Are bio-based isocyanates in polyurethane coatings a good idea?

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Recent Sirris research throws a light on the viability of eco-friendly alternatives

Polyurethane coatings have long been the exclusive domain for fossil-based raw materials, and it was believed there was no alternative. Lately, however, the interest in bio-based alternatives has grown substantially, driven by the increasingly demanding sustainability requirements. The eco-friendly alternatives are now available but are they as reliable, performant and qualitative as their fossil-based predecessors? Find out below by reading the findings of our latest research.

Polyurethane coatings are everywhere: on furniture, floors, cars, and industrial equipment. They are widely used in industrial and consumer applications because of their durability, chemical resistance, and aesthetic qualities. Traditionally, it was believed that these qualities could only be obtained by using fossil-based raw materials, particularly isocyanates such as hexamethylene diisocyanate (HDI).

However, growing sustainability requirements and tighter regulations have led to a search for bio-based alternatives which would yield the same high-quality results. Not only have regulations

become stricter, the customers are also asking for such sustainable solutions. Offering bio-based coatings helps you stay ahead and gives you a strong selling point: high performance under specific user conditions with lower environmental impact, by reducing reliance on fossil resources and lowering carbon emissions.

Bio-based PDI: a full-blown alternative to HDI?

In recent years, a new option has emerged as an alternative for the fossil-based raw materials. These so-called bio-based isocyanates, such as **pentamethylene diisocyanate (PDI)**, can replace traditional fossil-based hexamethylene diisocyanate (HDI) in polyurethane coatings, making use of renewable feedstocks such as starch, which is converted into pentamethylene diamine and then processed into isocyanate trimers. These trimers contain a significant share of renewable carbon

and can be integrated into existing polyurethane formulations.

The question is whether these bio-based alternatives can match or exceed the performance of fossil-based systems in real-world applications. That is what we have investigated in a recent study . We examined the performance of coatings formulated with PDI, a bio-based isocyanate, and compared it to conventional HDI systems. Here's what this latest research reveals.

PDI vs HDI: major findings

- **Superior Hardness and Scratch Resistance**

PDI-based coatings are tougher. They resist scratches better than coatings made with traditional hexamethylene diisocyanate (HDI). For technicians, this means fewer complaints about surface damage. For sales teams, it's a strong selling point for high-traffic applications.

- **Better Wear Resistance**

Whether on wood, metal, or composite substrates, PDI-based coatings stand up better to abrasion than their HDI-based counterparts. This translates into longer-lasting finishes and happier customers.

- **Enhanced Gloss and Smoothness**

A smoother surface isn't just about aesthetics, it's about quality. PDI coatings deliver higher gloss and more uniform finishes, making them ideal for premium products. Gloss measurements indicated that PDI-based coatings tended to have smoother surfaces and higher gloss values. This is linked to their higher cross-linking density and more uniform film formation.

- **Improved Hydrophobicity**

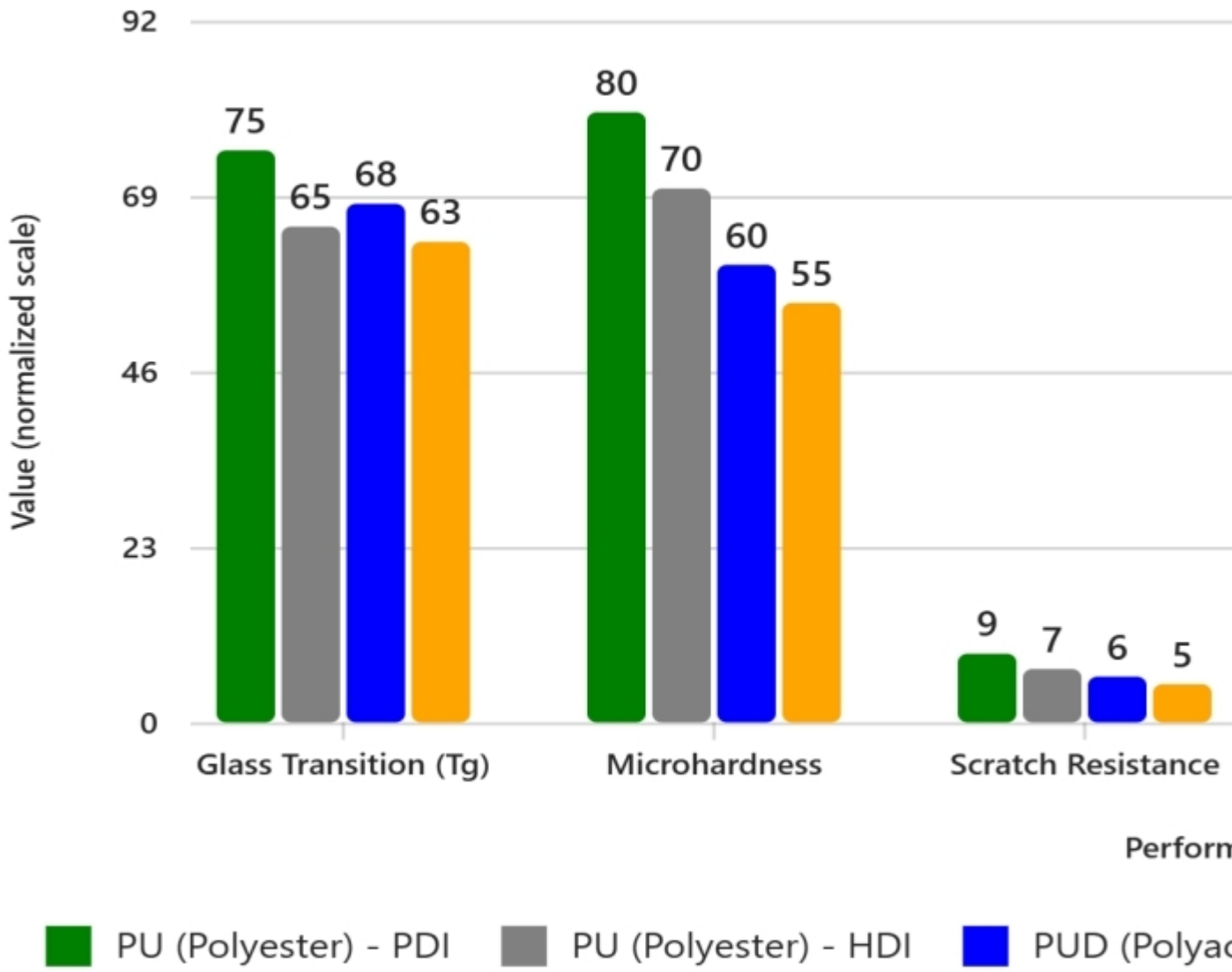
Water resistance matters, especially for outdoor applications. Water contact angle tests showed that PDI-based coatings were slightly more hydrophobic than HDI-based coatings, which can lead to products with a higher moisture resistance.

- **Balanced reactivity and thermal properties**

Coatings with PDI exhibited higher reactivity during curing, leading to higher glass transition temperatures (Tg). This suggests a more rigid polymer network compared to HDI-based coatings. However, thermogravimetric analysis (TGA) indicated that PDI-based coatings had slightly lower thermal stability. For most applications, this difference is not critical, but it is relevant for environments with high heat exposure.

- **Chemical stability**

The chemical integrity of the coatings highlighted differences in degradation mechanisms. Bio-based PDI coatings showed signs of surface oxidation and rearrangement after wear, which may contribute to protective behavior. Fossil-based HDI coatings, on the other hand, exhibited more chain scission, indicating mechanical degradation.



Summarizing figure giving some key properties of bio-based coatings (PDI) versus fossil-based coatings (HDI) for polyurethane resin coatings with polyester polyol or polyurethane dispersion coatings with polyacrylate polyol.

Conclusion

The transition to bio-based isocyanates in polyurethane coatings is technically feasible and offers clear environmental advantages. While some differences in thermal stability exist, overall performance is comparable or improved in key areas. The findings suggest that bio-based coatings can be integrated into existing processes with some adjustments to curing and formulation.

The research data provides a factual basis for discussing bio-based options with customers. The benefits are not limited to sustainability; they include tangible improvements in lifetime and performance characteristics. However, continued testing is essential to optimize performance for

specific substrates and conditions. The data provides a factual basis for discussing bio-based options with customers.

Are you ready to go bio-based?

Sirris is committed to support companies in the circular economy and transition towards bio-based materials. Besides offering formulation and testing capacities, we support companies in the framework of collective research projects such as AddBIO, where the use of residual biomass as functional fillers for coatings is demonstrated in several case studies.

Download the full study

To further prepare for the journey, you can also start by delving into the details of the study above.

Download the full study

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Interested to join or to learn more about the possibilities for cooperation? Just get in touch with our expert Pieter Samyn.

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