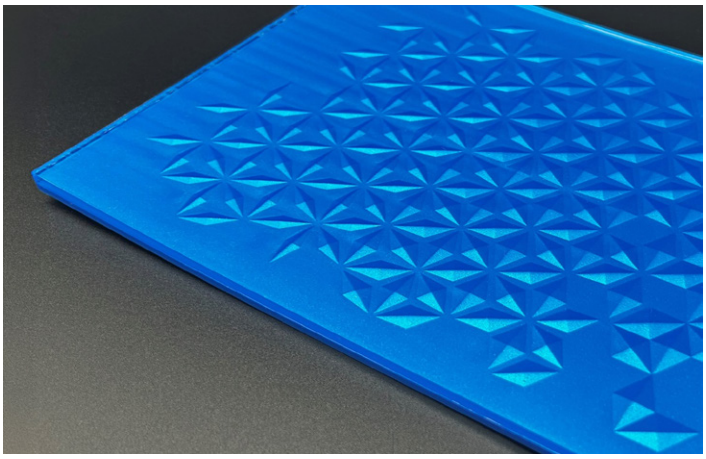
Advanced in-mold coating technology for automotive applications

Enhanced polyurethane chemistry delivers faster processing and improved sustainability

Revolutionizing surfaces with Direct Coating technology

The automotive industry faces mounting pressure to reduce manufacturing cycle times while maintaining high-quality surface finishes and improving environmental sustainability. Traditional automotive coating processes involve multiple energy-intensive steps including substrate production, transport to paint shops, cleaning, spray coating, and oven curing, which requires separate facilities and extended cycle times. A patented technology called in-mold coating (IMC) or Direct Coating (DC) offers a unique solution by combining injection molding with coating application in a single operation.



However, to achieve sufficiently fast curing speeds, most formulations still require high concentrations of tin-based catalysts. At Covestro we have developed an improved in-mold coating (IMC) formulation that can help reduce the amount of tin-based catalyst and thereby lower occupational exposure risks.

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This can be done by using polyisocyanates based on 1,5-pentanediisocyanate (PDI) oligomers. With PDI oligomers containing 68% renewable carbon, these formulations enable higher biobased content of the formulation compared to conventional hexamethylene diisocyanate (HDI) systems.

Materials used

The coating system centers on a polyisocyanate composition based on 1,5-pentanediisocyanate (PDI) -based isocyanurate (Desmodur® CQ ultra N7300). As a comparative product, hexamethylenediisocyanate (HDI)-based isocyanurate was used (Desmodur® ultra N3600). The polyol applied was the branched polyester polyol Desmophen® XP 2488.* The catalyst in all formulations was dibutyltindilaurate (DBTL), which is a well-known catalyst for polyurethane coatings.

*Desmodur® CQ N7300, Desmodur® ultra N3600 and Desmophen® XP 2488 were all obtained from Covestro Deutschland AG.

Determination of pot life

Pot life determination was conducted according to a procedure (standardized at Covestro) which measures the processing time of coating systems from crosslinking initiation until the system reaches a viscosity that prevents further processing.
The polyol component and catalyst were first weighed into a suitable speed mixer container and thoroughly mixed until no streaks were visible.
The isocyanate component was then added to the polyol component, and the crosslinked coating system was immediately mixed using a speed mixer with timing started simultaneously.

After mixing, the system was continuously monitored by gentle stirring with a wooden spatula to track viscosity development and flow behavior. Pot life was determined to have been reached when a significant viscosity increase and strong reduction in flow behavior indicated the onset of gelation and loss of processability. The time from mixing initiation to pot life endpoint was recorded.

Polyol	Desmophen® XP 2488	Desmophen® XP 2488	Desmophen® XP 2488
Polyisocyanate	Desmodur® ultra N3600	Desmodur® CQ ultra N7300	Desmodur® ultra N3600
Catalyst	DBTL	DBTL	DBTL
Amount of catalyst [wt% on total formulation]	0.15	0.15	0.18
Pot life [s]	111	99	98

Table 1: Overview of pot life experiments. Using the same amount of catalyst with Desmodur® ultra N3600 and Desmodur® CQ ultra N7300 will lead to longer pot life of the former. An increase in catalyst concentration is needed to achieve the same pot life.

Results

Reacting the polyester polyol with the HDI-based isocyanurate and a catalyst concentration of 0.15 weight% on formulation led to a pot life of 111 seconds. Replacing the HDI-based isocyanurate with the PDI-based isocyanurate while maintaining the same catalyst concentration led to shorter pot life of only 99 seconds, which brings an 11% increase in curing speed. For achieving the same pot life of 99 or 98 seconds respectively using the HDI-based isocyanurate, an increase of catalyst concentration from 0.15 weight% to 0.18 weight% was necessary, which translates to a 20% increase in pot life.

These performance gains by using PDI-based polyisocyanate can be used in two ways: faster cycle times enabling higher production throughput, or reducing catalyst amounts while keeping the cycle time which thereby lowers occupational exposure risks.

Conclusion

The advanced 1,5-pentanediisocyanate-based polyisocyanurate Desmodur® CQ ultra N7300 obtained from Covestro represents a valuable development for automotive manufacturers seeking to improve efficiency and sustainability while maintaining quality and standards. The demonstrated performance advantages of faster curing times, combined with the environmental benefits of a partially biobased feedstock derived from renewable sources and the potential for reduced catalyst dependency position this innovation as an important enabler for next-generation automotive coating applications, specifically for in-mold coating technology.

For automotive manufacturers operating in an increasingly competitive and environmentally conscious market, this technology offers a proven path forward that simultaneously addresses the critical needs of faster processing, enhanced sustainability, and maintained quality standards for both interior and exterior automotive components.

> “Covestro represents a valuable development for automotive manufacturers seeking to improve efficiency and sustainability while maintaining quality and standards.”

Are you interested in learning more?
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[1]Please see the “Guidance on Use of Covestro Products in a Medical Application” document.
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