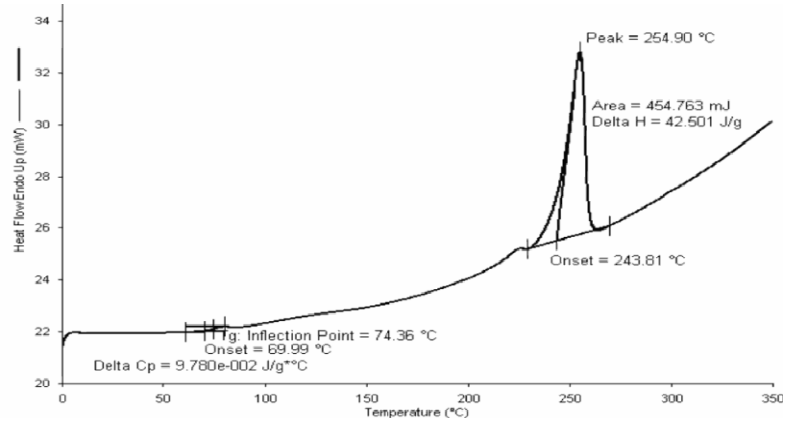

Fig. 1. DSC spectrum of PET substrate.

From Fig. 1, it can be found that the PET substrates have high melting point temperature, generally greater than 254 ºC. This value indicates that the incorporation of PET by promoted the thermal stability. Nevertheless, from the result of PET temperature measurements it can be recognized that PET obvious higher enough for optoelectronics applications.

The thermal properties of the PET substrate compounds were examined by thermogravimetric analysis under dry nitrogen atmosphere over a temperature range of 35 to 800ºC with a heating rate of 5 ºC per minute. The obtained results of differential thermogravimetric analysis of PET substrate are shown in Fig. 2.

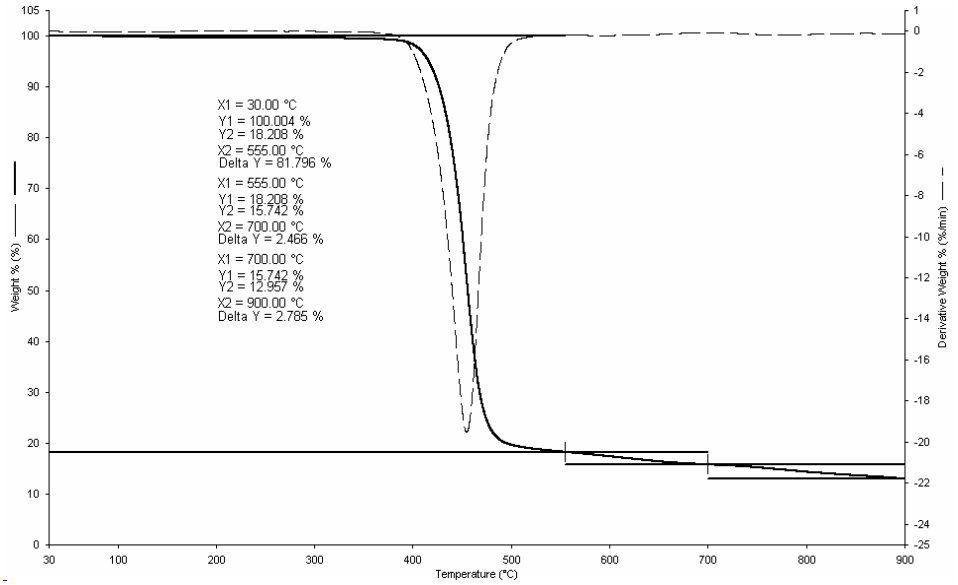

Fig. 2. The thermogravimetric data of PET compounds.

The Fig. 2 showed that temperatures of all PET substrate compounds are stable up to at least 451ºC under the above mentioned conditions. The PET substrate compounds display small percentage of weight loss at temperatures below 455°C. This weight loss in the PET substrate compounds may attribute to the loss of water molecules trapped inside the PET substrate samples. The obtained value of weight loss is 2.466 % between 455-900 °C, corresponding to loss of one coordinated water per formula unit. After losing incorporation water, PET substrate compounds, are still stable until about 300 °C after which these complexes undergo decomposition. This increase in the thermal stability can be attributed to the high thermal stability of PET substrate compounds.

3.2 Structural properties

The main peak corresponding to the PET substrate was observed at 2θ angle 26 0, as seen in Fig. 3, it has

very high intensity. This behaviour is in agreement with that reported in the literature [7-10].

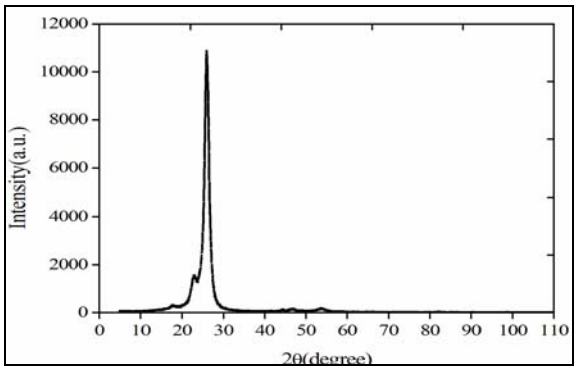

Fig. 3. XRD patterns of PET substrate.

Fig. 4 shows the EDX results of the PET substrate.EDX analysis confirm the composition of C and O in the PET substrate. These results are in good agreement with XRD data.

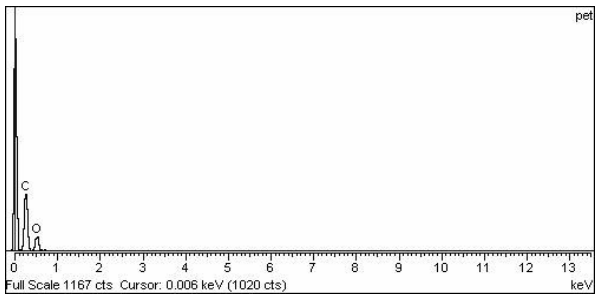

Fig. 4. Shows EDX spectrum of the PET substrate.

AFM image for surface morphologies of PET substrate is given in Fig. 5. The root mean square (RMS) for PET substrate is 13.57 nm. The surface of the PET substrate was smooth.

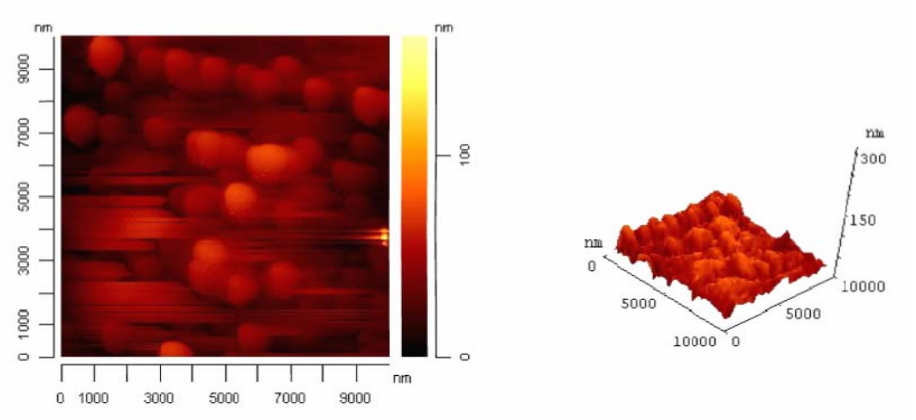

Fig. 5. AFM analysis of PET substrate.

3.3 Optical properties

Fig. 6 shows the optical transmission of PET substrate. High transmission in the visible range was observed for the PET substrate. The average transmission of the PET substrate in the visible range is about 87%. The high transmission in the visible range makes this PET substrate suitable and useful such as optoelectronic and other thin film applications.

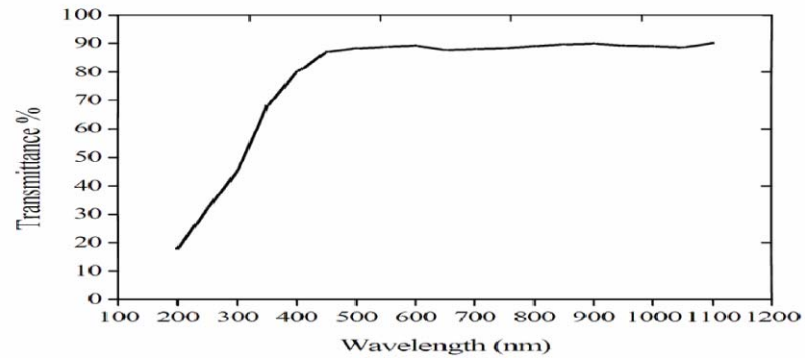

Fig. 6. Optical transmission of PET substrate.

4. Conclusion

In the present study, different techniques have been used for characterization of PET substrate. These techniques have been used to analyse the important properties of PET to be more suitable and useful in certain applications such as optoelectronic and other thin film applications. The surface morphology and optical transmittance of PET substrate have been reported. High quality films on PET substrate give the possibility to use as alternative substrates to the conventional glasses.

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