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Study on Printing Performance of Degradable Polylactic Acid Film Packaging Material

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Abstract

In this paper, the PLA resin of Ingeo 4032D from Nature Works(USA) is selected as the research object. Linear Low Density Polyethylene (LLDPE) or EPDM rubber grafted glycidyl methacrylate (EPDM-g-GMA) is selected for PLA blend modification. At first, the mixture was granulated in an extruder and then blown to obtain various films. The mechanical properties, optical transparency, barrier properties, contact angle and printability of the polymer film were measured. The results show that through the modification, without loss of transparency, the mechanical properties, barrier properties, polarity of the surface and the adhesion of the printing code of the PLA film are improved, which is beneficial to the solution of environmental pollution caused by the undegradable of current plastic film.

1.Introduction

Polylactic (PLA) resin is a biodegradable polymer material prepared by polycondensation reaction using lactic acid as the main raw material [1], which can be extracted from natural renewable resources such as corn and wheat. The production process has no pollution and the production energy consumption is only equivalent to 20% to 50% of the traditional petrochemical products while the carbon dioxide gas produced is only 50%, which can get rid of the dependence on oil resources [2]. After being discarded, PLA products can be decomposed in the natural environment and eventually degraded into water and carbon dioxide, without any pollution to the environment and realizing its circulation in the natural world. It is considered to be the most widely used type of biodegradable polymer material and has received wide attention in recent years.

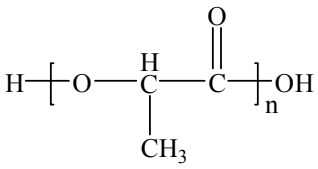

Fig1. Structural formula of PLA

PLA resin is a thermoplastic aliphatic polyester, whose glass transition temperature and melting point are about 60°C and 175°C, respectively [3] while the processing temperature is generally controlled between 170°C and 230°C which Suitable for extrusion, blow molding, Stretching and other processing processes. In food packaging, PLA film has physical properties equivalent to other films such as polyethylene, good crystal transparency, moisture resistance, and similar anti-permeation properties to polyester. In addition, polylactic acid film has good solvent resistance, insoluble in alcohols, fats, hydrocarbons, edible oils, and mechanical oils [4]. Moreover, There is a lower temperature heat sealing ability, better printability than polyolefins and good ink retention, which can retain the flavor and package aesthetics of foods to a greater extent.

PLA resin also has certain drawbacks inevitably. The disadvantages including lower processing temperature, high glass transition temperature, slow crystallizing rate, low crystallinity, difficulty in controlling the degradation cycle and expensive price limit its scope of application as a film packaging material.

Packaging product coding devices include ink jet printers and laser marking machines. Ink jet printers use ink to control the position of each ink drop with the amount of electricity charged to the ink drops to deflect the ink out of the normal flight path and deflect it toward the surface of the work-zone. Laser marking machine uses the laser beam to make the surface of the marking material to evaporate to expose the deep layer material or make the physical change of the object to produce traces, so that the material can display the required permanent symbols such as graphics, images, and words. Although the laser marking machine cannot be erased and changed, the anti-counterfeiting effect is better than that of ink jet printers that are easy to erase and change, but its coding principle may change the packaging performance of the film, so the ink jet printers, because of their price, having no effect on the packaging substrate, become the preferred coding method for food packaging bags.

So, the aim is to obtain PLA films of better properties.

2. Experiments

2.1Materials

Tab.2-1 Materials

Name	Type	Manufacturer
PLA	Ingeo4032D	Nature Works corp. of the US
LLDPE	7042	China Petrochemical corp.
EPDM-g-GMA	E533	Ningbo new material corp. of China

2.2 Manufacturing Methods

Pretreatment: At first, PLA resin is put into an 80□'s oven for drying, every two hours, it is taken out for weighing, until the sample weight is not change, it is finished for drying.

Mixed granulation: The PLA/ LLDPE and PLA /EPDM- g-GMA were mixed respectively in proportion to the mass of 95/5, and the granular resin that could be used for blowing film was produced by using the extrusion granulator of torque rheometer.

Film sample preparation: the granular resin was then added to blown film auxiliary of torque rheometer. The processing temperatures of the two samples were shown below:

Tab.2-2 The processing temperatures of the two samples

Sample	1zone/℃	2zone/℃	3zone/℃	4zone/℃
PLA/LLDPE	150	160	170	180
PLA/EPDM-g-GMA	140	145	150	155

3. Result and discussion

3.1 Effect of blending on mechanical properties of PLA film

PLA has high rigidity, low softness and low impact resistance, and is a hard and brittle material at room temperature. The PLA must be toughened and modified if it is used in situations where toughness is high or to make films as soft as PE.

Polymer blending is a more economical way to modify polymer properties. PLA also has the advantages of high mechanical strength, stable chemical performance and easy processing[5], it can be mixed with elastomers, tough polymers, fillers or plasticizers[6,7]. EPDM-g-GMA is an elastomer and PE is a tough polymer[8].

LLDPE is ethylene with a small amount of senior alpha olefin polymerization in the presence of catalyst between the copolymer, has the high softening temperature and melting temperature, has good strength and toughness, rigidity, heat resistance, cold resistance is good wait for an advantage.

The longitudinal and transverse tensile strength tests will be tested respectively at the tensile speed of 50mm/min.

Tab.3-1 Tensile strength of three materials

Material	Transverse tensile strength(MPa)	Longitudinal tensile strength(MPa)
PLA	11.224	44.355
PLA/LLDPE(95/5)	56.467	98.037
PLA/EPDM-g-GMA(95/5)	25.320	83.159

The results show that the mechanical properties of the two modified PLA films are improved, and the mechanical properties of PLA/LLDPE are better.

3.2 Effect of blending on optical properties and moisture permeability of PLA film

Tab.3-2 Optical properties of three materials

Material	Light transmittance /%	haze /%
PLA	92.5	1.84
PLA/LLDPE	92.12	2.64
PLA/EPDM-g-GGMA	89.96	3.0

Tab.3-3 Moisture permeability of three materials

材料	TR/(gm/[m^2-24h])
PLA	263.10
PLA/LLDPE	165.44
PLA/EPDM-g-GMA	88.808

Light transmittance as the name suggests is the proportion of light through the film, why do some light through, others can't, it is because of the crystals in the film. The transparency of blend films decrease little compared to pure PLA film but the moisture permeability improve a lot.

3.3 Effect of blending on printing properties of PLA film

Green printing refers to the use of environmentally friendly materials and technology, reduce the pollution of the printing in the process of production, reduce the use of resources and energy, print the legacy product can be recycled, can degrade, small print on the natural environment pollution way [9].

As is known to all, plastic film should be surface treatment before printing, so that the film surface graft -OH and other polar groups, treatment methods include ultraviolet radiation and oxygen plasma treatment.

Static drop contact Angle measuring instrument (DSA100)made by Kruss company of Germany was used to measure the contact angle of pure water on PLA film.

Fig2. Static Drop Contact Angle Measuring Instrument

Figure 3 shows the change of contact Angle of PLA film under different treatment conditions. It can be seen from the figure that different treatment conditions affect the change of surface contact Angle. FIG. 3 (a), (b) and (c) are the changes in the contact Angle of PLA film untreated, after ultraviolet 30 s and ultraviolet 50 s respectively, and continue to increase the ultraviolet irradiation time, resulting in severe deformation of PLA film.

The polymer will degrade when exposed to ultraviolet light with air, which will affect its shelf life [10,11]. Ultraviolet irradiation may cause significant physicochemical changes in polymers, involving reduction in molecular weight and mechanical properties [12]. The PLA is very sensitive to ultraviolet radiation, water and temperature [13], so treated with oxygen plasma is another choice.

Figure 3 (d), (e), (f), (g) and (h), appeared contact angle change of untreated, after oxygen plasma treatment 1 min, 3 min, 5 min and 10 min. Oxygen plasma treatment condition is 25 voltage regulator, oxygen flow rate is 10sec/cm^3.

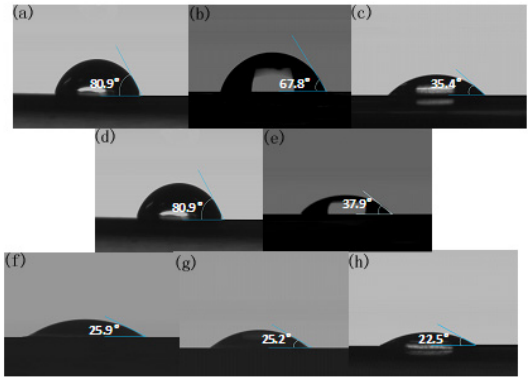

Fig.3 Variation of contact Angle of PLA film under different treatment conditions
(a)Untreated；(b)UV 30s；(c)UV 50s；(d) Untreated；(e) Oxygen plasma 1min；(f) Oxygen plasma 3min；(g) Oxygen plasma 5min；(h) Oxygen plasma 10min

PLA/LLDPE and PLA/EPDM-g-GMA films have the same trend to be treated before printing.

4. Conclusion

The physical properties of PLA/LLDPE(95/5) and PLA/EPDM-g-GMA(95/5) films blowed in our lab are better than the property of pure PLA film. They are suitable for making into degradable food packaging bags and using ink jet printer for of coding.

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Research direction: Research on the structure and properties of polymer materials; Application and development of materials related to packaging and printing