Development of Novel Rosin-Based Tackifiers

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1. Introduction

Rosin is a natural resin derived from pine trees and obtained from pine oleoresin. It has been widely used in a broad range of applications, including paper chemicals, printing inks, paints and coatings, pressure-sensitive and structural adhesives, and soldering materials. As a non-edible, carbon-neutral, and environmentally friendly material. For these reasons, rosin has recently attracted increasing attention.

In adhesive and pressure-sensitive adhesive applications, rosin derivatives are commonly used as tackifiers. Tackifiers are amorphous oligomeric materials with molecular weights typically ranging from several hundred to several thousand. When blended with elastomers, they impart tackiness and enhance adhesive and bonding performance.

Tackifiers are formulated into adhesives used for pressure-sensitive tapes and labels, as well as for applications such as corrugated box sealing, diaper assembly, bookbinding, and flooring installation. In addition, for optical and electronic material applications, there is a growing demand for rosin derivatives of particularly high quality.

In response to these needs, our company has been actively developing tackifiers that not only exhibit the performance of conventional products but also meet the requirements of newly emerging specialized applications. This paper introduces a newly developed rosin-based tackifier.

2. Ultra-Light-Color, High-Polarity Tackifier “PINECRYSTAL D-6021”

Conventional rosin derivatives are typically amber-colored resins and therefore have not been considered suitable materials for applications in which transparency and durability are critical, such as optical pressure-sensitive adhesives.

Our *PINECRYSTAL* series consists of ultra-light-color rosin derivatives. Similar to conventional rosin-based tackifiers, these materials exhibit good compatibility with a wide range of base polymers, including acrylics, ethylene–vinyl acetate (EVA), polyamides, and various rubbers. In addition, the *PINECRYSTAL* series offers excellent stability and contains lower levels of metallic impurities compared with conventional rosin derivatives. As a result, these materials can be used in optical pressure-sensitive and adhesive applications where the incorporation of rosin-based tackifiers has previously been difficult.

Acrylic pressure-sensitive adhesives generally exhibit excellent adhesion to highly polar substrates such as metals and glass; however, their adhesion to low-polarity substrates such as polyolefins is often insufficient. To enhance adhesion to low-polarity substrates, rosin-based tackifiers are commonly added. In optical and electronic material applications, however, substrates are frequently metals or glass, and further enhancement of adhesion to highly polar substrates is required.

The existing PINECRYSTAL series can sufficiently enhance tack performance on low-polarity substrates such as polyolefins; however, its tack performance on relatively high-polarity substrates such as metals and glass has not always been adequate. Furthermore, in optical and electronic material applications, extremely low acid values are required for tackifiers due to concerns regarding metal corrosion, making it difficult for the existing PINECRYSTAL series to meet these stringent requirements.

PINECRYSTAL D-6021 was developed to address these challenges. The physical properties of *PINECRYSTAL D-6021* are summarized in Table 1. For conventional rosin-based tackifiers, it is difficult to reduce the acid value to near 0 mgKOH/g. In contrast, *PINECRYSTAL D-6021*, while being a rosin-based tackifier, achieves an acid value of less than 1 mgKOH/g. At the same time, it exhibits a hydroxyl value of 160 mgKOH/g, indicating its high polarity. Consequently, as shown in Table 2, *PINECRYSTAL D-6021* demonstrates higher solubility in polar solvents compared with KE-311, a rosin ester in the same *PINECRYSTAL* series.

Table 1. Typical Properties of PINECRYSTAL D-6021

Item	PINECRYSTAL D-6021	PINECRYSTAL KE-311
Appearance	Pale yellow transparent	Pale yellow transparent
Color [Hazen]	180	30
Acid Value [mgKOH/g]	**< 1**	5
Softening Point [℃]	100	96
Hydroxyl Value [mgKOH/g]	**160**	10

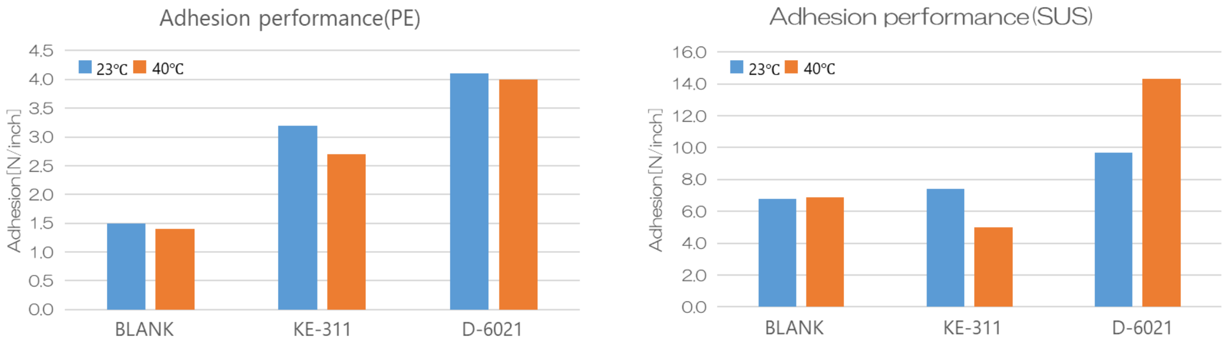
Table 2. Solvent Solubility of PINECRYSTAL D-6021

Product	n-Hexane	Xylene	THF	Ethyl Acetate	Acetone	IPA
D-6021	×	○	○	○	○	○
KE-311	○	○	○	○	○	×

THF: tetrahydrofuran, IPA: isopropanol

Figure 1 shows the adhesion strength of PINECRYSTAL D-6021 to polyethylene (PE) and stainless steel (SUS) when added to a solvent-based acrylic pressure-sensitive adhesive. Compared with the formulation without a tackifier, enhanced adhesion is observed for both olefin-based and metallic substrates. In addition, PINECRYSTAL D-6021 has a higher hydroxyl value than KE-311 and therefore exhibits higher polarity. As a result, it shows particularly excellent adhesion to metallic substrates, which also have high polarity. Consequently, the addition of PINECRYSTAL D-6021 can serve as a tackifier that significantly enhances adhesion to high-polarity substrates such as metals and glass.

Figure 1. Effect of PINECRYSTAL D-6021 Addition to a Solvent-Based Acrylic Pressure-Sensitive Adhesive



Base resin: butyl acrylate–rich polymer / tackifier / crosslinking agent = 90 / 10 / 0.3
Substrate: PET film (dry film thickness: approximately 50 µm)
Adherends: polyethylene (PE) sheet, stainless steel (SUS) sheet
Adhesion strength: 180° peel strength measured at 23 °C and 40 °C; tensile speed: 300 mm/min

3. Low Polymerization-Inhibiting Tackifiers for UV-Curable Hot-Melt Pressure-Sensitive Adhesives: "PENSEL GF Series"

In recent years, the use of pressure-sensitive adhesives has increasingly shifted toward solvent-free systems in order to reduce environmental impact and mitigate health risks to workers and consumers. As a result, the use of solvent-free UV-curable hot-melt pressure-sensitive adhesives has been growing. However, conventional rosin-based tackifiers exhibit strong polymerization-inhibiting effects, which has posed challenges when they are used in UV-curable hot-melt pressure-sensitive adhesives.

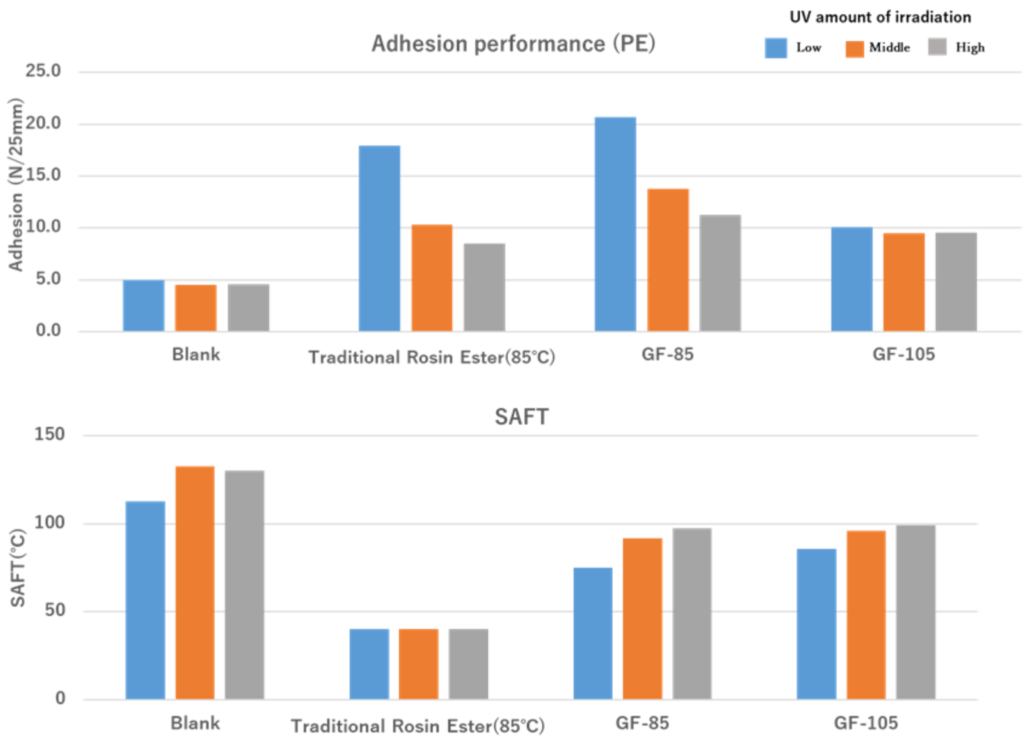
The newly developed *PENSEL GF* series is characterized by its low polymerization-inhibiting properties. Table 3 summarizes the physical properties of the *PENSEL GF* series, and Figure 2 presents fundamental data on tackifier performance when added to UV-curable hot-melt pressure-sensitive adhesives. These results show that the addition of a rosin-based tackifier significantly enhances adhesion to polyethylene. However, when a conventional rosin ester is used, elevated-temperature creep resistance (holding power) is markedly reduced due to polymerization inhibition.

In contrast, the *PENSEL GF* series exhibits significantly lower polymerization-inhibiting behavior compared with conventional rosin esters, and consequently, the reduction in holding power is substantially mitigated. Based on these results, the *PENSEL GF* series can be regarded as a tackifier that enables both enhanced adhesion strength and maintained holding power in UV-curable hot-melt pressure-sensitive adhesives.

Table 3. Typical Properties of the PENSEL GF Series

Item	GF-85	GF-105
Appearance	Pale yellow	Pale yellow
Color [G]	4	6
50% Tol. Color [G]	2	5
Acid Value	10	15
Softening Pt. [℃]	90	105

Figure 2. Effect of Addition to a UV-Curable Hot-Melt Pressure-Sensitive Adhesive



Base resin: commercially available UV-curable hot-melt acrylic pressure-sensitive adhesive / tackifier = 90 / 10

Substrate: PET film (thickness: approximately 30 µm); UV irradiation applied at three different exposure doses
Adhesion strength: 180° peel strength at 23 °C; tensile speed: 300 mm/min
Adherend: polyethylene (PE) sheet
Elevated-temperature creep: stainless steel (SUS) plate as adherend; load: 1 kg; temperature increased from 40 °C at a rate of 2 °C/min, and the failure temperature was evaluated

In addition, even for conventional solvent-based pressure-sensitive adhesives, there has recently been an increasing demand for low VOC emissions and low odors from the standpoint of reducing health risks to consumers. The *PENSEL GF* series is also characterized by its low-VOC and low-odor properties. Accordingly, it is introduced here together with *PENSEL D-125V*, a tackifier that likewise exhibits low-VOC characteristics.

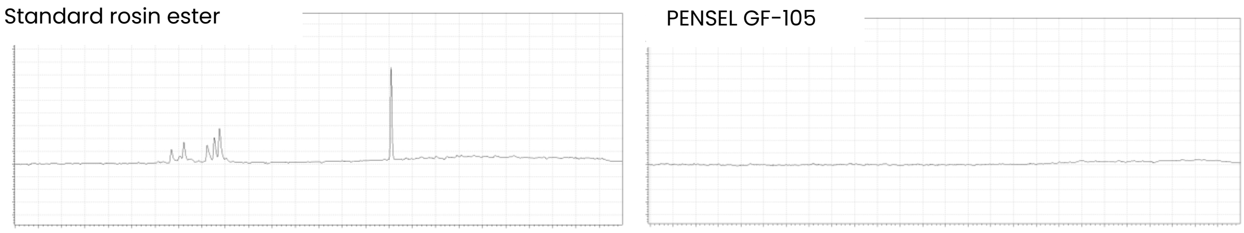
4. Low-VOC Tackifiers: "PENSEL GF" and "PENSEL D-125V"

In addition to the growing demand for low-VOC pressure-sensitive adhesives, even slight odor can become an issue in applications such as automotive interiors and building materials. Consequently, requirements have increased not only for low VOC emissions but also for low odor. For such adhesive and pressure-sensitive adhesive systems, tackifiers are likewise required to exhibit low-VOC and low-odor characteristics.

Our low-VOC and low-odor tackifiers include the previously introduced *PENSEL GF* series, as well as *PENSEL D-125V*, a high–softening point type tackifier. Figure 3 shows the results of VOC measurements conducted using headspace gas chromatography (GC) in accordance with VDA 277, a standardized VOC measurement method specified by the German Association of the Automotive Industry (VDA). Compared with a conventional rosin ester, the *PENSEL GF* series and *PENSEL D-125V* show a significant reduction in components eluting at column temperatures above 100 °C, achieving more than a 90% reduction in VOC components relative to the conventional rosin ester. These results indicate that our low-VOC tackifiers are suitable for applications requiring stringent VOC control, such as automotive interior materials, and are also expected to contribute to odor reduction.

Figure 3. Headspace GC Analysis of VOC Components (Column Temperature ≥ 100 °C)

Product Type	VOC Content (%)
Standard rosin ester	100
PENSEL D-125V	**5**
PENSEL GF-105	**3**
PENSEL GF-85	**9**



5. Conclusion

Rosin derivatives have long been widely used as tackifiers that exhibit excellent performance. In recent years, however, growing emphasis on reduced environmental impact and the transition away from fossil-based resources has drawn increased attention to rosin derivatives as biomass-based materials. In this paper, we have introduced rosin-based tackifiers that offer not only the advantage of being biomass-derived materials but also superior functionality. As a manufacturer of rosin derivatives—materials that are attracting attention for their relevance to the Sustainable Development Goals (SDGs)—we intend to continue proposing new rosin derivatives and thereby contribute to the development of a wide range of industries.