Opening new horizons in powder coatings for heat-sensitive substrates

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Powder Coating on Heat-Sensitive Substrates Covestro

For decades, the possibilities for powder-coating heat-sensitive substrates (HSS) were limited. Now, thanks to innovative low-temperature-curing solutions, the economic, functional, and environmental benefits of powder coating are open to a much broader application field.

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Like many other industries, the paints and coatings industry is facing strong pressure – from customers and regulatory bodies alike – to improve its environmental profile and help ensure high living standards without compromising the ability of future generations to do the same. In particular, coating and paint solutions must not only increasingly mitigate natural resource depletion, but also enable their users to lower their carbon footprints. While these efforts take many forms, something that could have a particularly significant impact is the wider adoption of powder coating.

Already a well-established technique for metal substrates, powder coatings can enable significant carbon emission reductions because they don't need to be diluted with any volatile organic compounds (VOCs) containing solvents. Indeed, a Covestro lifecycle assessment for various coating systems found that powder coating enabled a carbon footprint reduction of up to 75% compared with traditional solventborne polyester systems (Figure 1).

What's more, a high proportion of the powder used during the process goes toward the final coating, and any overspray can often be recycled, helping to reduce waste. In addition to these environmental advantages, powder coating also has proven commercial benefits. Applicators have claimed that powder can coat substrates up to 10 times faster when compared to liquid coatings, often in a single layer, with no need for long drying times. This results in higher productivity and reduced labour costs. Its low material waste also gives powder coating a high material efficiency. Together, these features enable a lower cost per square meter than for liquid coatings.

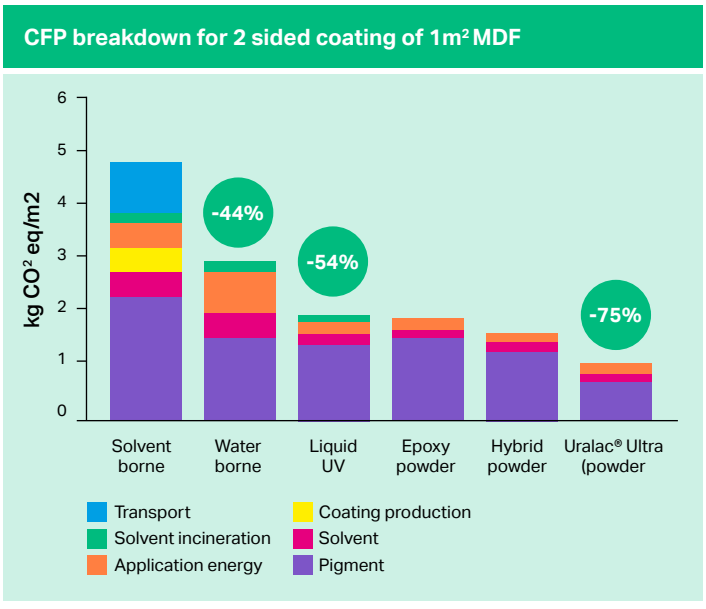

Figure 1. Carbon footprint of different coatings on a double-sided 1m² MDF sample

Next to this, powder coating also delivers durable, protective coating finishes. And, unlike liquid coatings, powder can be applied in a single layer, eliminating the need for a sanding stage between layers. This makes it easier to coat complex shapes. On top of this, powder coating can also produce differentiating textures, looks, and feels.

Heat-sensitive substrates: The next key challenge

But, for these advantages to make a wider impact across the coatings industry, powder coating technology will need to become applicable across a broader range of substrates and markets. And, until recently, several challenges have remained for application on non-metal substrates. Specifically, the high curing temperatures (180-200°C) required for powder coating have traditionally limited its use on heat-sensitive substrates (HSS) such as wood and engineered wood. Several coating and resin manufacturers have tried to develop solutions to this challenge. In the mid-1990s, for instance, several manufacturers developed UV-curable solutions. However, market uptake at the time was minimal; challenges with colors, inter-coat adhesion, and shadow spots needed to be solved. (Today interest in UV-curable powder coatings is growing again).

After this, in the early 2000s, manufacturers began to experiment with low-bake thermo-curing powders, which cured in a single layer at 150-170°C in 10-20 minutes. This had some success, but it was limited because the powders and oven conditions were designed for metal. The biggest breakthrough in this decade (in the mid-2000s) was the introduction of infra-red (IR) ovens that could be combined with low-bake, two-layer powder coatings.

Breakthrough low-bake solutions for HSS powder coating

Then, in 2013, coating resins supplier Covestro launched Uralac® Ultra on the market: a solution that cures at 130°C – the company's lowest-yet curing temperature – in just three minutes. This breakthrough was enabled by the resin's unique technology. Unlike the largely amorphous binder systems of traditional powder coatings, **Uralac® Ultra** uses an unsaturated, polyester-vinylether-based thermosetting system. The base of this system is a semi-crystalline binder combined with radical peroxide-curing chemistry.

In traditional powder coatings, the glass-transition temperature (Tg) of the binder plays a significant role in determining the flow of the final coating. Reducing the Tg improves this flow but sacrifices the powder's physical stability. By contrast, the crystalline part of the **Uralac® Ultra** binders enables a physically stable powder at room temperature, with a large drop in viscosity at the crystalline material's melting temperature. This makes it possible to achieve an exceptional flow at a temperature suitable for HSS. Combined with the right selection of peroxides, this technology makes a well-flowing, fast-curing system a reality.

As a result, **Uralac® Ultra** can coat a wide range of substrates – including MDF and solid wood. This solution has now been used for more than seven years by major furniture retailers on large production lines where safety, cost-efficiency, productivity, and reliability are essential. The product range and its special binders offer tremendous freedom – as well as meeting performance requirements – for product designers in a variety of end-applications. These applications include furniture (such as kitchen furniture, office furniture, children's furniture, and bathroom furniture) and building and construction items. The range also offers possibilities for a wide variety of finishes, including smooth, texture, transparent, and sandable primers.

To keep up with demand for two-layer solutions, Covestro also developed the still-growing Uralac® Engain portfolio in 2020. The technology for this portfolio uses an epoxy-based primer followed by a hybrid epoxy-polyester topcoat, cured in an IR oven. To meet a wide span of application requirements, the portfolio contains several solutions with varying reactivity levels and Tgs, from 53°C to 67°C. All cure in three to four minutes at temperatures between 140°C – 160°C, and their properties include good storage stability and flow.

As shown in Figure 2, both the Ultra and Engain portfolios deliver better performance – in particular, chemical and moisture resistance and nail scratch resistance- when compared with other benchmark coating systems. And, most importantly, all of these properties are made possible by a low-carbon-footprint, efficient application process.

Performance of Covestro's low-bake (Ultra) and two-layer (Engain)

	2K waterborne acrylic	Solventborne	Waterborne UV	Ultra powder coating	2-layer hybrid powder coating
Appearance	Smooth or texture	Smooth or texture	Smooth or texture	Smooth or texture	Texture
Chemical resistance	+/-	++	++	++	++
Nail scratch resistance	--	-	-	+/-	+/-
Humidity/ moisture resistance	-+	-+	-+	++	++
Process efficency	-	--	+/-	++	+
Carbon footprint kg eq/m² coated substrate	3,1	4,7	1,7	1,0	1,5

Figure 2. Performance of Covestro's low-bake (Ultra) and two-layer (Engain) powder coating solutions, compared with other benchmark coating systems.

Can be repeated in case of 2-layer application

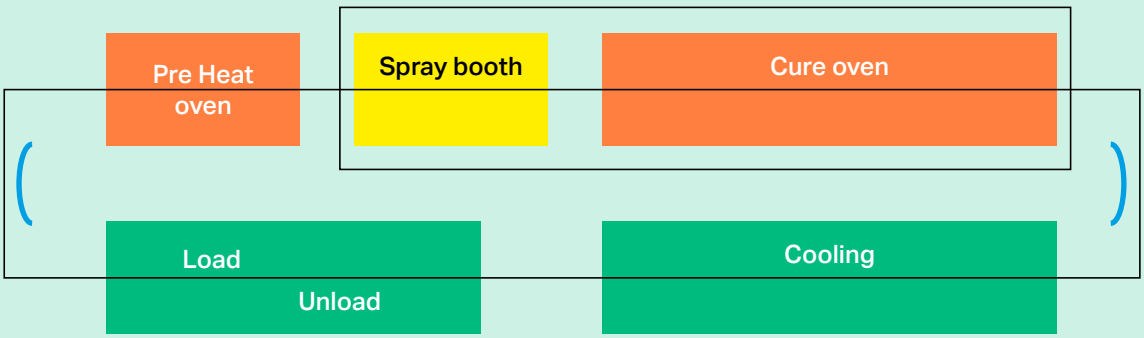

Figure 3. A typical MDF powder coating line

How does powder coating on wood work?

Compared to sprayed liquid coatings, powder coating application on HSS is a simple process: all six sides of an MDF panel can be covered in a single run. Typically, a powder coating line contains a conveyer belt, application booth, and two infrared ovens, which can be powered either by electricity or by a gas catalyst (Figure 3). The substrate is loaded on the conveyor belt and activated in a pre-heating oven, where its conductivity, especially around the edges, is enhanced. This enables an even layer of powder to be applied in the spray booth with electrostatic spray guns, as with metal. The powder is cured in the main oven for 3-7 minutes, depending on the binder system. On leaving the oven, the substrate is already cured and dry, and only needs some time to cool down.

One step further: Solutions for flatstock substrates

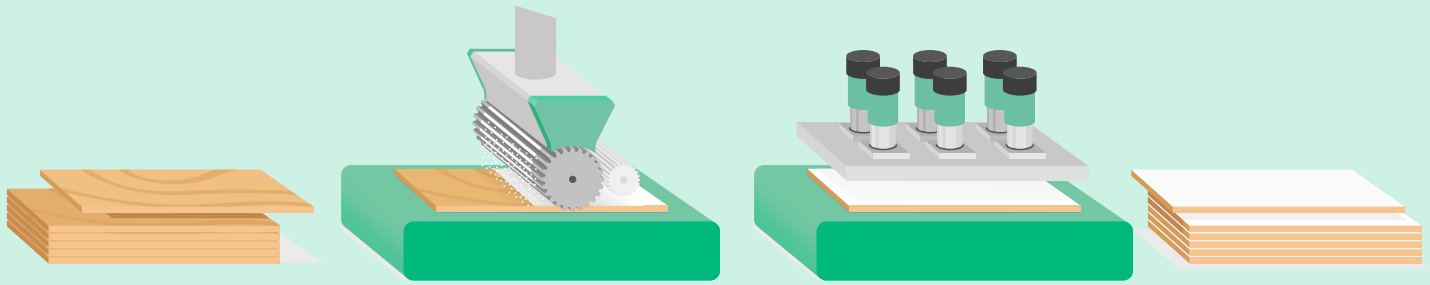

Figure 4. A typical powder-coating process for flatstock HSS

In 2019, Covestro took its powder coating technology one step further by developing a new technology for coating flat HSS, known as ImFuse™.

This technology combines a radical fast-cure, low-bake binder system with the existing technique of spraying or scattering powder on the surface and curing by using a press (Figure 4). This process is 3-5 times faster than other common powder coating processes for HSS, sometimes taking only one minute.

Because of these short curing times, the substrate receives a very low heat load. Next to that, a thinner layer is possible than with other HSS powder coating technology. This results in higher cost-efficiency and a carbon footprint up to 80% lower than that of traditional solventborne systems. What's more, the mold used for the press can be varied to create different textural effects, such as wood grain, and variations in gloss (Figure 5).

These solutions can be used to coat all kinds of HSS, ranging from lightweight MDF to particle board and solid wood. This includes substrates that are typically difficult to coat with liquids because of their open and uneven structure, such as oriented strand board (OSB). These properties make the solution ideal for high-throughput, flatstock applications, such as flat furniture, pre-finished boards and panels, and flooring.

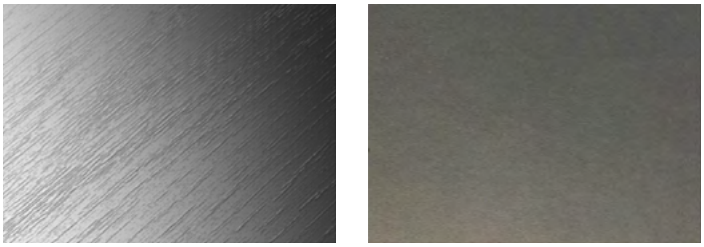

Figure 5. Different finishes possible when curing powder coatings using a press

Conclusion

Opening the opportunities of powder to new applications
Together, all these solutions open the benefits of powder coating to a wider range of applications, particularly in the building & construction and furniture segments. Covestro's powder coating resins for HSS are now used in everything from kitchen and bathroom furniture, where their performance adds value, to office and children's furniture, and where their low VOC content enables lower emissions (Figure 6).

Given the drive for more sustainable and environmentally friendly coating solutions, the market for HSS powder coatings is expected to grow. In China and Europe, powder coatings for HSS may even become the next major powder coating trend. And, while MDF is by far the biggest market today, the possibilities for wood, other types of engineered wood and other types of HSS are also exciting.

Figure 6. Various applications for powder coating on HSS

With powder coating, the possibilities are endless...

And it doesn't stop there: HSS powder coating solutions are likely to continue evolving and improving in line with market needs. Powder coating solutions aiming at lower curing temperatures and faster speeds are still requested to bolster even further a sustainable world.

Above all, extending the application scope of powder coatings will contribute significantly to improving the coating industry's environmental impact, creating value, and advancing sustainable societal approaches. At the same time, the improvements that powder coating enables in design flexibility, cost-effectiveness, and process efficiency could revolutionize HSS powder coating. Innovative powder coating solutions will help manufacturers and applicators take full advantage of these benefits – now and for many years to come.

Results at a glance

- Powder coatings can enable carbon emission reductions of up to 80%, as well as commercial and performance benefits.
- Low-bake powders, with curing temperatures as low as 130°C, now make it possible to powder coat a wider range of wood and engineered wood substrates (HSS).
- These powders can deliver smooth, matte, textured, and clear coatings in a wide range of applications. There is also a dedicated solution available for high-volume flatstock HSS.
- These solutions open the benefits of powder coating to a wider range of applications and markets, particularly furniture and construction.

For more information on powder-coating solutions for HSS, please contact: Sjoerd de Jong, sjoerd.dejong@covestro.com

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