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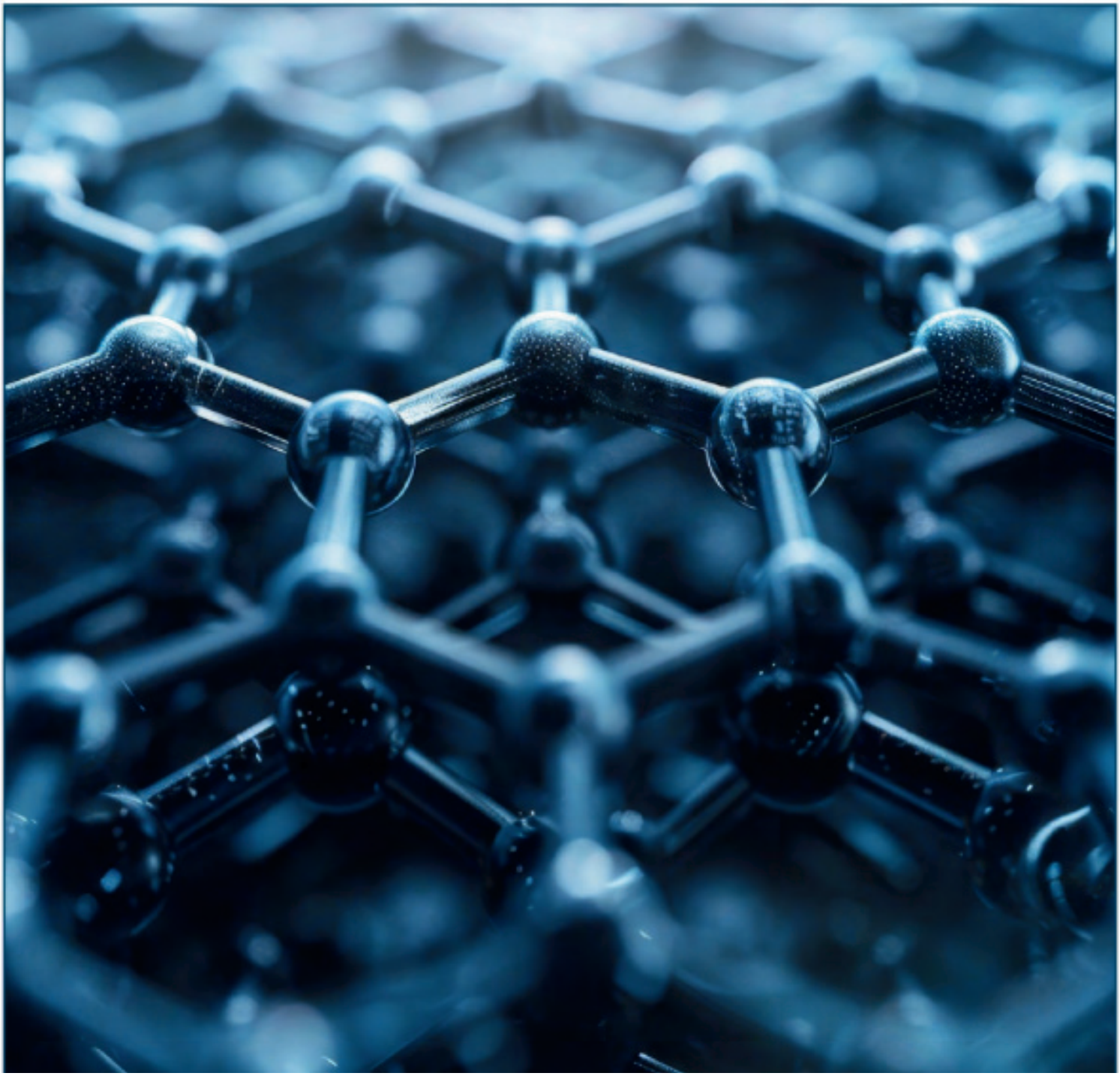

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INTERNATIONAL POLYURETHANES MAGAZINE

Biobased polyols in the manufacture of truck floor mats

The automotive industry faces mounting pressure to bolster sustainability across various sectors, with a notable emphasis on environmental, social, and governance (ESG) practices. Within this context, the polyurethane market has experienced significant growth, owing to its versatility and applicability in automotive manufacturing. However, the industry seeks alternatives to petroleum-based raw materials to meet sustainability targets.

A key aspect of sustainable solutions involves reducing carbon footprint compared to existing technologies. This imperative has spurred a demand for renewable source raw materials. Leveraging Purcom's innovative technology of renewable source polyols in truck floor mats not only addresses environmental concerns but also offers advantages in terms of processability, availability, and economics while preserving the final product's properties.

This study evaluates the viability of utilizing partly biobased polyols in elastomers and flexible foams. Results indicate noteworthy achievements in biobased carbon content and carbon footprint reduction compared to conventional methods while helping to ensure product integrity and performance. The findings underscore the possible environmental and economic benefits of biobased polyols, reinforcing their practical and commercial viability in the automotive industry.

The data suggests the adoption of biobased polyols, coming from used cooking oil that otherwise would be wasted. This represents a significant step towards sustainability and economic efficiency in the truck mat manufacturing sector. This comprehensive study not only highlights the substantial benefits of renewable polyols in terms of sustainability and economy but also underscores their ability to preserve essential product properties, thereby contributing to their acceptance and success in the truck mat industry.

Introduction

The soundproofing mat for trucks is composed of two materials: a flexible molded polyurethane foam and a solid material, which can be: rubber; TPO, or solid elastomeric polyurethane (**Figure 2**). In this article, the development of molded flexible foam will be shown in detail. The concept of sound insulation in truck cabins involves a multi-layer mat. A heavy layer absorbs low-frequency sounds such as road noise and loud speech or music. An open-celled flexible foam layer absorbs higher frequency sound such as engine and tire noise (**Figure 1**).

Experimental

A standard petroleum-based flexible molded foam for this application is composed of the following formula:

Component	Percentage
Polyol 4500 MW EO capped	88.8
Chain extenders	3.0
Pigment	1.0
Amine catalysts	1.2
Surfactants	0.5
Water	5.5
Polyol isocyanate ratio (P/I)	100/65
Reactivity cream time	12 s
Gel time	54 s
Rise time	80 s
Free rise density	22.7 kg/m³ (1.42 pcf)

Table 1:
Standard formulation of flexible molded petroleum-based

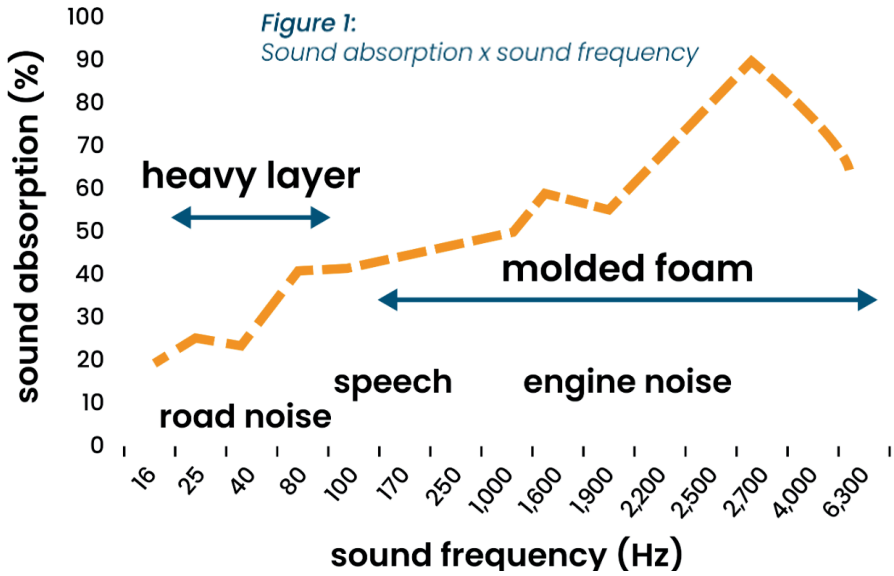

Figure 1:
Sound absorption x sound frequency

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The first challenge was developing basic polyols using post-consumer vegetable oils to replace petroleum-based polyols, maintaining chemical, mechanical, and sound properties.

After many trials, the following polyols were developed:

Name	Material category	pMC	Percentage bio-carbon*	Functionality	OHv** (mgKOH/g)	Viscosity cPs at 25°C
Polipur bioflex 95 pol	biobased	93.96	94	3.76	90	3,800
Polipur bioflex 70 pol	biobased	71.81	72	2.0	80	920

* bio-carbon % results were made by Beta Analytics following ASTM D6866-22 Method B (AMS) TOC

** OHv: hydroxyl number

Following experimentation, it was decided to use both polyols to achieve better viscosity and functionality.

	Percentage
POLIPUR BIO FLEX 95 POL	16
POLIPUR BIO FLEX 70 POL	55.35
4500 MW Polyol EO capped	15
Chain extender	1.5
Water	5.2
Catalyst	2.95
Surfactant	0.5
Black pigment	0.5
Additive	3
	100 %

Table 2:
Biobased polyol formulation

The isocyanate side is a blend of bio-attributed isocyanates (mass balance) with a final NCO of 31.1 %.

The ratio was 100 polyol / 75 isocyanate.

All the experimental formulations injected at the customer plant behaved equivalently to the conventional formulation.

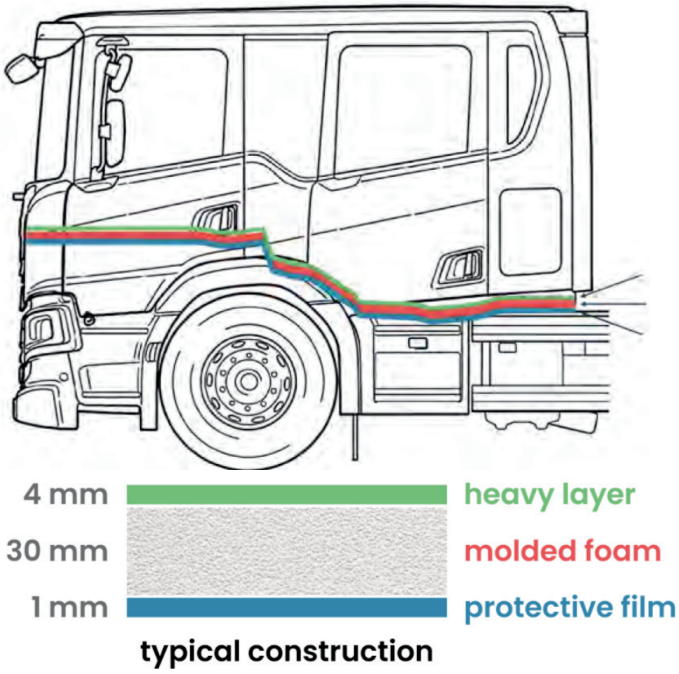

Figure 2:
Parts of the truck floor mats

Figure 3:
Typical manufacturing process

Summary of results

The chemical properties of the components are summarized in **Table 3**, and the physical properties in **Table 4**. **Table 5** and **Figure 5** show the sound attenuation properties using the "speaker chamber."

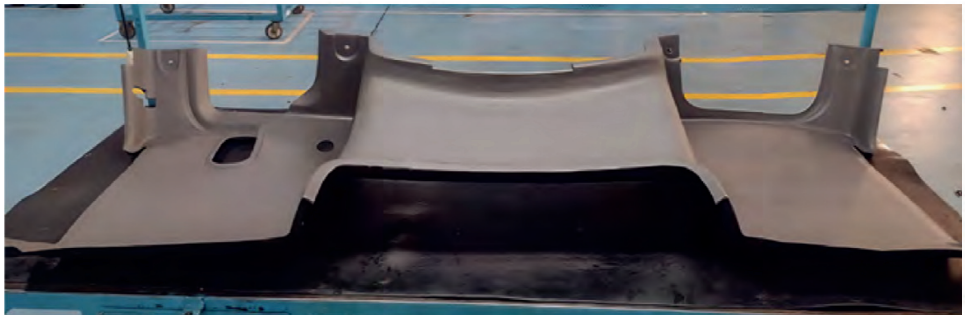

Figure 4:
Picture of truck floor mat manufactured with biobased polyol and bio-attrubuted icocyanate

Property	Petroleum-based system	Bio-polyol based system (Semirigipur flex 2110)	Units
Specific gravity polyol	1.03	1.00	gm/cm³
Specific gravity isocyanate	1.23	1.23	gm/cm³
Viscosity polyol at 25 °C	1,900	2,250	mPa·s
Viscosity isocyanate at 25 °C	190	78.5	mPa·s
Ratio polyol/isocyanate	100/65	100/75	weight
Reactivity – laboratory cup test			
Cream time	12	13	seconds
Gel time	50	53	seconds
Rise time	74	75	seconds
Free rise density	22.7 (1.42 pcf)	24.0 (1.5 pcf)	kg/m³

Table 3:
Chemical properties

Physical testing of foams				
	Petroleum-based system	Bio-polyol and bio-attributed isocycante based system (Semirigipur flex 2110)	Specification	Units
Overall density with skin	59.0 (3.68 pcf)	57.23 (3.57 pcf)	55–70	kg/m³
Tensile str. 40 % Elong.	0.14	0.14	11.8–19.6	kPa
Comp. set 50 % def.	42.1	43	≤45 (22h at 70 °C)	%
Tear strength	404	447.2		N/m

Table 4:
Physical properties

Frequency (Hz)	100	125	160	200	250	315	400	500	630	800	1,000	1,250	1,600	2,000	2,500	3,150	4,000	5,000	6,300	8,000	10,000
biobased	7.7	5.9	3.4	5	0.8	0	0	4.2	9.2	11.6	11.8	13.7	17.5	21.1	26.2	27.9	28.4	26.9	24.4	24.5	24.5
petroleum-based	7.7	6.2	5.6	5.6	0.8	0	0	3.7	9.9	13.9	13.6	15.1	19.2	25.6	30.6	30.9	26.4	24.6	23.9	25.6	27.9

Table 5:
Sound attenuation properties

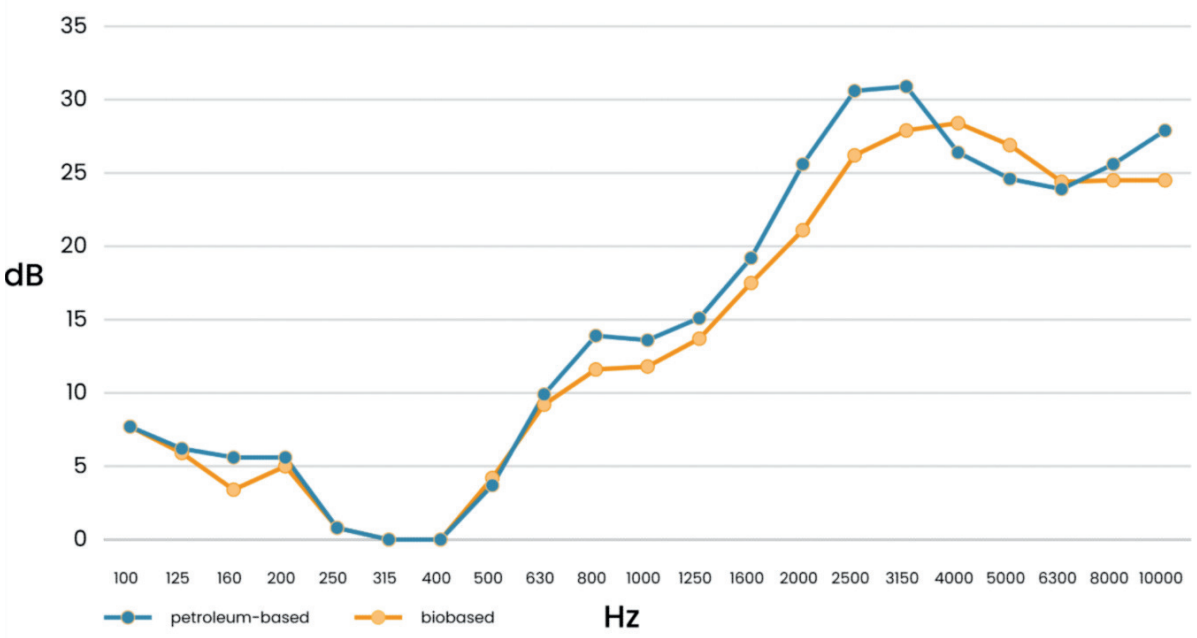

Figure 5:
Sound attenuation (dB) versus frequency (Hz)

Sustainability

A life cycle analysis of the polyols was carried out, revealing a 85 % reduction in CO_2 emissions. For the bio-attributed isocyanate, a 60 % reduction of CO_2 emissions was found (following the ISO 14040/44 standard). This leads to a 74 % CO_2 reduction for the whole system.

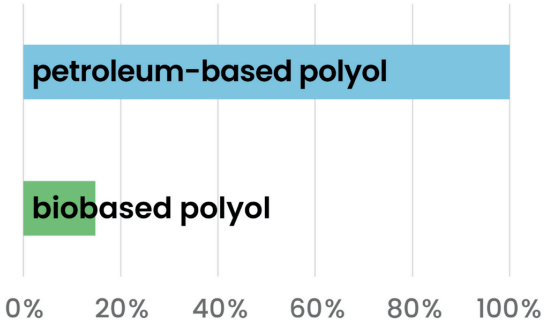

Figure 6:
CO_2 emission reduction in formulated polyol (preliminar results based on standard 14040/44:2006)

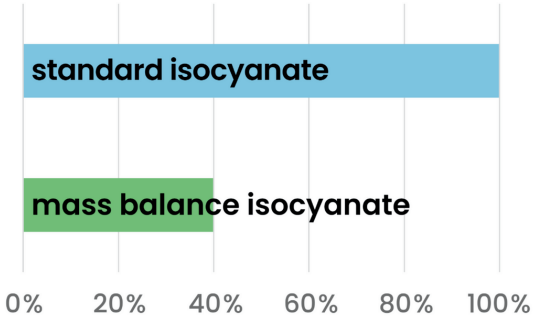

Figure 7:
CO_2 reduction in bioattributed vs. petroleum based isocyanate – mass balance (following the ISO 14040/44 standard).

Conclusion

All chemicals and molded foam physical properties remained within those specified by the manufacturer. Some properties were improved, such as: tear strength improved by 10 % and sound attenuation improved by 13 %.

The biobased/bio-attributed product showed processability very similar to the petroleum-based product. The final piece has a visual appearance in accordance with what is required by the truck manufacturer.

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It was possible to develop a product with 56 % biocarbon content based on polyol (the biocarbon percentages were determined by Beta Analytics following the ASTM D6866-22 Method B (AMS) TOC standard).

A new biobased polyol formula presents an 85 % emission reduction in kg CO_2e (following ISO 14040/44).

A new bio-attributed isocyanate formula (mass balance) showed a 60 % reduction in kg CO_2e (following ISO 14040/44).

The foam system (57,14 % polyol + 42,86 % isocyanate) presented a 74 % reduction in CO_2 emission.

The life cycle analysis (LCA) provides transparency and management throughout the supply chain, being able to measure and track the entire chain certified by ISCC+.

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