

● Pressure-Sensitive Adhesive for Decorative Film “ARONTACK MPT-29, MPT-69”

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Keywords : Pressure-Sensitive Adhesive, Decorative Film, Out Mold Decoration

1. Introduction

1.1 Film decoration via vacuum pressure forming

In recent years, the automotive industry has been exploring alternative decorative methods to painting in order to reduce CO₂ emissions and improve design quality. Among these, one method that is attracting attention is the film decoration method known as vacuum pressure forming (also known as Out Mold Decoration (OMD)), in which thermoplastic films with colors, patterns, uneven surfaces, and other designs that cannot be reproduced by painting are bonded to three-dimensional parts using adhesive materials¹⁻⁵⁾. **Figure 1** shows an example of a decorative film formed using vacuum pressure forming.

Vacuum pressure forming has been increasingly used for automotive interiors and exteriors, home appliances, and housing equipment due to the following characteristics:

- Excellent designability, including color patterns and surface texturing that cannot be achieved by painting
- High durability and designability due to film edge wrapping
- Applicability to 3D deep-drawing parts
- A high degree of freedom when selecting the adherend material
- Applicability to large parts such as automobile roofs

Figure 2 shows the principle of vacuum pressure forming. Well-known vacuum pressure forming machines include the TOM forming machine from Fu-se Vacuum Forming, the NATS air transfer machine from Nis, and the TFH hot-plate vacuum coating forming machine from ASANO Laboratories. All of these machines use the same mechanism: the decorative film is heated under reduced pressure to soften it, then compressed air is applied to bond the film to the adherend, conforming to its shape.



Figure 1: Example of film decoration by vacuum pressure forming ⁶⁾

1.2 Issues with the adhesive material

During vacuum pressure forming, decorative films are bonded while stretched by up to approximately 200%. As a result, peeling and displacement may occur due to the shrinkage stress on the decorative film during durability testing, which is considered a challenge for adhesive materials. In particular, automotive applications require adhesives with excellent high-temperature adhesion, since a heat resistance of 100°C or higher is necessary. The use of engineering plastics and polypropylene (PP) is increasing to reduce the weight of automobiles. Consequently, the need for bonding decorative films to these difficult-to-bond materials is expected to grow.

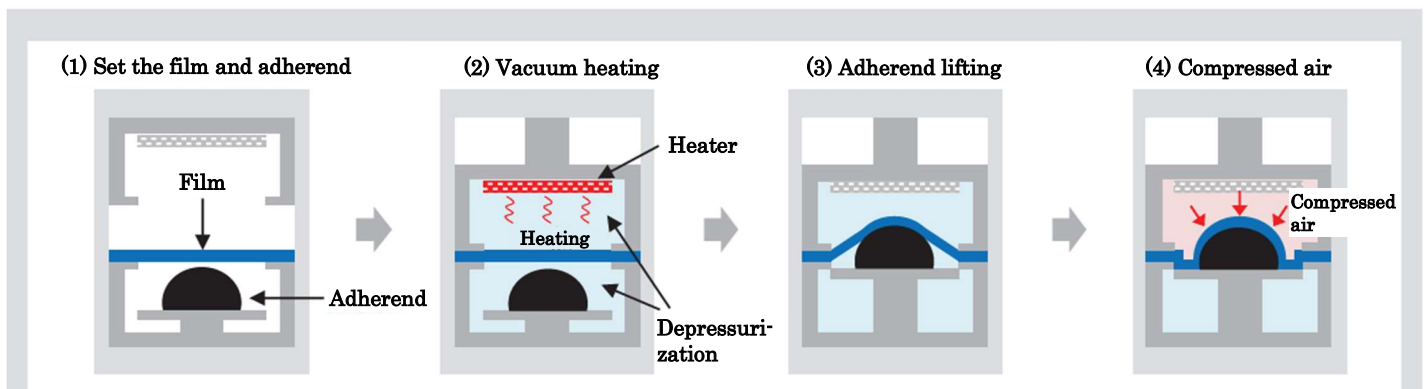


Figure 2: Principle of vacuum pressure forming

1.3 Application of solvent-based acrylic pressure-sensitive adhesives

Since solvent-based acrylic pressure-sensitive adhesives (PSAs) can copolymerize various monomers through radical polymerization, they are known for their high degree of design freedom and excellent weather resistance and transparency, which are typical characteristics of acrylic resin. For these reasons, they are also used in high value-added applications, such as displays and automobiles. However, they also have drawbacks, including reduced adhesion at high temperatures and poor adhesion to low-polarity materials, such as polyolefins.

We discovered that adding an appropriate tackifier (TF) to acrylic PSAs causes the TF to segregate at a high concentration on the surface of the adhesive coating film, significantly improving adhesion at high temperatures^{7), 8)}.

This paper introduces the performance and characteristics of ARONTACK MPT-29 and MPT-69, adhesives for decorative films, which were developed by applying TF's segregation technology.

2. Grades of PSAs for decorative films

Table 1 shows the grades of PSAs for decorative films. The product lineup includes the solution-type MPT series and the MF series, a substrate-less, double-sided PSA film made by coating the MPT series into film form. MPT-29 (MF-29) has excellent adhesion to acrylonitrile butadiene styrene (ABS) copolymer resin and polycarbonate (PC), both of which are widely used in automobile interior materials. MPT-69 (MF-69) is ideal for bonding low-polarity PP materials. Both grades have low tack and are easy to handle during vacuum pressure forming.

It is also possible to customize the PSA properties according to the required properties, the adherend material, and the bonding process.

Table 1: Grades

Grade	Product form	Recommended adherend
MPT-29	Solution	ABS, PC
MPT-69		PP
MF-29	Film (Standard film thickness of 50 μm)	ABS, PC
MF-69		PP

3. Adhesive performance

3.1 Evaluation sample

A 50-μm thick adhesive film made from MPT-29 and MPT-69 was used for evaluation. A general acrylic PSA with 30 wt% of styrene-TF added was also evaluated for comparison of PSA performance.

For the easy-adhesion PET film serving as the base material, Lumiror 125U34 (125 μm, TORAY INDUSTRIES, INC.) was used. The adherends used, ABS, PP, PC, acrylic plate (PMMA), and hard polyvinyl chloride (PVC) resin, were purchased from the test piece manufacturers. PP that did not contain talc or rubber components was used.

3.2 Peeling strength to various adherends

Test pieces were prepared by bonding an easy-adhesion PET film and various adherends with an PSA. In order to reproduce a pressure bonding similar to that of vacuum pressure forming, the test pieces were subjected to a heat press treatment at 120°C and 0.8 MPa for 20 seconds. Peeling strength was measured by peeling the test piece 180° at a peeling rate of 300 mm/min under various temperature conditions.

Figure 3 shows the temperature dependence of the peeling strength of MPT-29 on ABS boards, and **Figure 4** shows the temperature dependence of the peeling strength of MPT-69 on PP boards.

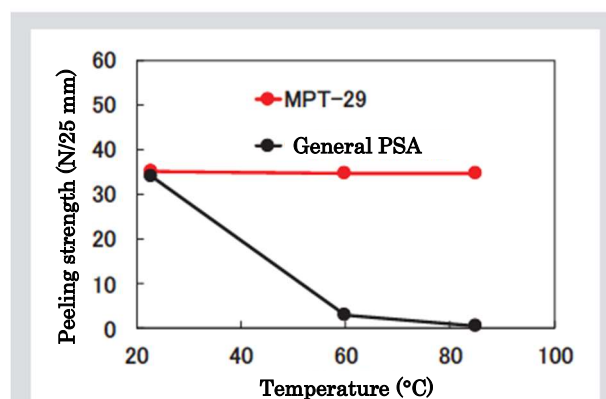


Figure 3: Temperature dependence of peeling strength for ABS

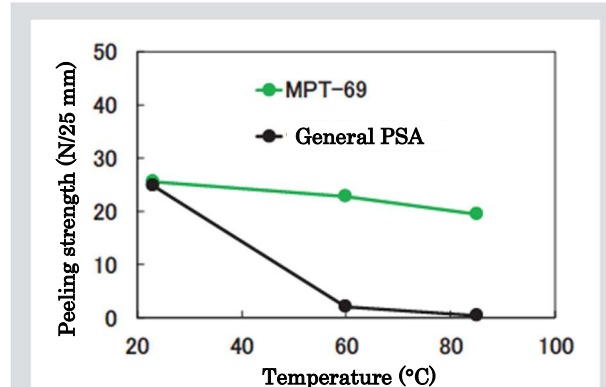


Figure 4: Temperature dependence of peeling strength for PP

The general PSA exhibited high peeling strength at 23°C, but the strength decreased significantly at temperatures of 60°C or higher, showing almost no adhesion.

Conversely, MPT-29 and MPT-69 maintained high peeling strength across a broad temperature range for their respective adherends.

MPT-29 exhibits excellent high-temperature adhesion with adherends made of various materials in addition to ABS. **Table 2** shows the peeling strength on PC, PMMA, and PVC, which are heavily used as base materials for decorative films.

Table 2: Peeling strength of MPT-29 on various adherends

Adhesive	Adherend	Peeling strength (N/25 mm)	
		23°C	85°C
MPT-29	ABS	35	35
	PC	36	42
	PMMA	34	30
	PVC	44	28

3.3 Holding power

Decorative films stretched and bonded by vacuum pressure forming tend to shrink during durability testing. Because the PSA is subjected to shear-direction forces, holding power is important.

Using the test pieces from the previous section with a bonded area of 25 mm × 25 mm, a 1 kg weight was suspended in a 90°C atmosphere to apply a shear force to the PSA, and any displacement was examined after 24 hours.

The results are shown in Table 3. While the general PSA caused the weight to drop immediately at the start of the test, MPT-29 and MPT-69 demonstrated excellent holding power with no displacement after 24 hours.

Table 3: Holding power

PSA	Adherend	Results of holding power
MPT-29	ABS	No displacement
MPT-69	PP	No displacement
General PSA	ABS	Dropped immediately
	PP	Dropped immediately

3.4 Peeling strength after the durability test

Durability was evaluated using the same test pieces as in the previous section. The test pieces were subjected to the following conditions for up to 1,000 hours: heat resistance at 100°C or 80°C, humidity resistance at 85°C/85%RH, and immersion in hot water at 40°C. The peel strength was measured at each time point during the treatment. The peeling strength of MPT-29 on ABS boards is shown in Figure 5 and that of MPT-69 on PP boards is shown in Figure 6.

MPT-29 and MPT-69 demonstrated excellent durability, with no deterioration of peeling strength after a 1,000-hour durability test.

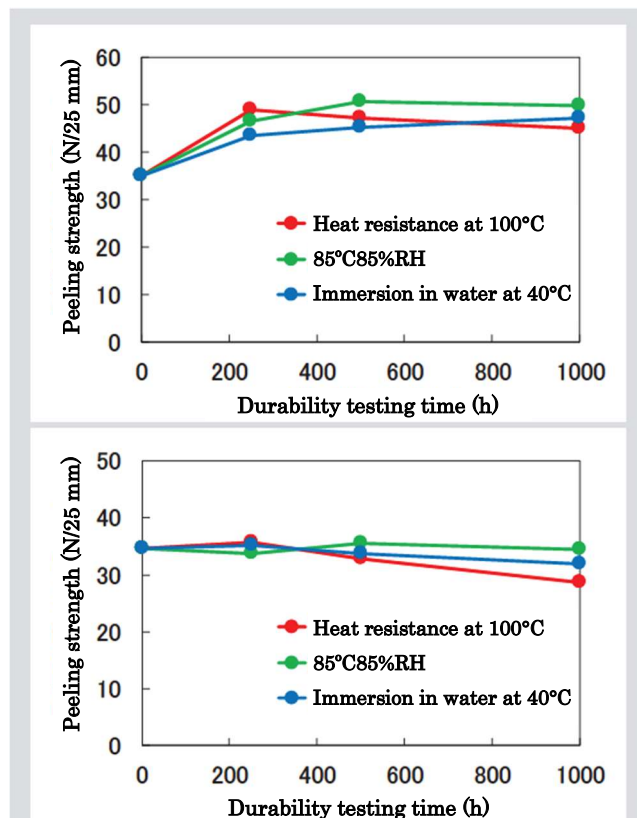


Figure 5: Time-dependent change in peeling strength of MPT-29 for ABS
(Upper: peeling strength at 23°C, lower: peeling strength at 85°C)

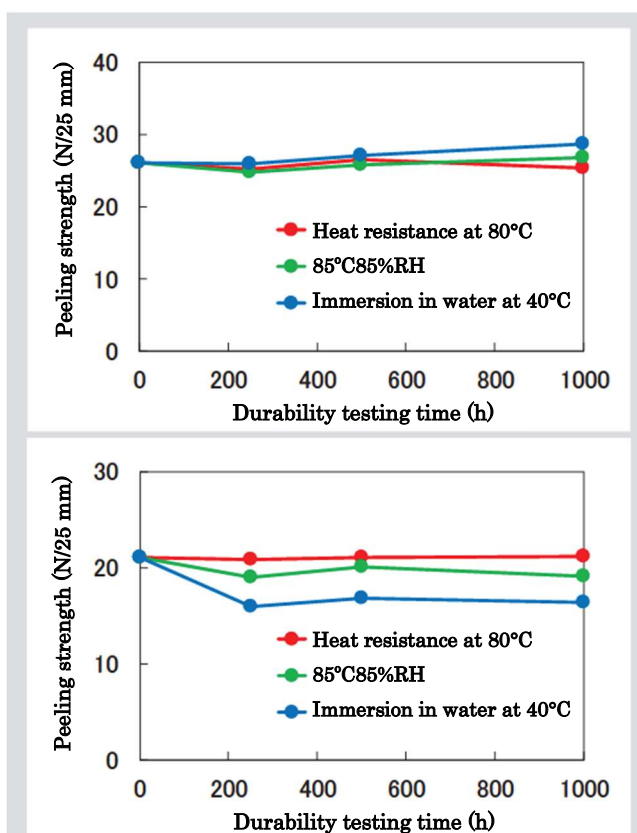


Figure 6: Time-dependent change in peeling strength of MPT-69 for PP
(Upper: peeling strength at 23°C, lower: peeling strength at 85°C)

3.5 Heat resistance evaluation by vacuum pressure forming

PSAs for decorative films must have the performance to suppress peeling and displacement caused by the shrinkage stress of the decorative films during durability tests. For this reason, cross-cut heat resistance tests were conducted under the assumption of a deep-drawn shape and wrapped sections. **Figure 7** shows the evaluation method.

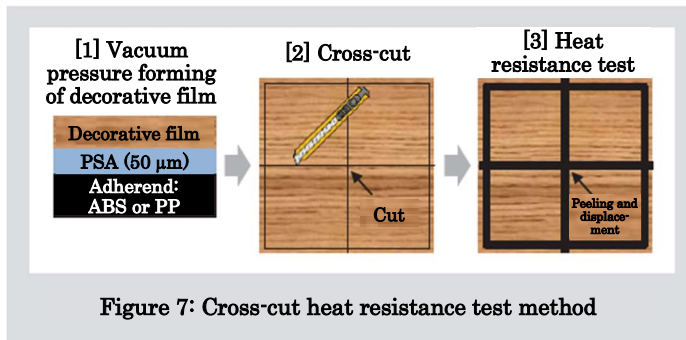


Figure 7: Cross-cut heat resistance test method

The PSA-coated decorative film is bonded to a 10-cm square ABS or PP board using a vacuum pressure forming machine. A NATS-0612B (Nis) forming machine was used. The forming conditions were as follows: film heating temperature of 120°C, and compressed air at 0.2 MPa applied for 10 seconds. The film stretch ratio was set to 200% to apply a load to the adhesive. A cross-cut was made on the test pieces using a cutter. Then, heat resistance tests were conducted at 110°C for ABS boards and at 80°C for PP boards for 15 hours to evaluate peeling and displacement of the cross-cut areas. **Figures 8** and **9** show the results of the cross-cut heat resistance tests for MPT-29 and MPT-69, respectively.

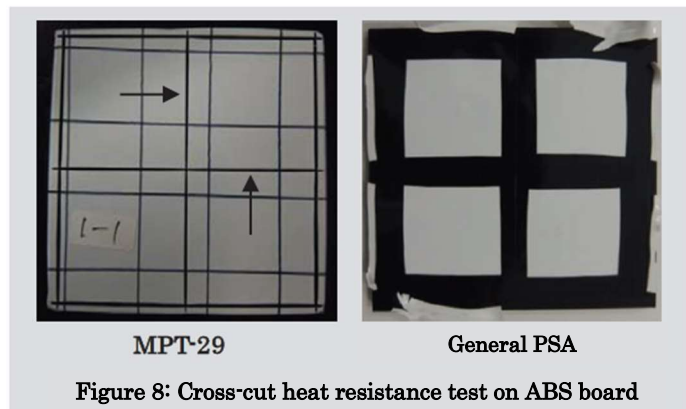


Figure 8: Cross-cut heat resistance test on ABS board

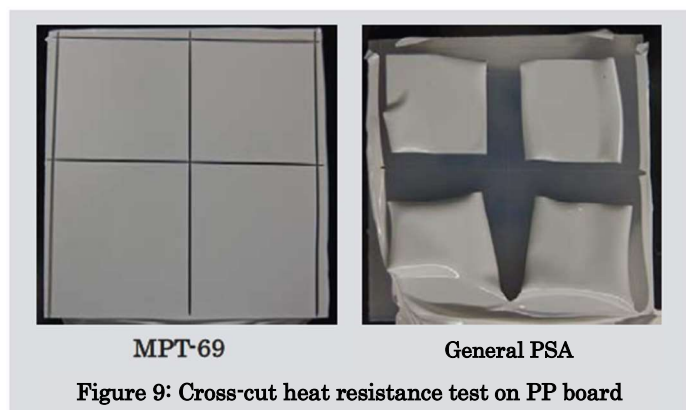


Figure 9: Cross-cut heat resistance test on PP board

With general PSAs having poor adhesion at high temperatures, the decorative film shrank and exposed the resin plate on both adherends. Peeling and lifting were also observed.

On the other hand, MPT-29 and MPT-69 maintained a good appearance, with the width of the displacement in the cut area suppressed to less than 1 mm, and no peeling was observed. The MPT series has superior peeling strength and holding power at high temperatures, suggesting that it can inhibit peeling and displacement due to shrinkage of the decorative film.

Thus, we confirmed that MPT-29 and MPT-69, which have excellent high-temperature adhesion, are ideal for decorative film lamination applications.

4. Summary

ARONTACK® MPT-29 and MPT-69, developed as PSAs for decorative films, demonstrated high peeling strength for various adherends across a wide temperature range. Additionally, they maintained their adhesion even after treatment at 100°C or 80°C, under 85°C/85%RH conditions, and immersion in water at 40°C for 1,000 hours. Furthermore, they exhibited excellent practical performance in cross-cut heat resistance tests using vacuum pressure forming, with minimal peeling and displacement of the decorative film.

Going forward, we plan to market these products for decorative film applications and promote their application in fields requiring high heat resistance.

Reference

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