

A Durable Hydrophilic Agent for Nonwoven Fabrics with Enhanced Repeated Liquid Permeation

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Nonwoven fabrics are sheet-like materials produced by bonding fibers, rather than weaving or knitting them. Their breathability, filtration, and heat retention properties make them suitable for various applications, including medical and hygiene products, as well as use in the automotive, agriculture, civil engineering, construction, and industrial sectors. The global nonwoven fabric market is projected to reach US\$57.14 billion in 2024, with an anticipated annual growth rate of approximately 6%^{1), 2)}.

Since 2019, domestic production of nonwoven fabrics in Japan has declined, according to the Ministry of Economy, Trade and Industry. However, while trade statistics from the Ministry of Finance indicate a significant import surplus by weight, the export-import value difference is small, suggesting that domestic nonwoven fabrics maintain competitiveness in high value-added markets.

Driven by rising birth rates in the Asia-Pacific region, especially in India and China, and the growing elderly population in countries like Japan, the demand for products such as baby diapers and adult incontinence products is expected to increase³⁾. This trend will like-

ly drive increased exports of high-value-added products and the expansion of overseas production.

Nonwoven Fabrics in Hygiene Products

Nonwoven fabrics are lightweight, versatile, and easily functionalized, leading to their widespread use across many industries. In particular, polyolefin nonwovens, such as those made from polypropylene (PP) or polyethylene (PE), and polyethylene terephthalate (PET) nonwovens are commonly used in hygiene products like diapers and sanitary products. This is due to their excellent breathability, flexibility, quick-drying ability, and soft texture.

However, the polymers used in polyolefin and PET nonwovens are inherently hydrophobic, meaning they repel water and impede its passage. This

can cause urine and menstrual fluid to spread, making hydrophilic treatment necessary. The duration of liquid permeability and the fabric's durability under repeated use significantly influence how often hygiene products need to be changed.

This article introduces HYDROTHROUGH PS-887, our durable hydrophilic agent for nonwoven fabrics, which enables nonwovens to maintain high hydrophilicity even after repeated fluid contact.

Hydrophilic Treatment of Nonwovens for Hygiene Products

Hygiene products must not only absorb and retain urine and menstrual blood within their absorbent core but also meet increasing consumer demands for functionality, comfort, convenience, and sustain-

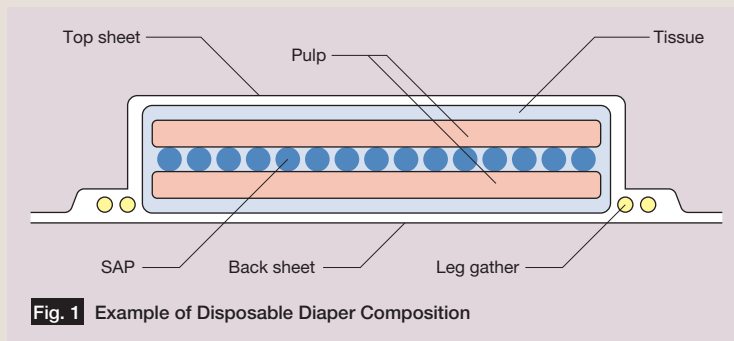


Fig. 1 Example of Disposable Diaper Composition

ability. These demands include preventing leaks during movement, quickly absorbing fluids, minimizing discomfort from rewetting or stuffiness, and allowing for extended wear. To achieve these performance requirements, nonwovens have undergone various technical innovations.

Hygiene products typically consist of an absorbent core, such as pulp or superabsorbent polymer (SAP), sandwiched between a water-permeable top sheet and a water-impermeable back sheet (Fig. 1).

Polyolefin nonwovens and PET nonwovens are frequently selected for top sheets because they offer excellent breathability, flexibility, quick-drying properties, and a soft feel against the skin. However, the hydrophobic nature of polyolefins and PET causes them to repel water, hindering its passage and leading to leakage, fluid retention, and discomfort for the user. Therefore, hydrophilic agents are applied to these nonwovens to make them water-attracting and enhance their ability to absorb fluids.

Conventional hydrophilic treatments often lose effectiveness after only one or two uses. Continued use can result in issues like fluid pooling, spreading, and leakage. This is because

fluids like urine gradually wash away the hydrophilic agent from the fiber toward the absorbent layer, reducing the nonwoven's hydrophilicity (Fig. 2).

When fluid pooling, spreading, or leakage occurs, disposable diapers or sanitary products must be replaced. Frequent changes are inconvenient and time-consuming for both users and caregivers. Moreover, changing hygiene products can be particularly challenging in places like workplaces, schools, or during travel. As a result, there's a growing need for hygiene products designed for longer wear, which reduces the frequency of changes.

HYDROTHROUGH PS-887: A Durable Hydrophilic Agent for Nonwoven Fabrics Enabling Repeated Liquid Permeation

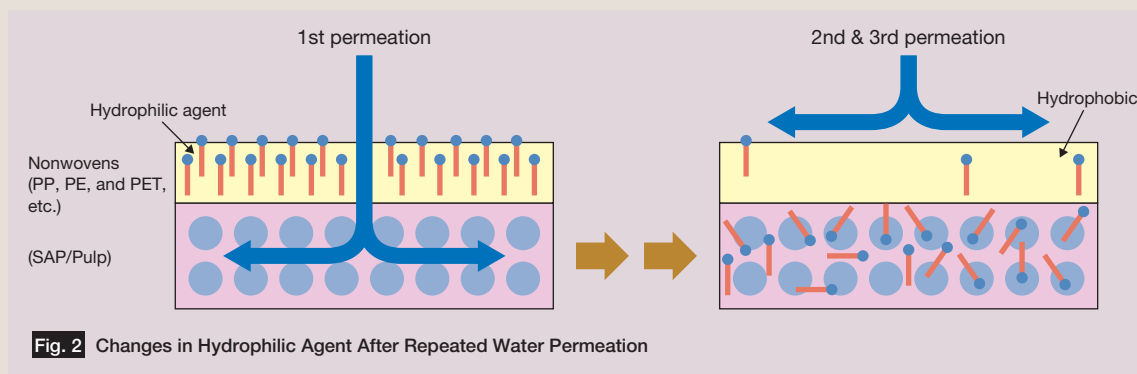
Leveraging our expertise in interfacial control technology, we developed HYDROTHROUGH PS-887, a durable hydrophilic agent that significantly enhances repeated liquid permeation in nonwoven fabrics compared to conventional agents. This improvement results from optimizing the balance of hydrophilic groups, which enhance water-permeability in polyolefin and PET nonwovens, and

hydrophobic groups, which ensure long-lasting hydrophilicity. HYDROTHROUGH PS-887 also exhibits excellent fiber penetration, enabling uniform deposition even at low dosages and preserving the inherent softness of polyolefin and PET nonwovens. When used as a top sheet in hygiene products, nonwovens treated with HYDROTHROUGH PS-887 offer a comfortable feel, even with less frequent changes. This translates to improved usability and user satisfaction, while also providing economic benefits by reducing waste and lowering environmental impact. Furthermore, the highly concentrated formulation of HYDROTHROUGH PS-887, designed for dilution before use, helps to reduce transportation costs. Despite its high concentration, HYDROTHROUGH PS-887 is a low-viscosity, oil-like liquid with

Table 1 Typical Properties of HYDROTHROUGH PS-887

Analysis Items	HYDROTHROUGH PS-887
Appearance	Pale yellow liquid
Active Ingredient	Approximately 80%
pH (1% Emulsion)	Approximately 6.5
Viscosity	Approximately 200 mPa-s

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excellent self-emulsifying properties, ensuring ease of handling (Table 1).

Performance Evaluation of HYDROTHROUGH PS-887

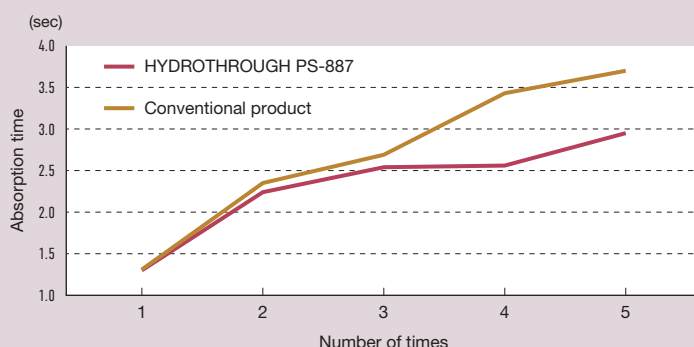
The results of the "repeated liquid strike-through time" test (conducted according to EDANA WSP 70.7) are shown in Figure 3 and Table 2. In this test, using a Lister tester, filter paper was placed beneath the nonwoven fabric, and 5 mL of saline solution was passed through both. The absorption time was measured; lower values indicate faster absorption. Compared to fabric treated with a conventional product, the nonwoven fabric treated with HYDROTHROUGH PS-887 demonstrated a consistently faster absorption rate across repeated liquid strikes, confirming its high "repeated water permeability."

Furthermore, we conducted another evaluation of "repeated water permeability" (Figure 4). This involved repeatedly performing the following operation five times: a single drop of saline solution was placed on each of 10 arbitrary points on the nonwoven fabric, and the number of drops absorbed within 5 seconds was counted. Before the second and subsequent rounds, 50 mL of saline solution was poured

over the nonwoven fabric, and after wiping off any excess moisture, the test was repeated by placing a single drop of saline solution on each of the same points as in the first run and counting the number of absorbed droplets. In this test, a higher number of absorbed droplets indicates greater hydrophilicity. In other words, maintaining a high number of absorbed droplets even with repeated trials signifies sustained hydrophilicity.

ty. Because typical hydrophilic agents are washed away when 50 mL of saline solution is poured, the hydrophilicity decreases with repeated trials, resulting in a reduction in the number of absorbed droplets.

In contrast, the number of absorbed droplets decreased with each trial for conventional products, eventually resulting in no absorption by the fifth trial. However, the nonwoven fabric treated with HYDRO-

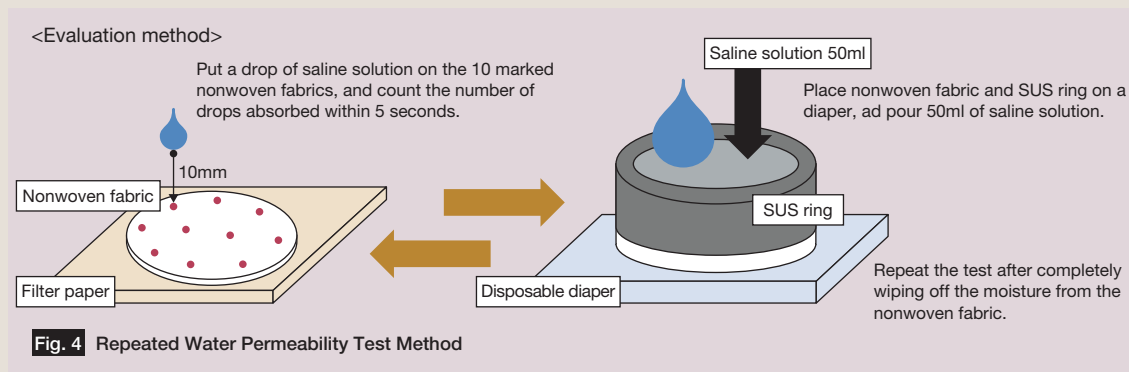


Amount of hydrophilic agent applied : approx. 0.5%
Nonwoven fabric: PP/PE core sheath air-through nonwoven fabric (23 g/m²)

Fig. 3 Repeated Water Permeability Evaluation

Table 2 Results of Repeated Water Permeability Evaluation

	Absorption time (sec)	
	HYDROTHROUGH PS-887	Conventional product
1st	1.30	1.31
2nd	2.24	2.35
3rd	2.54	2.69
4th	2.56	3.43
5th	2.95	3.70



THROUGH PS-887 absorbed all 10 droplets for the first three trials and still absorbed 7 droplets in the fifth trial, demonstrating its superior "repeated water permeability" (Figure 5).

Generally, hydrophilic agents that tend to remain on the surface of nonwoven fabrics improve repeated wettability. However, these agents also tend to retain moisture, leading to increased liquid residue. Excessive liquid residue can create a sticky feeling when hygiene products are used. Therefore, it is crucial to minimize liquid residue while maintaining high repeated

water permeability.

Figure 6 and Table 2 illustrate the results of the "repeated water permeability" test (based on EDANA WSP 70.7). In this test, filter paper was placed on a Lister testing machine, followed by the nonwoven fabric. Then, 5 mL of saline solution was passed through, and the time taken for the solution to be completely absorbed was measured. Lower values indicate faster absorption. The nonwoven fabric treated with HYDROTHROUGH PS-887 maintained a faster absorption rate compared to nonwoven fabric treat-

ed with a general-purpose agent, even after repeated permeation tests, demonstrating its superior "repeated water permeability."

Future Plans

Our newly developed HYDROTHROUGH PS-887 not only imparts durable hydrophilicity to hydrophobic nonwoven fabrics but also has the potential to improve antistatic properties by promoting the adsorption of water molecules on the fabric's surface. With these functionalities in mind, we intend to explore various applications in the future, aiming to contribute to improved comfort and reduced environmental impact.

References

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- 3) Nonwoven Fabrics Market Research - By Technology (Spunbond, Wetlaid), By Material (Polyester, Polypropylene, Polyethylene, Rayon), By End-user Industry - Global Demand and Supply Analysis and Opportunity Outlook 2023-2035 (Research Nester)

*The titles of these references have been directly translated from Japanese for informational purposes.

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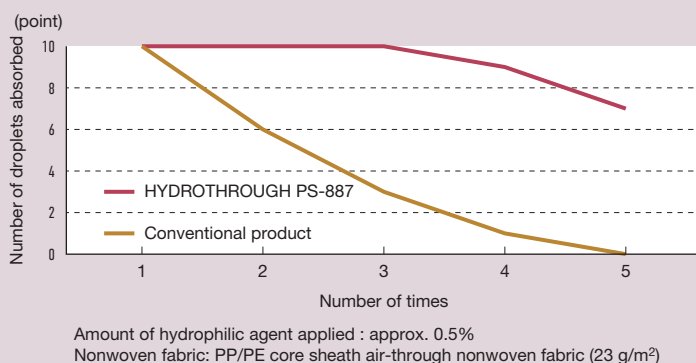


Fig. 5 Repeated Water Permeability Evaluation

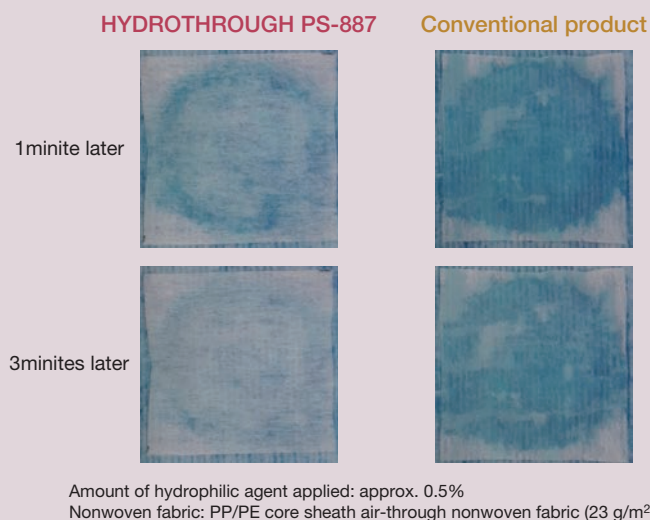


Fig. 6 Liquid Residue After Permeation (Lighter Blue Indicates Less Liquid Residue)