Longer-lasting wood coatings with waterborne UV-curing technology

How **Bayhydrol® UV 2901** provides the freedom to formulate wood coatings with high hardness as well as chemical, blocking, and scratch resistance

Bayhydrol®

covestro

How Covestro developed a solution to improve wood coating resistance, sustainability, and productivity

Covestro applied its industrial expertise in high-tech radiation curing to develop an innovative UV-curable waterborne polyurethane dispersion that improves both performance and productivity at the right cost level. With **Bayhydrol® UV 2901**, wood coatings manufacturers gain the productivity and sustainability benefits of both UV-curing and waterborne technology.

Due to its faster curing and lower energy consumption, **Bayhydrol® UV 2901**'s UV-curing technology enables high-performance, efficient coating systems. In addition, its waterborne technology enables solutions that are easy to down-gloss, low in volatile organic compounds (VOCs), less toxic, and can be applied by spraying thanks to their lower viscosity.

Key finding: Bayhydrol® UV 2901 delivers durability and formulation flexibility

Bayhydrol® UV 2901 greatly improves hardness as well as chemical, blocking, and scratch resistance. These benefits are achieved whether it is used as a standalone coating agent, as a booster to existing UV-curable coatings, or in dual-cure systems, providing manufacturers with greater formulation flexibility.

Key benefits of Bayhydrol® UV 2901

- High double-bond density, providing outstanding durability compared to other UV-curable resins.
- Very high hardness, as well as chemical and scratch resistance.
- Improved blocking resistance when used as booster resin.
- Increased productivity thanks to fast water release and high reactivity.
- No physical drying required before curing.

Growing demand for more sustainable wood coatings

In the industrial wood coatings sector, the growth of waterborne (WB) dispersions and UV-curing technology is mainly driven by VOC regulations and end-consumer demand for more sustainable wood furniture. However, compared to solventborne UV coatings, conventional UV-curable waterborne coatings have so far provided only moderate performance in water, chemical, and scratch resistance.

In commercial use in Europe since the mid-1960s, UV-curing technology has many application areas, such as inks, coatings, and 3D coatings. The market for UV-curable dispersions is expected to grow in Europe by about 3-4% per year from 2021-2026 (IHS Markit - Coatings, radiation-curable, December 2021).

However, the moderate performance of conventional UV-curable waterborne coatings has limited their application in certain fields. Furthermore, conventional waterborne systems require a drying step before curing, limiting productivity. It is therefore important to investigate how to improve the performance and productivity of UV-curable waterborne dispersions. This would enable wood coating manufacturers to gain from sustainability, productivity, and performance benefits.

Achieving greater durability with Bayhydrol® UV 2901

In this internal study, Covestro tested the performance of its innovative **Bayhydrol® UV 2901** waterborne, UV-curable polyurethane dispersion (PUD) when used as a standalone coating agent, as a booster to existing UV-curable coatings, and in dual-cure systems. By combining high double-bond density, fast water release, and high reactivity, **Bayhydrol® UV 2901** provides improved sustainability and productivity compared to standard solventborne technologies, and improved productivity and performance compared to standard waterborne technologies. It offers these benefits at a suitable price point for the wood coatings industry.

Developing an innovative wood-coating solution

Poor durability of conventional waterborne UV-curable dispersions could be related to low double-bond content and high molecular weight, resulting in a low crosslink density after UV curing. Increasing double-bond content was therefore a high priority when developing **Bayhydrol® UV 2901**. Other parameters were also targeted for improvement, including physical drying and dispersion stability.

Achieving high double-bond content

Double-bond content can be increased by blending with either high-functional UV monomers or oligomers. As such, the first step in developing **Bayhydrol® UV 2901** was an extensive study that identified the structure and amount of reactive diluent needed to achieve the desired double-bond content (see Figure 1).

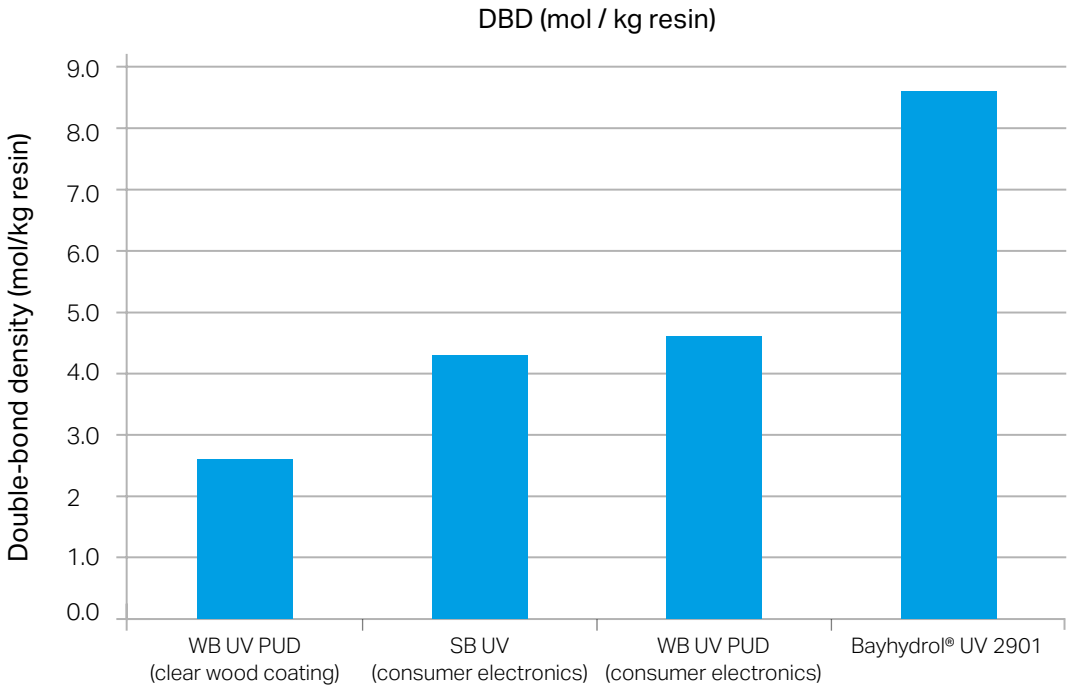

Figure 1. Double-bond density of the new waterborne UV PUD compared to other conventional UV systems for wood coatings and consumer electronics.

Using **Bayhydrol® UV 2901** to enable greater formulation flexibility

The result of the development process was a waterborne, UV-curable dispersion that could be used by manufacturers in varied ways, providing greater formulation flexibility. **Bayhydrol® UV 2901** was therefore tested internally as a standalone binder, in blends with acrylic dispersions and dual-cure systems, and as a booster to already-existing UV-curable dispersions for its improvement of hardness and chemical, blocking, and scratch resistance. The results are outlined below.

Performance as a standalone binder

The high double-bond density of **Bayhydrol® UV 2901** provides extremely high hardness, as well as chemical and scratch resistance. After a photoinitiator is added, it displays a König hardness of more than 160 seconds and a pencil hardness of 3H.

When formulated alone into a white matt coating with 3% silica matting agent and 30% white pigment paste, it achieves an R0 chemical resistance rating per IKEA IOS-MAT-0066 or DIN 68861-B1 even on the pigmented coating. This is the highest rating, passing resistance against coffee, red wine, black tea, and ethanol (see Table 1).

Test liquid	Test period	Rating
Chemical resistance according to IKEA Class R2		
Water	24h	5
Ethanol, 48%	1h	5
Coffee	1h	5
Paraffin oil	24h	5
Chemical resistance according to IKEA Class R0		
Water	24h	5
Ethanol, 48%	6h	5
Coffee	6h	5
Paraffin oil	24h	5
Chemical resistance according to DIN68861-Class 1B		
Mustard	6h	5
Red wine	6h	5

Table 1. Chemical resistance of the new UV PUD according to DIN 12720, as performed on applied beech veneer. (5: best; no detectable change). Drying for 10 minutes at 50°C and curing under Ga/Hg lamps at 80W/cm² (total energy approx. 1,950mJ/cm²)

Although the new **Bayhydrol® UV 2901** PUD dispersion shows very high performance as a standalone binder, the product is very hard and could, in some cases, be too rigid – for example, on flexible substrates such as wood. However, this high-end performance could be utilized to enhance the properties of conventional resins when blended with **Bayhydrol® UV 2901**. Therefore, a second possible use of this new product, namely as a blending partner/booster for other resins, was explored as well. This alternative also opens possibilities for using partially biobased resins as blending partners, which would enable the formulation of partially biobased waterborne UV-curable systems.

Performance in combination with acrylic dispersions

Conventional 1K waterborne acrylic dispersions can also be turned into UV-curable solutions by adding 20-30% **Bayhydrol® UV 2901** content, improving productivity and performance. The effects of adding the new dispersion were studied using a simple coating formulation including photoinitiator (HMPP) cosolvent (PnB) and the different acrylic resins (PAC1-4).

There were no compatibility problems with any of the tested blends, and high stability in all cases. The addition of **Bayhydrol® UV 2901** resulted in clear improvements in chemical resistance (see Figure 2) and blocking resistance (see Figure 3), as well as sandability after curing. Chemical resistance was increased especially against coffee and wine stains, a critical benefit for wood furniture.

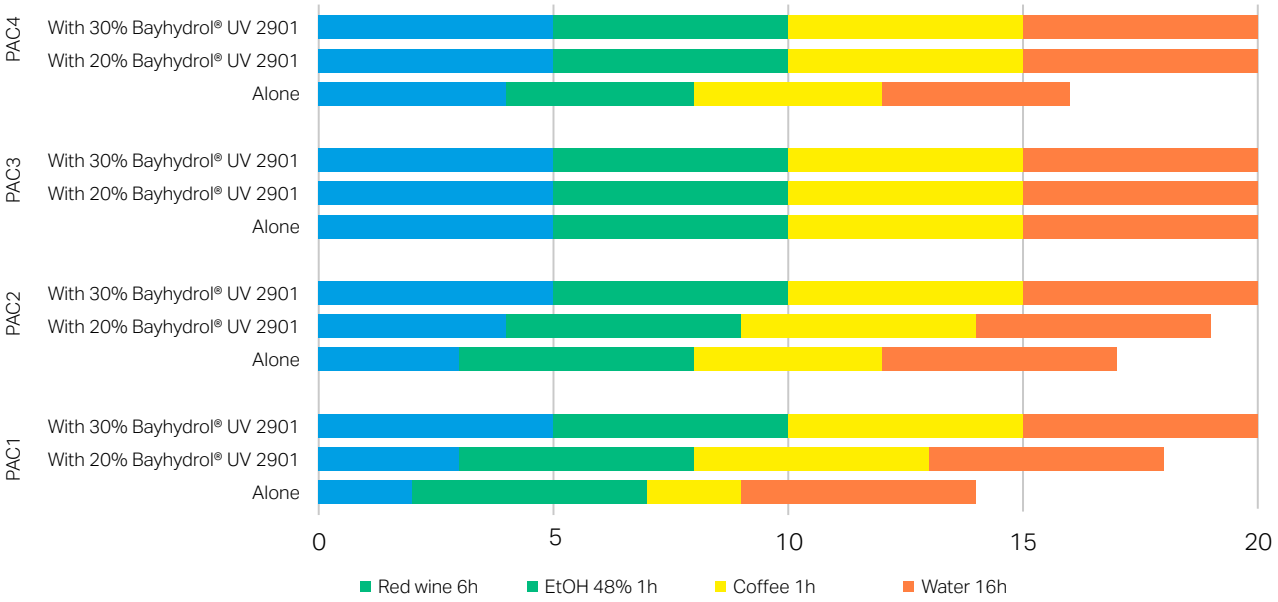

Figure 2. Chemical resistance on a beech panel of a 2-layer clear coating (2x90g/m²) based on different acrylic dispersions blended with **Bayhydrol® UV 2901** and evaluated according to DIN 12720. (5: best; 1: worst). Drying 10 minutes at 50°C; UV curing with Hg lamp (650 mJ/cm²).

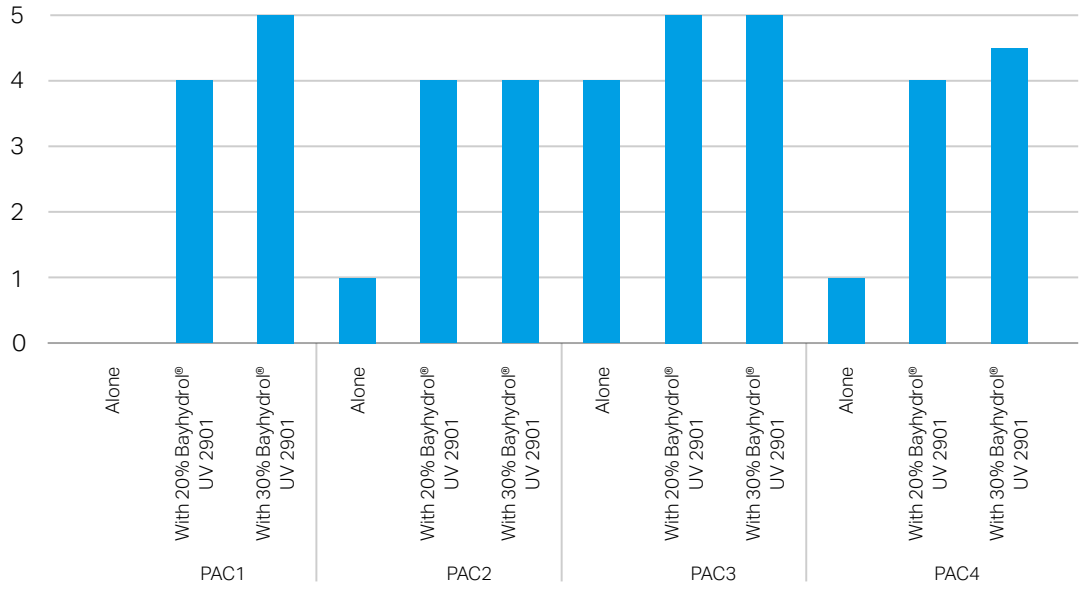

Figure 3. Blocking resistance of different acrylic dispersions before and after addition of 20% and 30% of **Bayhydrol® UV 2901**. Blocking tested on melamine panels after exiting the tunnel, overnight at RT with a weight of 100g/cm². (0: panels sticking; 5: panels separated with no marks). Drying 10 minutes at 50°C; UV curing with Hg lamp (650 mJ/cm²).

In combination with partially biobased acrylic dispersions

A biobased acrylic resin (Bio-PAC) could also be used as a blending partner. The acrylic used has 30% biobased content. Adding 10% of **Bayhydrol® UV 2901** resulted in a final product with 27% biobased content. Furthermore, the addition of the UV-curable resin improved the coffee resistance of the system (Figure 4) and improved the blocking resistance after drying/curing.

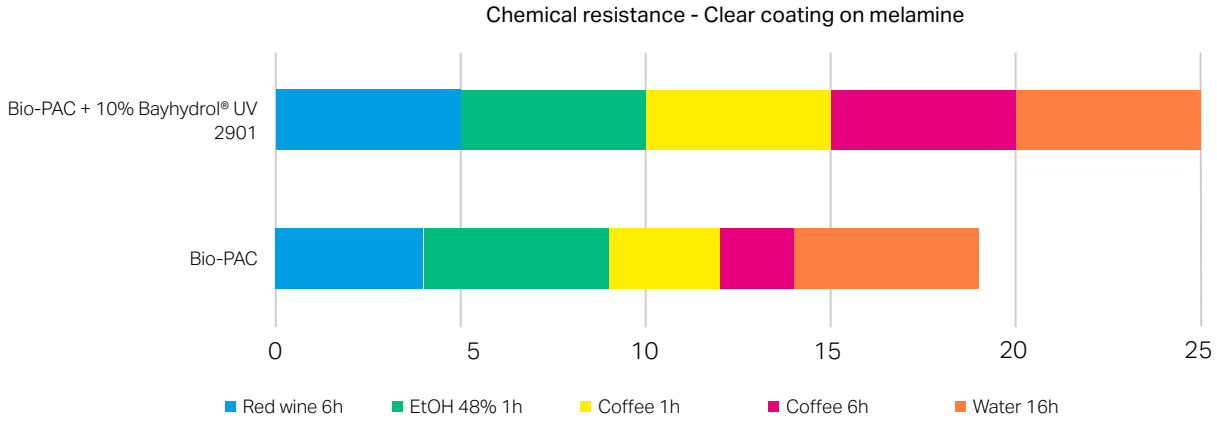

Figure 4. Chemical resistance on a melamine panel of a 2-layer clear coating (1x90g/m²) based on a partially biobased acrylic dispersion blended with **Bayhydrol® UV 2901** and evaluated according to DIN 12720. (5: best; 1: worst). Drying 10 minutes at 50°C; UV curing with Hg lamp (650 mJ/cm²).

Performance as a booster in UV-curable dispersions

As mentioned, a third option would be to boost waterborne UV-curable systems. When blended at 20-30% into existing WB UV PUDs, **Bayhydrol® UV 2901** substantially increases their chemical resistance and resistance to stains like coffee and wine, while maintaining other desirable properties like hardness and appearance (Figure 5). In the same way, if the system used contains biobased raw materials like UV-bio-PUD, this enables the formulation of a high-performance, partially biobased, UV-curable system.

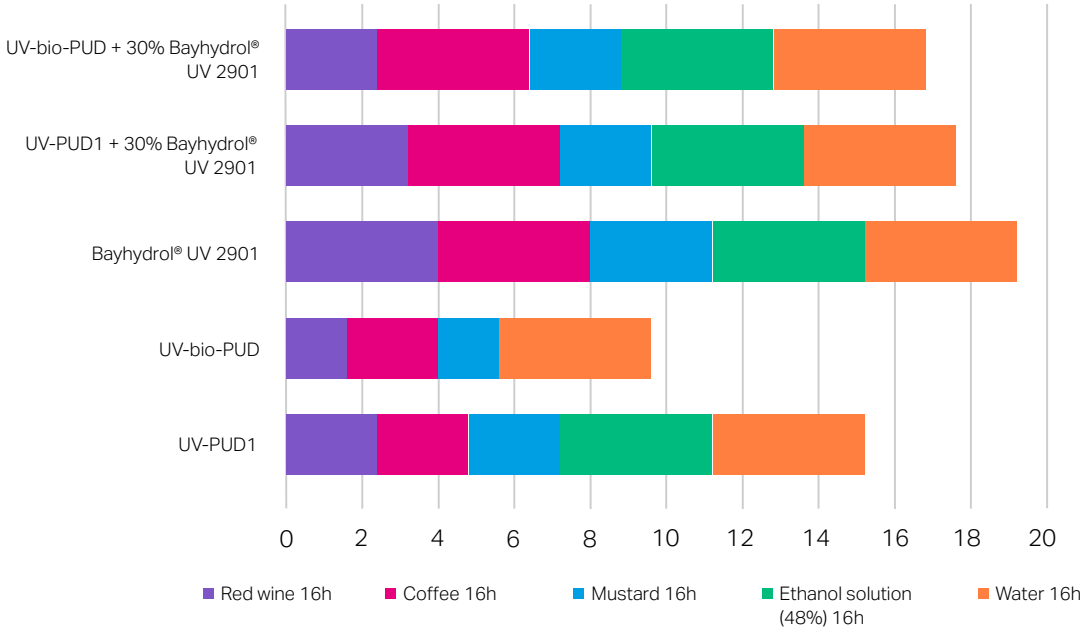

Figure 5. Comparison of the chemical resistance of white pigmented WB UV-curable coatings (two 90g/m² layers on a beech panel) according to DIN 12720. Dried for 10 minutes at 50°C and then cured with Hg and Ga lamps at 80W/cm² and a belt speed of 3m/minute.

Conclusion

Bayhydrol® UV 2901 in multiple formulations means more durable wood coatings

Based on the strengths of waterborne and UV-curing technology, **Bayhydrol® UV 2901** means wood coating manufacturers can simultaneously improve performance, sustainability, and productivity. The balance of this performance with the right cost level further enables manufacturers to develop formulations according to their needs, using **Bayhydrol® UV 2901** as a standalone binder, as a booster to existing solutions, or in blends with acrylic dispersions and in dual-cure systems.

Covestro is one of the world's leading polymer companies

With sales of EUR 14.4 billion in the fiscal year of 2023, with 48 production sites worldwide and approximately 17,500 employees, Covestro is among the world's largest polymer companies. Its business activities focus on the manufacture of high-tech polymer materials and the development of innovative, sustainable solutions to the greatest challenges of our time. Covestro is focusing its efforts on the Circular Economy and renewable energy is a major driver for the company.

For the wood coatings industry in particular, Covestro is striving for more sustainable, cost-effective, and high-performance solutions to support the transition from solventborne systems to waterborne dispersions. The company leverages its global materials and processing expertise for this purpose.

If you're interested in the waterborne UV-curing dispersion highlighted in this paper, it's available as **Bayhydrol® UV 2901**.

If you're interested, please **contact us via these pages –** where you can also learn more about our portfolio of solutions for wood coatings: solutions.covestro.com/en/industries/wood-and-furniture and solutions.covestro.com/en/digital-event-space/status-next/industries/wood-and-furniture.

Edition: 2022 · Printed in Germany

Covestro Deutschland AG
Kaiser-Wilhelm-Allee 60
51373 Leverkusen
Germany

www.covestro.com