Newly-Designed SIS Block Copolymer for Improving Die-Cut Performance and New Evaluation Method for Die-Cut Property

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Abstract

I. INTRODUCTION

There are various types of styrenic block copolymers (SBC). These thermoplastic elastomers can be used for hot melt pressure sensitive adhesives (HMPSA). Styrene-Isoprene-Styrene block copolymer (SIS) is preferably used in HMPSA fields because it has several advantages as follows.

i) SIS is softer than other styrenic block copolymers and can give an aggressive tack.
ii) SIS can be used with various types of tackifier resins.
iii) SIS contains less gels than other styrenic block copolymers, such as Styrene-Butadiene-Styrene block copolymer.

Historically, SIS has been developed with various structures for adjusting PSA performance and its processability.

A. Conventional SBC for HMPSA label application

For label application, HMPSA using SIS comes into wide use in the world. Generally, HMPSA for label needs good adhesive performance and high die-cut speed. It is difficult to have good adhesive performance with high die-cut speed by changing conventional polymer design factors like styrene content, molecular length, linear or radial structures and Styrene-Isoprene (SI) diblock content.

B. Alternative evaluation method for the die-cut performance

Die-cut process has several processes like die-cutting, matrix-stripping. Historically, Dynamic Mechanical Analysis (DMA) is one of the alternative evaluation method for die-cut performance. It can predict die-cut performance effectively, but it is difficult to cover all die-cut performances especially matrix-stripping process.

II. RESULTS AND DISCUSSION

A. New SIS with Asymmetric Styrene block

To meet the requirements for label application, we have developed new SIS design factor, “Asymmetric Styrene block”. SIS which installed new design factor has a unique morphology (micro segregated structure).

Normally, SBC consists of polystyrene endblocks and the elastomeric midblock. They create a two-phase structure consisting of polystyrene domains and elastomeric matrix. The morphology of the two-phase structure depends on the ratio of endblock (polystyrene) and midblock. SBC of low polystyrene content forms a spherical structure of polystyrene domain. In the label application, they are commonly used.

Their morphology can be observed by Transmission Electron Microscope (TEM). Generally, in the case of conventional SIS block copolymer containing polystyrene endblocks less than about 20% shows the spherical morphology. But in higher-styrene copolymers, the cylindrical or lamellar morphology can be observed.

New SIS contains the asymmetric styrene blocked SIS. It is a triblock SIS copolymer with different polystyrene molecular lengths. The unique morphology is attributed to this new factor. For example, Higher polystyrene content 30% of SIS which contains the asymmetric styrene blocked SIS shows the spherical morphology (Figure 1). This is soft polymer from the spherical morphology with high styrene content. It can improve both the adhesive performance and the die-cut performance. It also has the good anti-oil migration performance and broad temperature performance for the label application.

Styrene content=30%, spherical morphology

Fig.1 Newly SIS morphology (TEM)
B. New alternative evaluation method for the die-cut performance

Matrix-stripping process has the tensile break of thinner adhesive after die-cutting process. We have developed new alternative evaluation method using “High speed tensile test (HST) equipment. It can simulate the matrix-stripping tensile break process with the maximum 100 (m/minute) speed like actual die-cut machine speed. Both lower elongation and lower tensile strength, that is lower breaking energy shows better die-cut property (Figure 2). In this high speed region, there is high correlation between the breaking energy of SIS and the actual die-cut performance.

Our new SIS shows good die-cut performance using the HST equipment.

Fig.2 Image of breaking energy