

Natural Oil Polyol (NOP) Based Polyurethane Slabstock Foam for Automotive Interior Foam-Fabric/Vinyl Laminate Construction

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ABSTRACT

The drive to incorporate renewable resources continues to gain momentum within the automotive industry. FXI has developed a grade of low (1.7 pcf) density slabstock foam which uses a natural oil polyol in place of a petroleum-based polyol. This foam grade, trademarked GreenBlend™, has been developed specifically to produce foam-fabric/vinyl laminates for automotive seating, and interior trim applications such as headrests, armrests, visors and door panels. This new foam grade satisfies all of the OEM specifications for physical properties, including fogging and flammability, and yields satisfactory bond strengths when flame-laminated to cover stock. It is also a cost competitive technology compared to conventional slabstock foam using petroleum-based polyols.

INTRODUCTION

Approximately 2.2 billion lbs of slabstock (or bunstock) free-rise polyurethane (PU) foam are produced annually in North America [1], for applications including automotive, furniture, bedding, packaging and carpet underlayment. Slabstock foams can be polyether or polyester-based. Slabstock foam production, typically in square-block or round-block form, is roughly three times as large as molded PU foam production for similar application segments. Foam buns resulting from the slabstock free-rise process are skived to precise thicknesses depending upon intended end-use. Different means of skiving are available but most commonly involve horizontal slitting (square-block) or peel slitting (round-block).

Conventional polyether slabstock flexible foam production utilizes 3000-4000 molecular weight polyols derived from

petroleum feedstock. These polyols constitute 50-70 % of the final foam on a per parts basis. The ever-increasing drive to utilize renewable resources wherever possible includes efforts in the PU (both slabstock and molded) foam industry to replace petroleum-based polyether polyols with similar-performing polyols derived from natural oils, in as high a replacement content as the application and performance parameters will allow.

SLABSTOCK PU FOAMS FOR AUTOMOTIVE INTERIOR APPLICATIONS

The automotive industry utilizes slabstock PU foam for a variety of interior articles, including seating (cushions and backs, plus headrests and armrests), headliners, sun visors, carpet underlayment and door panels.

The most significant application for these foams is as a thin (typically in the 3-6mm thickness range but sometimes as much as 12mm) foam layer attached to the cover stock, typically fabric or vinyl. Roughly 96 MM linear yards per year of slabstock PU foam is produced for this use; 65MM of which is for seating and trim, and the balance for headliners. Different means are utilized to attach the thin foam layer to the cover stock. Some include use of a solvent-based or thermoplastic adhesive, but the most common attachment means in North America is flame lamination. In this method, the thin foam is passed over an open flame, creating a very thin (typically in the 0.3-1.0 mm range) layer of molten polymer which is then brought into contact, under pressure, with the cover stock to develop a cohesive bond between the surfaces. For seating applications, this thin flexible foam layer serves the purpose of providing an enhanced layer of

Table 1. FXI A173040NL PU Seating Foam Physical Properties vs. OEM Specifications

			Typical Automotive OEM PU Seating Foam Specifications					
			GM	Ford	Chrysler	Toyota	Nissan	Hyundai
Property	Units	A173040NL	GMW 15058	ESBM2D243A	MS-AY309A	TSM6712G	NESM8047	MS 257-06
Density	pcf	1.73						
	kg/cu.m	27.7	27 min	24 min	27 min			24-28
25% CFD	lbf	0.4						
	kPa	2.76						
Tensile Strength	kPa	145	>82	>83	>83	>69	>58	>79
Elongation	%	187	>150	>170	>175	>120	>80	>100
Tear Strength	N/m	423	>260	>350	>350	>390		
50% Comp Set	%t	4	<10	<7.5		<8	<9	<5
90% Comp Set	%t	8.2	<25		<13.5			
50% Comp Set*	%t	7.6	<10	<10				
Fogging	mg	0.23	<2				<1	
MVSS-302	mm/min	0 (SE)	<101	<101	<101	<101		<80
*Steam Autoclave								

comfort between the occupant and the molded foam seat cushion and seat back, it positively impacts the long-term wear performance of the cover stock, and it hides imperfections on the molded foam seating surface. This thin foam layer is subjected to the same physical property requirements as the molded seat cushion/back; including strength properties (such as tensile, tear and elongation) and compression set properties. Generally speaking, the property specifications for seating are the most stringent of all the automotive interior applications, so a foam system which can meet the property specifications for seating in all likelihood will also satisfy the specifications for other automotive interior applications.

Additionally, the composite comprised of the thin foam layer and cover stock must also satisfy specifications related to bond strength, flammability and fogging. The thin foam layer must also withstand conditions of high humidity, particularly when the occupant is seated, and thus the foam layer must be polyether and not polyester as the latter is well known to degrade due to hydrolytic instability [2]. Figure 1 shows a cross-section cut of an automotive seat cushion adorned with the flame laminated foam-fabric cover.

In keeping with the drive to incorporate renewable materials into automotive interior applications, the goal of this work was to develop a natural oil based polyol foam system to produce slabstock PU foams geared for flame laminated composites for the automotive interior market and particularly the seating segment. Given the North American production rate of 96 MM linear yards per year for the automotive interiors market, assuming a foam density of 1.80 pcf, this would equate to roughly 3.5 MM lbs/yr of petroleum-derived polyol which would be eliminated if a natural oil polyol could be used in its place at a level of 10% based on the final foam product.

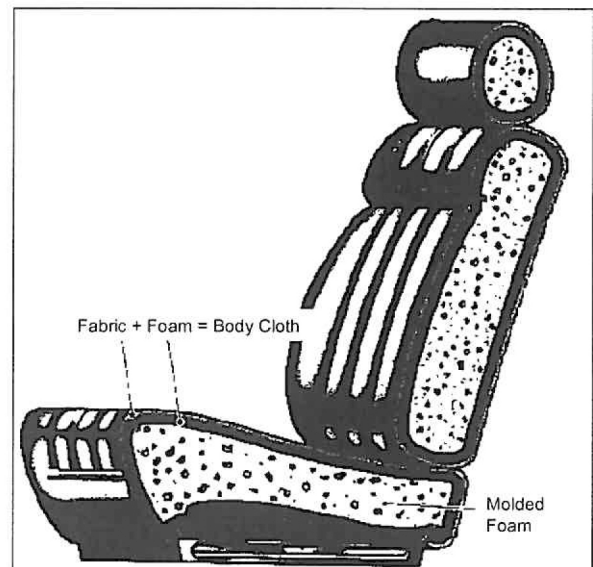


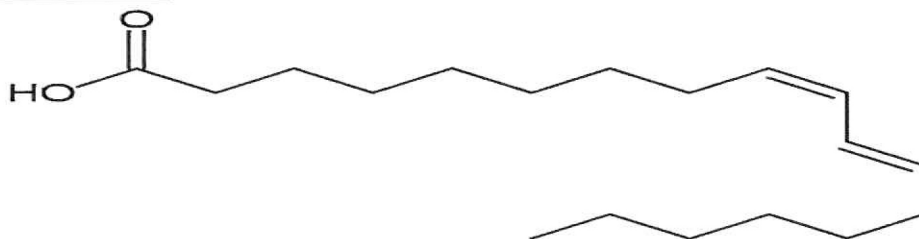
Figure 1. Cross-Section View of Seat Cushion and Back with Foam-Fabric Cover

EXPERIMENTAL PROGRAM

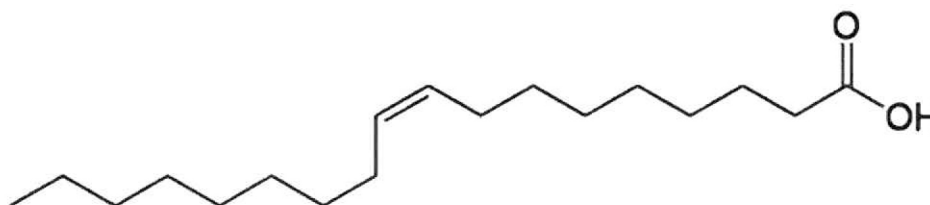
FXI is a major industry producer of slabstock PU foams for a variety of applications including automotive. FXI's A173040NL, based upon petroleum-derived polyol(s), is the workhorse grade of polyether slabstock foam intended for use as the thin foam layer for flame laminated foam-fabric/vinyl composites for automotive seating applications. This foam is being widely used for GM, Ford, Chrysler, Toyota, Honda, Nissan, Hyundai, Kia, Mitsubishi and Subaru vehicles. The foam-only physical properties of A173040NL versus typical major OEM specifications are shown in Table 1. This was the foam product used as the control for subsequent natural oil polyol evaluations.

Natural oil polyols (NOP) are based upon fatty acids or triacylglycerols [3]. There are a number of natural oils which

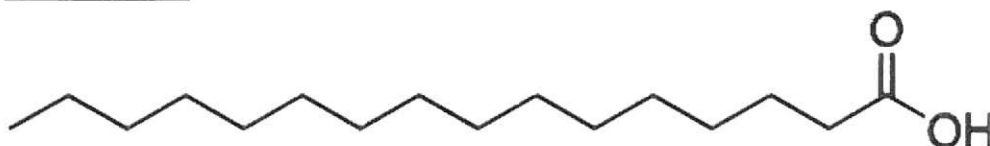
Linoleic Acid



Oleic Acid



Palmitic Acid



Ricinoleic Acid

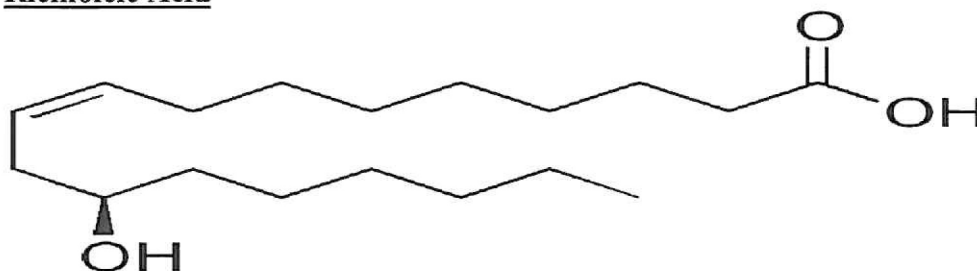


Figure 2. Natural Oil Chemical Structures

can be used to synthesize an NOP. Primarily, NOP's are either soy-, palm-, or castor-oil based. These NOP's contain varied levels and varied distribution consistency of different fatty acids (Table 2, Figure 2). Depending on the natural oil, the process of conversion to a useable NOP for PU foaming can either be a physical or a reactive conversion.

Table 2. Fatty Acids Content in Natural Oils

Fatty Acid	Natural Oil		
	Soy	Palm	Castor
Linoleic Acid, C18:2	54%	10%	4.20%
Oleic Acid, C18:1	37%	40%	3%
Palmitic Acid, C16:0	3%	45%	1%
Ricinoleic Acid, C18:1	0%	0%	90%