Effects of Transverse Stretch on Structure and Mechanical Properties of Biaxially Oriented PET Film

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Introduction

The polyethylene terephthalate (PET) is a slow crystallizing polymer. It can be quenched from the melt into amorphous or a semi-crystalline state by high cooling rate. As the film is stretched above the glass transition temperature, PET shows stress-induced crystallization because of the orientation of polymer chains.

The biaxially oriented PET (BOPET) films have wide applications including packaging films, heat shrinkage flexible films, optical films, capacitance films, etc. because of its excellent end-use properties such as high mechanical strength, optical clarity and high barrier properties. And such special properties are all achieved through the control of manufacturing processes. Hence, the influence of manufacturing processes (including transverse stretch ratio and stretch temperature) on structure and mechanical properties are investigated in this work. In the past several months, the investigation about orientation distribution has been finished.

Furthermore, I have also asserted to develop the on-line detection equipment of cast film, which has been used successfully to process the CPP and CPE.

Experiments and Data

Material: PET commercial film provided by Anhui Guofeng Plastic Industry Co. was used in this study. The thickness of the film is 0.260mm. Its glass transition temperature is 72.36ºC and melting point is 254.98ºC.

Experiment: The biaxial stretching system constructed by our laboratory can apply to a wide range of processing modes as: Uniaxial Constant Width (UCW), Simultaneous Biaxial (SB) and Sequential Biaxial (SEQB). The samples measured 13cm×13cm as cut from the cast film. When the temperature of the heating oven reached 93ºC, 100ºC and 105ºC, the film was inserted in the chamber and held by pneumatically activated clamps. After an additional time of 90s for heating the film, the stretch was started. The films were stretched at constant rate of 10mm/s. Finally, the films were heated in the heating oven at the stretch temperature for 5min after the stretch was finished. Then the biaxially oriented films were divided into 25 parts, as shown below. And the FTIR spectras of different parts of the BOPET film were obtained by Fourier transform infrared spectrometer. The peak located at 727.2cm^{-1} was investigated in this work.

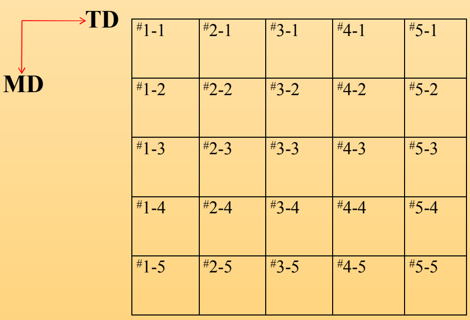

Figure1. The 25 parts of biaxially oriented PET film

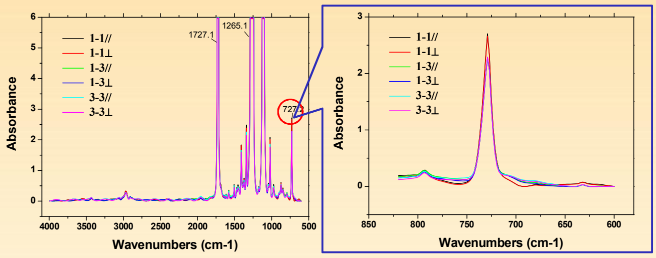

Figure 2. The FTIR spectras of different parts of BOPET film.

Instrument

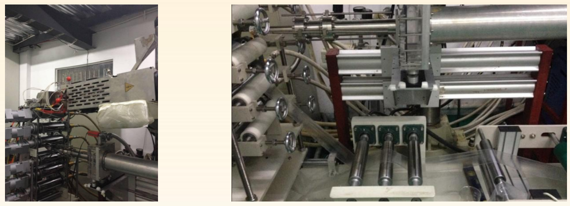

Figure 3. The on-line detection equipment of cast film

In the past year, I have also asserted to develop the on-line detection equipment of cast film. This equipment consists of X-ray Scattering System and a casting machine with six rollers. The casting machine, designed by the research group, can not only process cast film, but also realize the stretching process of cast film as four rubber rollers are added creatively. Besides, microstructure changes (e.g., lamellar thickness, orientation, crystallinity, etc) in the film during processing can be in-situ monitored by X-ray Scattering System, which can guide production .

Discussion and Conclusion

	1	2	3	4	5
1	0.984	1.014	0.975	0.998	0.990
2	0.953	1.020	0.997	0.961	0.949
3	1.013	0.997	1.004	0.937	0.980
4	1.031	0.996	1.048	0.956	0.973
5	0.986	1.021	0.992	1.014	1.056

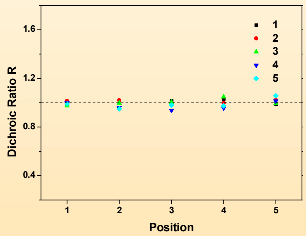

Figure 4. The dichroic ratios of different parts of BOPET film.

From Figure 4, it is obvious that the dichroic ratios of different parts of BOPET film are almost the same. Hence, the axial orientation is definitively negligible on the section of BOPET film we investigate. As the area of the section we studied is 75% of the whole film, the inner section of the film (75% of the film area), gotten from biaxially stretching, can be used to study the structure and mechanical properties of the BOPET film.

Annual Plan in 2015

- Study the effects of transverse stretch ratio and stretch temperature on the structure and mechanical properties of the BOPET film through WAXD, SAXS and some other instruments;
- Do more research and study more about the optical film;
- Learn more about the stretch of amorphous film.

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