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EFFECT OF POLYETHYLENE TERPHALET (PET) ON MECHANICAL AND OPTICAL PROPERTIES OF POLYLACTIC ACID (PLA) FOR PACKAGING APPLICATION

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Abstract: Blends of polyethylene terphalet (PET) with polylactic acid (PLA) were investigated to study the influence of the additive of PET on (tear, impact strength) and (transparency, color). The compositions were prepared in wt (20/80), (50/50), (80/20). Mechanical properties like tear strength and Impact Izod, and optical properties like colors and transparency were also reported. Polyethylene terphaletee decrease the tear strength when additive PET and Impact Izod strength of PLA was increased when additive PET when tested in the machine directions. Optical property such as colors was increased and the value of transparency was decreased as the loading of PET increased.
Keywords: PET, PLA, tear strength, impact strength, color and Transparency

INTRODUCTION

Poly(lactic acid) (PLA) is known a biodegradable to be a useful material in substituting the conventional petroleum-based polymer used in packaging, due to its biodegradability and used as alternatives polymers for conventional plastics such as polyethylene PE), polypropylene (PP), and polyethylene terephthalate (PET). Because biodegradable plastics used for manufacturing packagings application are predominantly made from renewable raw materials such as, starch-based plastics, polylactide (PLA) [1].

Poly(lactic acid),is a linear aliphatic polyester, are made from lactic acid monomers produced by condensation polymerisation of lactic acid. Ultimately made from lactose (or milk sugar) derived from renewable plant sources, such as starch and sugar. The building block of PLA is lactic acid (2-hydroxypropionic acid) which can exist as optically active D- or L-enantiomers. PLA has found many applications in the packaging, medical and automotive industries. PLA possesses high strength, good crease-retention, grease and oil resistance and excellent aroma barrier properties [2]. From packaging field PLA is used for food trays, water bottles and flexible packaging and also applications for PLA are constantly being identified, and the automotive industry has begun producing interior and exterior car parts from biodegradable polymers [3]. PLA is biomaterials and composted to water and CO_2 that useful in future with the potential to replace conventional petrochemical-based plastics such as polyethylene terephthalate (PET) that used in packaging. PLA stiffness is similar to that of PET but major limitations of PLA are due to its high brittleness, low toughness and low tensile elongation (because that percentage elongation at break (6- 10%). There is very limited available information on the mechanical properties such as tear resistance test, elongation and impact strength of PLA [4].

PLA will degrade approximately six weeks or one year's this is advantages of PLA when compared to PET. PLA has a tensile modulus of about 2-3 GPa, which is considerably higher. PLA products are more brittle compared with PET or PVC packaging and low impact resistance therefore PLA may be more brittle than desired is some applications [5].

Polyethylene terphalate (PET) is being widely used in packaging applications. PET is a linear thermoplastic made from ethylene glycol and terephthalic acid, or ethylene glycol and dimethyl terephthalate [5]. PET is used in many rigid food and beverage containers due to a good balance of physical and mechanical properties,

barrier properties, processability and formability, toxicological and ecological, and economics [6,7].Its excellent mechanical strength and, consequently and transmission is one of the most abundant plastics in solid urban waste. In order to minimize the huge environmental problem created by this non-biodegradable plastic waste [8].

Most of the physical and mechanical properties of PET improve as the molecular weight increases is a hard, stiff and strong material with a decent resistance to degradation upon exposure to chemicals PET. Some of the polymer blend approaches show promise, the options become limited when the biomaterials carbon content and comptability of the blend are deemed important [9].

Tear strength is one of the most important properties for the packaging application films. Tear resistance as determined is a measure of the force necessary to primitive e tearing in materials films tapes. This is contrasted with other methods which measure the force necessary to propagate a tear after it has been initiated. Tear resistance in plastic film tapes indicates how well-integrated the material will remain when it is used to conform to irregular shapes under tensions which vary across the width of the applied strip [9, 10].

Tear strength measured by the ASTM D-412 method (as a same used measure the tensile strength, modulus and elongation of plastics materials), that mean measure the resistance to the formation of a tear (tear primitive) and the resistance to the expansion of a tear (tear sperated) on films. In any case of which of these two is being measured, the sample is caught between two holders and a uniform pulling be force applied until the aforementioned deformation occurs. Tear strength is then calculated by dividing the force applied by the thickness of the material.

Impact strength is defined as the absorbing of energy before failure or is a measure of the work done to break a test specimen. When the striker impacts the specimen, the specimen will absorb energy in KJ until it yields. At this point, the specimen will begin to undergo plastic deformation at the notch. The test specimen continues to absorb energy and work hardens at the plastic zone at the notch. When the specimen can absorb no more energy, fracture occurs that test vary important in packaging application.

In this research, PET was chosen as a polymer for rapprochement with PLA as its visibility ease of processing and favorable mechanical properties make it one of the most widely used polymers in the food packaging industry parallel, with PET the main damage, of PLA with respect to material properties are primarily associated with its brittleness. Goal is to improve tear resistance and impact strength has been developed

impact resistance agents, compatible with the same PLA blend with PET.

MATERIALS AND METHODS

» **Materials**

Lactic acid (99.9%), Tin chloride dehydrated ($SnCl_2.2H_2O$) P-toluene sulfonic acid (TSA), were purchased from Fluka. Methylene Chloride was purchased from Sigma-Aldrich

» **Preparation of pure Polylactic acid**

The reaction was conducted in 250ml, two necked flask reactor armed with a magnetic stirrer and a reflux condenser .200 gm of aqueous solution of lactic acid acid was mixed with methylene chloride for 8hrs at refluxed temperature without any catalyst .After the removal of water of the condenser , the reaction vessel was cooled at 60°C, the required amount of catalyst $SnCl_2.2H2O$ (0.5wt%), TSA(0.4wt%) were add and this was followed by slow heating of the reaction blend to the refluxing temperature of the solvent under mild stirring with the help of magnetic stirring bar.

The temperature gradually increased to 140°C in 2 hrs, and the reaction mixture was stirred continuously. Polymerizations are done at 120-160°C for 5hrs. At the end of the reaction, the flask was cooled, and the product was dissolved in chloroform and subsequently precipitated in methanol. The resulting solid was filtered and dried under vacuum at 60°C under vacuum at 24hrs. Powder PLA weighted grade (1wt%) by using electronic balance of four digits type (Sartorius H51) and then dissolved in chloroform to obtain 20 wt% solution of PLA grade by slowly in 60°C for 3 hours warming until the solution become viscous using magnetic stirrer hot plate, then cast into petri dish at field temperature for 24 hour to ensure perfect solvent removal.

» **Preperation of Polyethylene terphatalete /Polylactic acid blend**

PLA was dehydrated in an oven at 70 °C for 4 hours to reduce humidity. All blends of each PET/PLA(20/80) (50/50), (80/20) blends were mixed using an internal mixer (Hakke Rheomix, 3000p) at temperature of 170°C with a rotor speed of 60 rpm for 10 min. Compression molding (LabTech, LP20- B) were used to set up the samples. The fusion temperature of 165 °C and form temperature of 25 °C were used.

» **Tear Test**

Tear intensity of films was calculated on the same Universal Electronic Dinamometer above indicated. The test was load out according to ASTM D-1922 standard, using the trouser tear method. The sample size was 100 mm long and 40 mm wide having a cut of 50 mm at the center of one end. The experiments were made at 180 mm/min extension rate. A pendulum impact tester is used to measure the force wanted to propagate slit a stable distance to the end of the test model. One use of

these results would be for the designation of materials and thickness for plastic samples used in packaging

» **Impact Izod Test**

The Izod impact testing was perfect on the same impact tester (GT-7016-A2, Gotech Testing Machines, Taiwan) with maximum hammer energy of 4 J. Geometry of the specimens condition to ASTM D256 standard method of calculated the impact resistance of materials. An arm held at a specific height (constant potential energy) is freed, the arm hits the sample and the specimen either fracure or the weight break on the specimen. From the energy absorbed by the sample, its impact energy is planned. A notched sample is generally used to determine impact energy and notch softness.

» **Color Test**

Color advantage were predestined measuring color assortment in the CIELAB color space L* (lightness), a*(redness and greenness) and b* (yellowness and blueness) were analyzed using a KONICA CM-3600d COLORFLEX-DIFF2. The tolls were check with a white standard tile. Measurements were take out in quintuplicate at passing positions over the samples surface. Average values for samples were studied. Total color differences (ΔE) was evaluated by Equation (1)

$$\Delta E = \sqrt{(\Delta a^2 + \Delta b^2 + \Delta L^2)} \qquad (1)$$

where $\Delta L = L_{stander} - L_{sample}$, $\Delta a = a_{stander} - a_{sample}$, $\Delta b = b_{stander} - b_{sample}$,

Stander rate for white sheet were L = 96.86, a = - 0.02 and, b = 1.99 respectively. Five measurements were possessed on each film, one at the center and four around the surrounding, and the mean values were used.

» **Transparency**

Transparency of the samples was calculated by scale the percent transmittance at 600 nm using a UV- visible spectrophotometer Shimadzu UV.

RESULTS AND DISSECTION

» **Tear strength**

Generally plastic sheet with a property of brittleness will have very low tear strength, since neat PLA is a vary brittle material it shows tear strength is 0.11N and tear resistance was obtained dividing the tear strength by the thickness of neat PLA is 3.1 N/mm that appear in Table (1). That mean low tear resistance tend to have poor resistance to abrasion and when damaged will quickly fail.

Table 1: Tear Resistance of neat PLA and PLA blend

Materials	Tear Strength (mPa)	Tear Resistance (N/mm)
Neat PLA	0.11N	3.1
PET/PLA 0/80	0.23	4.3
PET/PLA 0/50	0.45	5.18
PET/PLA 0/20	0.76	6.25

In blend PET /PLA films shows better performance in tear propagation than neat PLA because that PET has better ductility, good strength, stiffness, and hardness this is an important issue of food packaging applications.

» **Impact Izod Test**

Polylactic acid is brittle materials have lower impact stregths, while Poly ethylene terphalate have one of the highest impact impedance values that mean PET is a rigid materials absorb a lot of energy, while brittle materials tend to absorb very little energy before to damage .

Table (2) showed the impact strength of neat PLA and PET/PLA blend, the results showed that the impact strength of neat PLA was 3.5 KJ/m². The impact strength of the blends was insignificantly changed and increasing to became 6.25 KJ/m²

Table 2: Impact strength of neat PLA and PET/PLA blend

Materials	Impact strength (KJ/m²)
Neat PLA	3.5
PET/PLA 20/80	4.3
PET/PLA 50/50	5.18
PET/PLA 80/20	6.25

» **Color**

Color is leading factors to be look in food packaging since it could affect consumer agreement and commercial prosperity of a food output. Show Table (3) the some differences in the CIELAB coordinates L* (lightness), a*(red-green) and b* (yellow-blue) and ΔE between neat PLA and   PLA/PET blends.

Table (3) Color parameter of neat PLA and PLA/PET blend

Sample	L*	a*	b*	ΔE
Neat PLA	94.05	1.01	1.31	-
PET/PLA 20/80	94	0.98	1.27	0.26
PET/PLA 50/50	93.85	0.95	1.22	0.35
PET/PLA 80/20	93.12	0.91	1.20	1.24

Table (3) shows the results obtained from the colorimeter analysis. When polyethylene terphalete is additive to the film, a slight low in lightness values (L*) was noticed. However, PLA and also both PET/PLA blends presented high L* values showing their high brightness. Furthermore, no major differences were set for full color difference values.

This result suggested high transparency for samples containing PET and the chance to see out of the film is one of the most important requirements for consumers. Negative values obtained for a* coordinate are indicative of a deviation towards green. However, these data are close to zero so the green tone was not apparent. Positive values obtained of b* match point a slight deviation towards yellow.

» **Transparency**

Transparency is an important property of Packaging films used in food application. Transparency was calculated by equation (2)

$$Transparency = A600/t \qquad (2)$$

Where A600 Absorbance at 600 nm and t thickness at mm of samples.

Table (4). Transparency of neat PLA and PLA/PET blend

Sample	T %
Neat PLA	80
PET/PLA 20/80	78
PET/PLA 50/50	75
PET/PLA 80/20	74

Neat PLA showed the maximum transparency specific of the high brightness of PLA films. The additive of PET no significant differences between PET and PLA were observed.

CONCLUSIONS

PLA is a promising biodegradable polymer for use in food packaging .However, because of its inherent brittle behavior need to be blended with PET for some specific applications in particular production of films .In the present have shown a good improvement in tear and impact strength to make them useful for this particular application.

The PLA has been receiving a great deal of attention, essentially due to its degradability and biomaterials. With this environmental-friendly property, along with a highly transparent appearance similar to that of polyethylene terephthalate (PET), PLA has undoubtedly become one of the most promising alternatives to non-biodegradable synthetic polymers conventionally derived from petroleum-based chemicals.

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