Development of CPP Based Low Temperature Heat Sealing Film Material

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Abstract. The casting polypropylene (cpp) heat sealing film was prepared by adding the homemade smooth masterbatch, in the storage period of 30 days measured the surface tension is greater than 38 mN/m, the non-corona surface friction coefficient between 0.1 ~ 0.2, corona surface is 0.5, the longitudinal tensile strength reached 60 MPa, transverse tensile strength reached 27 MPa, the films have high surface tension, low friction coefficient, high mechanical strength properties. Measured at the same time its initial heat sealing temperature, heat sealing strength and optical properties are better than the national standard, to maintain film comprehensive properties are stable during the storage period.

1. Introduction
CPP (casting polypropylene) heat sealing film has the characteristics of high transparency, good mechanical properties and high heat sealing strength, and is widely used in the packaging industry. However, it tends to be brittle at low temperatures, and the toughness is deteriorated, which limits its use under low temperature conditions. Domestic low temperature modification of CPP heat sealing film has been a research hotspot. For example, the use of polyolefin elastomer to blend and modify it can reduce the film haze and improve the transparency. It is expected to replace the low transparency used in low temperature refrigeration. PE (polyethylene) film. However, the elastomer has problems of stickiness and blemish, which causes the mechanical strength of the film to decrease and the friction coefficient to increase.¹⁻⁶

In this paper, the self-made smooth masterbatch is added in the preparation process of CPP heat sealing film. The produced film has the characteristics of high surface tension, low friction coefficient and large mechanical strength, and can maintain the performance of the film stable within 30 days of storage period.

2. Experimental Part
2.1. Main Raw Materials
Polypropylene homopolymer (FC-801, Sinopec Shanghai Petrochemical Co., Ltd.), polypropylene copolymer (H531PL, Singapore Polyolefin Corporation) and other commercially available. Sleek masterbatch homemade.
The self-made smooth masterbatch carrier is a polypropylene homopolymer which is granulated by a twin-screw extruder and contains 10% high-purity non-toxic erucamide, water ≤0.06%, and melt flow rate of 5~7g/10 min (temperature 230°C, load 2.16 kg), added to the core layer of the film.
2.2. Basic Formula and Sample Preparation

Basic formula (parts by mass): heat seal layer (layer A): copolymerized polypropylene resin 95.0% to 97.0%, auxiliary agent (3.0 to 5.0) g/kg; core layer (layer B): homopolymer polypropylene resin 97.0%~97.5%, auxiliary agent (2.5-3.0) g/kg; corona layer (C layer): homopolymer polypropylene resin 96.0% to 96.5%, auxiliary agent (2.0-3.5) g/kg.

Sample preparation: CPP heat-sealing film was prepared by three-layer co-extrusion casting method of A, B and C. The process flow was: CPP resin, other additives → metering → extrusion plasticization → shunt → die → casting → cooling → molding → Thickness measurement → Corona treatment → Trimming → Winding → Finished product after 48h normal temperature aging treatment → slitting → inspection → CPP heat sealing film.

2.3. Performance Test Method

The surface tension is tested according to GB/T 14216—2008 “Determination of Wetting Tension of Plastic Film and Sheet”; the friction coefficient is tested according to GB 10006-1988 “Method for Measuring Friction Coefficient of Plastic Film and Sheet”; Light transmittance/haze reference GB/T 2410-2008 "Determination of Transparent Plastic Transmittance and Haze" test; mechanical properties refer to GB/T 13022-1991 "plastic film tensile properties test method" test; gloss according to ASTM D523-1989 (1999) material gloss Degree test; heat shrinkage rate is tested according to GB/T 12027-2004 "Test method for dimensional change rate of plastic film and sheet heating"; heat seal strength is tested according to QB/T 2358-1998 "Test method for heat seal strength of plastic film packaging bags". [7-11]

3. Results and Discussion

3.1. The Effect of Storage Time on the Surface Tension of the Film

A self-developed smooth masterbatch is added to the formulation to produce a 3-layer structure of 25 μm thick CPP heat seal film to track the surface of the CPP film within 30 days (1, 2, 3, 14, 21, 30). The tension changes and the result is shown in Figure 1.

![Figure 1](image)

**Figure 1.** The surface tension change of CPP heat sealing film within 30 days.

When the CPP heat-sealing film was just off the line, the surface tension value reached a peak value of 46 mN/m, and began to decrease with time in the 30 days after tracking. At the 30th day, it was 38 mN/m. It can be seen that the CPP heat seal within 30 days of the storage period. The film can meet the requirements of surface tension of more than 38 mN/m for secondary processing such as printing and coating.

During the processing of CPP heat-sealing film, the external tensile force causes the mechanical properties of the orientation direction to increase significantly. Under the condition of rapid quenching, the viscosity of the CPP melt is high, and the internal stress cannot be relaxed quickly, usually after 3 days of the offline. At the beginning of the relaxation, the properties of the film changed. It can be seen from Fig. 1 that the surface tension of the film decreased significantly after the third day. In the
study, the self-made smooth slip masterbatch contains 10% high-purity non-toxic erucamide, which has smooth and anti-blocking effect, and can migrate from the film core layer to the film surface during storage, which relieves to some extent. The decrease in surface tension value is due to the fact that the lubricity of erucamide increases the mobility of movement between the macromolecular chains or segments of the polypropylene, and the surface of the film maintains a high surface tension for a long period of time.

3.2. The Effect of Storage Time on the Friction Coefficient of the Film

A self-developed smooth masterbatch is added to the formulation to produce a 3-layer structure of 25 μm thick CPP heat seal film, and the corona film is tracked within 30 days (1, 2, 3, 14, 21, 30) after the CPP film is taken offline. The coefficient of friction between the surface and the non-corona surface is shown in Figure 2.

![Figure 2. The friction coefficient change of CPP heat sealing film within 30 days.](image)

Under normal circumstances, the migration of the smoothing aid can rapidly reduce the friction coefficient of the film, but the loss of the smoothing aid in the later migration also causes the surface friction coefficient of the film to gradually increase. It can be seen from Fig. 2 that the friction coefficient of the non-corona surface when the film is just off the line is 0.3, and then starts to decrease, and is stable between 0.1 and 0.2 during the tracking period. The corona surface is forced to break due to electron breakdown, air oxidation, etc. on the surface of the film to form a partial region. The unevenness of the film surface causes the various additives in the inner layer of the film to migrate to the film. After the surface is easy to disperse unevenly, the friction coefficient of the corona surface is obviously increased after being placed for a period of time, and the stability of the friction coefficient can be impaired. After adding the self-made slippery masterbatch, the friction coefficient of the corona surface of the CPP heat seal film changed greatly after the line was removed, but the loss increase after aging treatment was stable below 0.6 after 21 days of tracking, and decreased to 0.5 after 30 days. The self-made smooth masterbatch can effectively ensure the stability of the friction coefficient of the CPP heat seal film.

3.3. The Effect of Storage Time on the Tensile Strength of the Film

A self-developed smooth masterbatch was added to the formulation to produce a 25-μm thick CPP heat seal film with a 3-layer structure, and the pull of the CPP film within 30 days (1, 2, 3, 14, 21, 30) was traced. The tensile strength is shown in Figure 3.
Figure 3. The tensile strength change of CPP heat sealing film within 30 days.
As the storage time increases, the tensile strength of the film continues to increase, with the largest change in the first 3 days of the off-line. After 30 days, the film has a tensile strength of 60 MPa and a transverse tensile strength of 27 MPa. It is because when the film is just off the wire, the polymer chain and the segment are oriented in the direction of the tensile force in the film, and the internal stress is generated. After 3 days, the internal stress begins to relax, and the polymer chain and the segment occur. Retracting or entanglement, the straightening state is destroyed, and the variation range of the transverse and longitudinal tensile strength of the film fluctuates obviously; with the increase of the standing time, some polymer chains and segments are under the action of the environment. The change of stress returns to equilibrium, so the tensile strength increases gently in the first 3 days before the line, and the growth rate is basically small in the 21- to 30-day interval, which tends to be stable.

3.4. Comprehensive Performance of CPP Heat Sealing Film
When the CPP heat seal film with a total thickness of 25 μm was placed for 30 days, it was compared with the national standard GB/T 27740-2011 "cast polypropylene (CPP) film". The results are shown in Table 1. It can be seen that the film produced by the CPP heat sealing film prepared by using the self-made smooth masterbatch can maintain the high surface tension, low friction coefficient, high mechanical strength and meet the national standard during the storage period, and the initial heat sealing temperature and heat sealing. Both strength and optical performance are superior to national standards, and the comprehensive performance of the product is stable.

Table 1. Effect of slipping masterbatch on other Porperties of CPP heat sealing film.

| Test items                  | GB/T 27740-2011 | Measured |
|----------------------------|------------------|----------|
| Thickness,μm               | -                | 25       |
| Tensile Strength MPa,MD    | ≥35              | 60       |
| Tensile Strength MPa,TD    | ≥25              | 27       |
| Elongation at break %,MD   | ≥280             | 570      |
| Elongation at break %,TD   | ≥380             | 650      |
| Gloss %                    | -                | 82.9     |
| Haze %                     | ≤5.0             | 2.5      |
| Initial heat sealing       | <145             | 115      |
| temperature℃               |                  |          |
| Heat seal strength N/15mm  | ≥8               | 10.14    |
| Friction coefficient (hot  | ≤0.5             | 0.5      |
| cover)                     |                  |          |
| Surface tension (treatment | ≥38              | 38       |
| surface)mN/m               |                  |          |
4. Conclusion

The surface tension of CPP heat-sealing film prepared by using self-made smooth masterbatch is more than 38 mN/m when stored for 30 days; the friction coefficient of non-corona surface is stable between 0.1 and 0.2 during the tracking period, and the corona surface is stable at 0.5.

With the increase of storage time, the tensile strength of the film continued to increase. After 30 days of standing, the longitudinal tensile strength of the film reached 60 MPa, and the transverse tensile strength reached 27 MPa, which was higher than the national standard.

The initial heat-sealing temperature, heat-sealing strength and optical performance of the CPP heat-sealable film prepared by using the self-made smooth masterbatch are better than the national standard at the storage period of 30 days, and the comprehensive performance is stable.

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