

● Pressure-sensitive Adhesive for fabric materials 「ARONTACK MPT-500」

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1. Introduction

1.1 Seamless clothing trend

In recent years, there has been a trend in the apparel industry toward seamless construction, where fabric pieces are joined and hems are folded using adhesives rather than sewing^{1),2)}. In addition to enhancing design appeal, seamless construction offers benefits such as reduced skin irritation in underwear and improved wind resistance and heat retention in winter clothing. Fabrics are typically bonded together by melting a urethane-based hot-melt adhesive in tape or film form using a hot press or similar equipment. However, urethane-based hot-melt adhesives have durability issues such as texture degradation, yellowing, and age-related deterioration in the bonded area.

1.2 Application of solvent-type acrylic pressure-sensitive adhesives

Solvent-type acrylic pressure-sensitive adhesives are used not only for daily miscellaneous goods but also for high-value-added applications in the home appliance and automobile fields because of their excellent weather resistance, light resistance, etc. They also have a high degree of freedom in polymer design, as it is possible to introduce functional groups into the molecular chain and control the SP value, molecular weight, and molecular weight distribution by selecting monomer species and polymerization methods.

We operate businesses in solvent-type acrylic and emulsion-type pressure-sensitive adhesives for general use, and in recent years have developed a new solvent-type acrylic pressure-sensitive adhesive with excellent heat resistance through surface segregation of tackifier^{3),4)}.

This article introduces the performance and characteristics of the newly developed solvent-type acrylic pressure-sensitive adhesive for textile materials (ARONTACK MPT-500).

2. Development of MPT-500

2.1 Balancing cohesion and fluidity

In order for a pressure-sensitive adhesive to exhibit high adhesive strength and durability under room temperature and other environments, cohesion should be increased through a crosslinking structure, and chemical crosslinking is generally formed with an isocyanate-based curing agent, etc. However, chemically crosslinked pressure-sensitive adhesives do not flow even at high temperatures, and they have been shown to result in poor adhesion to fiber fabrics (discussed in detail below in 3.3).

Therefore, we decided to use physical crosslinking by microphase separated structure of triblock copolymers as a method to achieve both cohesion and fluidity. **Fig. 1** shows a schematic diagram of an A-B-A triblock polymer consisting of a hard segment A with a glass transition temperature (hereinafter " T_g ") above room temperature and a soft segment B with a T_g below room temperature. An A-B-A triblock polymer with a low hard segment ratio forms a spherical microphase separated structure as shown in **Fig. 2**. At room temperature, the polymer exhibits high cohesion like a chemically crosslinked system since the hard segment behaves as a physical crosslinking point, and it exhibits fluidity when heated above the softening temperature of the hard segment.

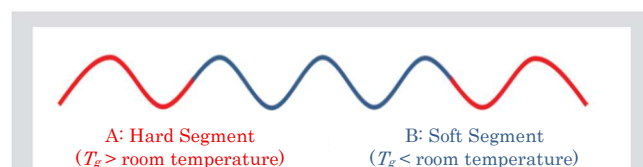


Figure 1: Schematic diagram of an A-B-A triblock polymer

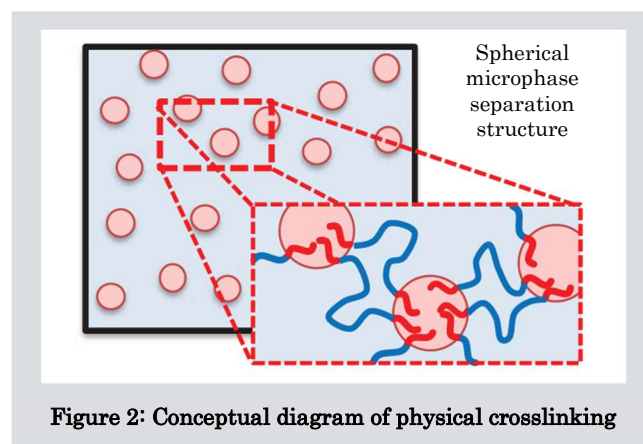


Figure 2: Conceptual diagram of physical crosslinking

2.2 Design of the triblock polymer

We synthesized the A-B-A triblock polymer by living radical polymerization, and conducted various studies on the monomer species, solubility parameter, and molecular weight of A and B segments. By designing with consideration of two points, which were (1) forming a spherical microphase separation structure, and (2) exhibiting fluidity during thermocompression bonding (130 to 150°C), we developed a solvent-based acrylic pressure-sensitive adhesive for textile materials (ARONTACK MPT-500), combining flexibility and adhesion.

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3. Performance evaluation

3.1 Preparation of film samples

We obtained film samples by coating release-treated PET film with MPT-500 using an applicator and allowing the solvent to dry. We set the film thickness after drying to 100 μm , and used this pressure-sensitive adhesive film for the evaluation in the next and subsequent sections.

3.2 Flexibility evaluation

The storage modulus at 23°C obtained from viscoelastic measurements was used as an indicator of hardness and flexibility. For comparison with MPT-500, we used: (1) a film sample obtained by chemically crosslinking a solvent-based acrylic pressure-sensitive adhesive based on *n*-butyl acrylate with an isocyanate-based curing agent (hereinafter “general acrylic pressure-sensitive adhesive”); and (2) a commercially available film-form urethane-based hot-melt adhesive (hereinafter “HM adhesive”).

As shown in **Table 1**, the storage modulus of MPT-500 at 23°C was more than one order of magnitude smaller than that of the HM adhesive and comparable to that of the general acrylic pressure-sensitive adhesive. **Photo 1** shows a film sample of MPT-500 being held and stretched by hand, demonstrating its excellent flexibility and elasticity.

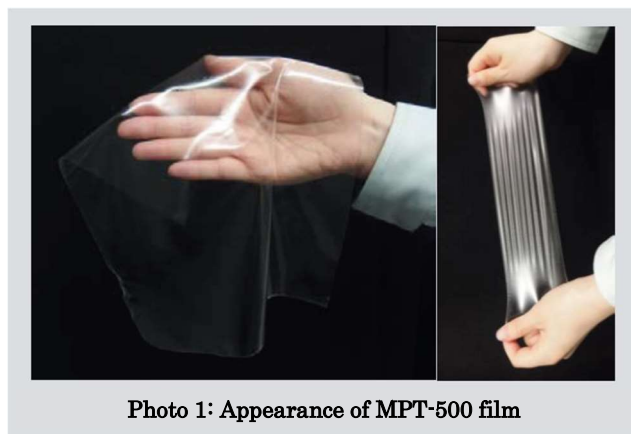


Photo 1: Appearance of MPT-500 film

3.3 Adhesion test

Using the same three types of adhesives as in the previous section, we measured the peel strength on polyester fabric (for underwear, knitted fabric, surface roughness $R_a = 200 \mu\text{m}$) and water-repellent-treated nylon fabric (for winter clothing, woven fabric, surface roughness $R_a = 50 \mu\text{m}$). The test pieces were prepared by placing the adhesive film, cut to 1 cm width, between two pieces of fabric and bonding them by thermocompression with a hot press at 130 to 150°C. **Table 1** shows the results of peeling strength measurement. MPT-500 showed favorable adhesion to fabrics for underwear and winter clothes with results comparable to or better than those of HM adhesive. On the other hand, the chemically crosslinked general acrylic pressure-sensitive adhesive showed a lower peeling strength for both fabrics. To confirm the conformability to the fabric surface, we observed the cross section of the bonded area by X-ray micro-CT using the polyester fabric with high surface roughness mentioned above (**Fig. 3**). In this observation, the fabrics that are relatively transparent to X-rays appear darker, and the adhesive layer that is relatively impervious to X-rays appears brighter.

Table 1: Storage modulus and adhesive strength to various fabrics

Type of adhesive	Storage modulus ^{a)}	Peel strength on underwear fabric ^{b)}	Peel strength on winter clothing fabric ^{c)}
	MPa	N/10mm	N/10mm
MPT-500	0.1	14.8	11.1
General acrylic pressure-sensitive adhesive	0.1	0.4	2.6
HM adhesive	2.00	14.5	5.0

a) Frequency 1 Hz, strain 0.1%, b) 23°C, T-peel, 300 mm/min

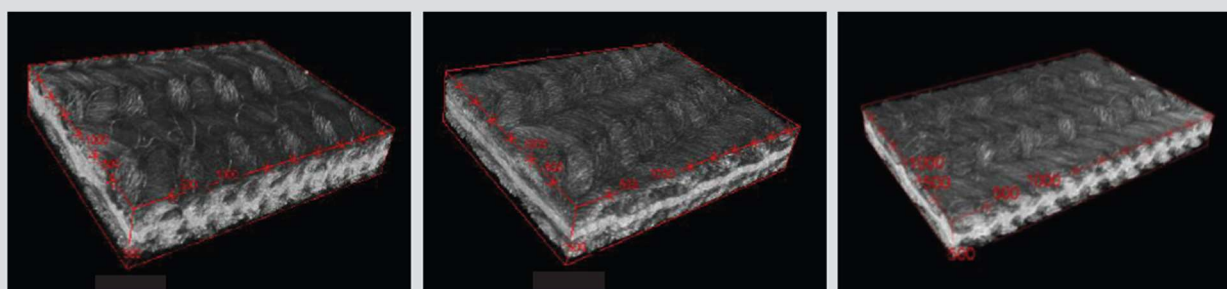


Figure 3: X-ray micro-CT image of cross section of the adhesion area

Left: MPT-500, middle: General acrylic pressure-sensitive adhesive, right: HM adhesive (observation range: X = 5 mm, Y = 3.5 mm, Z = 1.0 mm)

In the CT image of the chemically crosslinked general acrylic pressure-sensitive adhesive (middle figure in Fig. 3), the adhesive layer between the fabrics is clearly visible, and the adhesive layer is not able to follow the surface roughness of the fabric. In contrast, MPT-500 (left figure in Fig. 3) and HM adhesive (right figure in Fig. 3) were observed to follow the wave-like roughness of the textile fabric surface.

These results suggest that the chemically crosslinked pressure-sensitive adhesive, which does not exhibit fluidity at high temperatures, failed to conform to the fabric surface roughness during thermocompression bonding, resulting in low peel strength. In contrast, the thermoplastic MPT-500 and HM adhesive flowed during thermocompression bonding and conformed to the fabric surface roughness, resulting in high peel strength.

3.4 Durability test

In the durability test, resistance to yellowing and aging was evaluated. The performance of MPT-500 was also compared with that of the HM adhesive.

Yellowing resistance was assessed by evaluating discoloration under light (UV) exposure and in the presence of nitrogen oxides (NOx).

Table 2 shows the results. MPT-500 showed excellent yellowing resistance under light exposure and nitrogen oxides, whereas the HM adhesive yellowed upon contact with nitrogen oxides.

	Yellowing resistance (light) ^{a)}	Yellowing resistance (nitrogen oxides) ^{b)}
MPT-500	No discoloration	No discoloration
HM adhesive	No discoloration	Discoloration

a) JIS L 0842 Class 4, b) JIS L 0855 strong

Aging resistance was evaluated in accordance with ATTS2102:1992 established by the Association for Textile Technical Study (ATTS). Specifically, bonded underwear fabric specimens were placed in an artificial sweat environment and subjected to moist heat conditions at 70°C and 90% relative humidity (RH) for up to 10 days. Peel strength was measured before and after exposure, and strength retention was calculated as a function of exposure time.

Fig. 4 shows the results. While MPT-500 maintained high strength retention regardless of the number of days, HM adhesive showed high strength retention after 1 day of moist heat stress but its strength retention dropped sharply as the number of days increased, reaching around 10% after 10 days. GPC measurement of the HM adhesive recovered from the test piece after the test showed that its molecular weight had decreased to about half its original value. This suggests that hydrolysis is the cause of the decrease in strength of the HM adhesive.

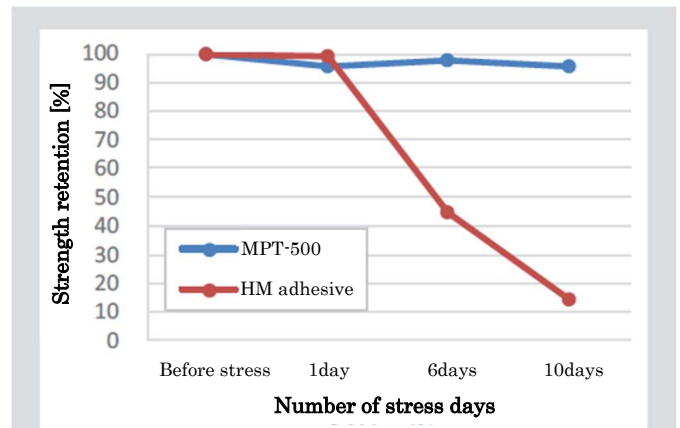


Figure 4: Changes in strength retention in accelerated deterioration test

Environment: Artificial sweat solution, humid heat conditions: 70°C, 90% RH

4. Conclusion and future prospects

4.1 Characteristics of MPT-500

This newly developed product is a pressure-sensitive adhesive for textile materials, and it shows high adhesion to fabrics for underwear and winter clothes. It also has good texture (flexibility and elasticity) at the bonded area and excellent durability (resistance to yellowing and aging).

4.2 Introduction of the grades

The grades we offer include MPT-500, which is a solution type, and MF-500, which is a film type made by film formation with MPT-500. In addition, we added to the lineup MF-500NTD, a grade that eliminates the surface tack (stickiness) characteristic of pressure-sensitive adhesives in response to requests from users of the film type (Table 3).

Grade	Product form	Remarks
MPT-500	Solution	Ethyl acetate solution with 40% solid content
MF-500	Film	MPT-500 film product
MF-500NTD	Film	Grade with reduced surface tack

4.3 Future prospects

Taking advantage of the above features, we will first expand our business to seamless clothing applications. In addition, this product may also be applicable to bonding non-apparel fabrics (such as nonwoven fabrics and artificial leather) and to bonding inorganic fiber materials such as glass fiber and metal fiber. We will pursue market development with a wide range of such applications in view.

Reference

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