TERRIN™

Technical Data Sheet

INVISTA TERRIN™ Polyols

Cost-Effective Alternative to Conventional Polyether and Polyester Polyols

Introduction

TERRIN™ polyols can be used in lieu of or in combination with conventional polyether or polyester polyols to formulate a variety of polyurethane products designed to be soft and flexible—or hard and stiff. These versatile, aliphatic, polyester polyols can be used in applications ranging from viscoelastic foam to spray coatings and adhesives to elastomeric resins. TERRIN™ polyols:

- Are cost competitive in comparison to conventional polyols
- Contain a minimum of 50% recycled or renewable[1] content
- Have similar hydroxyl values to castor oil, and can be substituted on a nearly equal weight basis
- Are REACH and TSCA compliant

In addition, TERRIN™ polyols are an easily handled, low-viscosity liquid at room temperature. TERRIN™ product offerings—especially 168 and 168G—remain pourable liquids at -15°C/5°F and below[2]. TERRIN™ polyols do not crystallize and exhibit Tg in a range of approximately -60°C to -75°C.

Application

Viscoelastic Polyurethane Foam

This Technical Data Sheet is intended to illustrate how TERRIN™ polyols can be used in viscoelastic polyurethane foam (VE foam, also known as memory foam). VE foams are typically open-cell, flexible foams with low resilience and relatively slow post-deformation recovery. Lab tests show that TERRIN™ polyols can be used as partial drop-in replacements for polyether polyols in a model water-blown VE foam formulation. Foam properties can be achieved that are comparable to the reference VE foams made using polyether polyols, including resilience, tensile strength, elongation, tear strength, compression force deflection, hysteresis, and wet or dry constant deflection compression set. The mix of performance over this range of properties can be customized by adjusting the formulation.

[1]As defined by ISO 14021, Section 7.8; preliminary estimate based on small-scale production.
[2]Patents pending; consult the SDS for additional physical-chemical, safety and health information

July, 2015

Result Summary

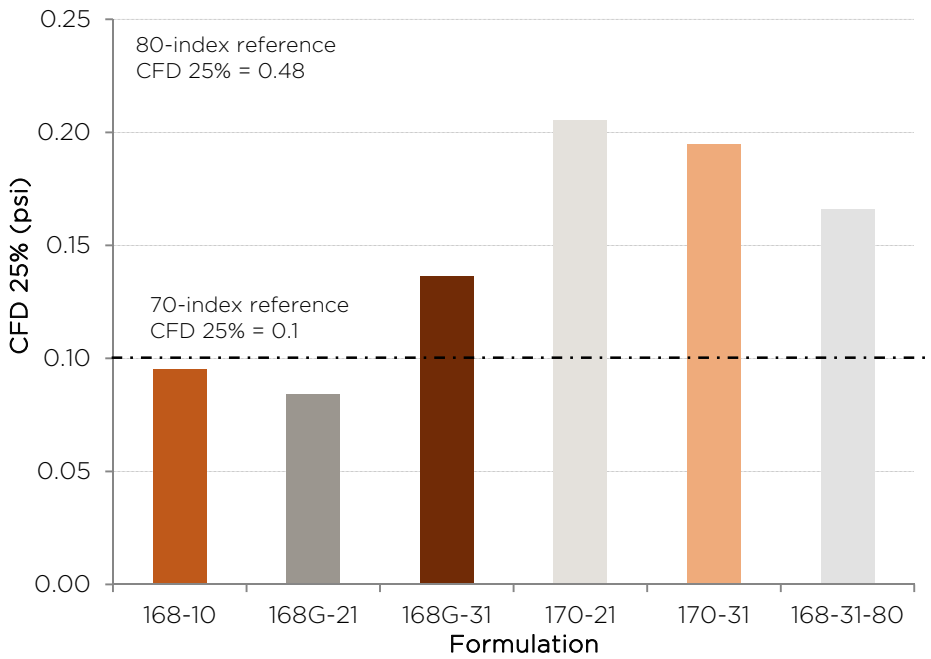

Figure 1: Compression force deflection (CFD) at 25% deflection, normalized to density of the 70-index reference foam

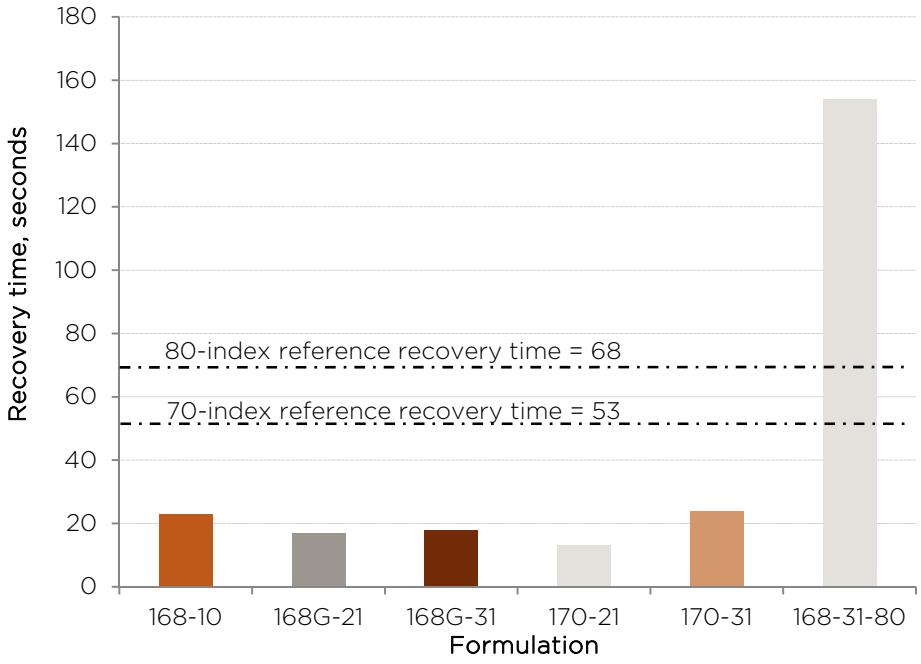

Figure 2: Recovery time in seconds (method described in text)

Formulation and Preparation

A model viscoelastic foam (VE foam) formulation based on 2,4'-rich diphenylmethanediisocyanate was used to evaluate performance of TERRIN™ polyols when substituted for polyether polyols.

Polyols used in the formulations are described in Table 1, other materials in Table 2, formulations in Table 3, and foam properties in Table 4. Reference foams were prepared at 70 and 80 percent isocyanate index using the three POLY-G® polyols only (REF-70 and REF-80 in Table 3). Comparison VE foams were prepared by substituting TERRIN™ polyol first for POLY-G® 30-240 and then for POLY-G® 76-120. The substitution rates of TERRIN™ polyol and isocyanate indexes for the comparison formulations were determined from screening experiments; other substitution rates are of course possible. In all formulations, the amount of isocyanate was adjusted as needed to maintain the desired isocyanate index, but the amounts of other ingredients including catalysts were held constant. All TERRIN™-polyol-containing foams were made to isocyanate index 70 except 168-31-80, which was made to isocyanate index 80 because screening experiments showed that higher index improved strength and recovery time of foams made using high TERRIN™ 168 content.

Table 1: Polyols

Polyols	Description	Supplier	Hydroxyl Value
TERRIN™ 168	Aliphatic polyester polyol	INVISTA	164.8
TERRIN™ 168G	Aliphatic polyester polyol	INVISTA	165.8
TERRIN™ 170	Aliphatic polyester polyol	INVISTA	160.8
POLY-G® 30-240	Oxypropylated polyether triol	Monument	230
POLY-G® 76-120	Ethylene oxide-capped polyether triol	Monument	121.3
POLY-G® 85-34	Ethylene oxide-capped polyether triol	Monument	35.4
LUMULSE® POE 26	Ethoxylated glycerine cell-opening polyol	Lambent Technologies	134.8

POLY-G® is a registered trademark of Monument Chemical, LUMULSE® is a registered trademark of Lambent Technologies.

Table 2: Other Materials

Material	Description	Supplier	Function
TEGOSTAB® B8871	Polyether-modified polysiloxane copolymer	Evonik	Surfactant
Diethylene glycol	Diethylene glycol, equivalent weight 53.06	Sigma-Aldrich	Chain extender
DABCO® 33-LV	Triethylene diamine in dipropylene glycol, equivalent weight 105	Air Products	Catalyst
NIAX® A-1	Bis(2-dimethylaminoethyl)ether in dipropylene glycol, equivalent weight 233.7	Momentive	Catalyst
MONDUR® MRS-2	2,4-rich diphenylmethanediisocyanate (functionality = 2.2, NCO% = 32.6, equivalent weight = 128.8)	Bayer	Isocyanate

TEGOSTAB® is a registered trademark of Evonik Industries. DABCO® is a registered trademark of Air Products and Chemicals. NIAX® is a registered trademark of Momentive. MONDUR® is a registered trademark of Bayer MaterialScience.

All foam tests reported in Tables 3 and 4 were scaled to use a total of 400 g polyol components. To prepare a foam, the polyols and other non-isocyanate components were combined, isocyanate added, and the formulation mixed for 10 seconds using a high-torque mixer. The mixture was transferred to an open polyethylene container and allowed to free rise. As the foaming reaction occurred, cream time, gel time, and rise time were noted then the foams were placed into a preheated 70°C air-circulating oven for 60 minutes to complete their cure.

Foam Testing

Foams were aged for at least one week at ambient room conditions before testing. The following properties were measured according to ASTM D 3574-08:

- Foam density (Test A)
- Resilience by ball rebound (Test H)
- Tensile strength at break (Test E)
- Elongation at break (Test E)
- Tear strength (Test F)
- Compression force deflection (CFD; Test C)
- Hysteresis (Procedure B – CFD hysteresis loss)
- Dry constant deflection compression set (Test D)
- Wet constant deflection compression set (Test D and Wet heat aging, Test L)

Recovery time was measured on an INSTRON® tester by the following procedure: A 64 mm2 indenter foot was brought into contact with a foam specimen (2" x 2" x 1"). The specimen was indented 80% of its initial thickness at a rate of 500 mm/min and held for 60 seconds. A timer was started as the indenter was returned to 0% deflection at a rate of 500 mm/min. Recovery time was recorded as the time when the imprint of the indenter foot was no longer visible. A burn rate test was performed to evaluate relative flammability of the VE foam samples. Note that this test is for comparative purposes only within this study. Results should not be compared to results from other studies or results using different methods.

Results of the above tests are given in Table 4. Compression force deflection at 25% deflection and recovery time are shown graphically in Figures 1 and 2.

VE foams have their greatest degree of viscoelasticity in the region of their glass transition temperature. Glass transition temperature, Tg, was determined from tan (δ), measured using a TA Q800 dynamic mechanical analyzer (DMA) with compression clamp, over the temperature range from -100 to +80°C. The largest peak in the tan(δ) curve occurred around room temperature and was assigned to Tg.

The results (Figure 3) show that, in every case, substituting TERRIN™ polyols into the reference foam formulation decreases Tg. The decrease averaged 6.7°C and ranged from 4°C (168-10 or 170-21 vs. 70-index reference) to 11°C (168-31-80 vs. 80-index reference foam).

The ideal Tg for a particular application depends on the desired characteristics of the VE foam at use temperatures. To illustrate one common use, memory-foam pillows, three different, randomly-selected VE foam pillows purchased at retail were tested by DMA. The three pillows exhibited Tg in the range 6 – 30°C. All of the TERRIN™-polyol-based foam formulations prepared as part of this study exhibited Tg within that same range.

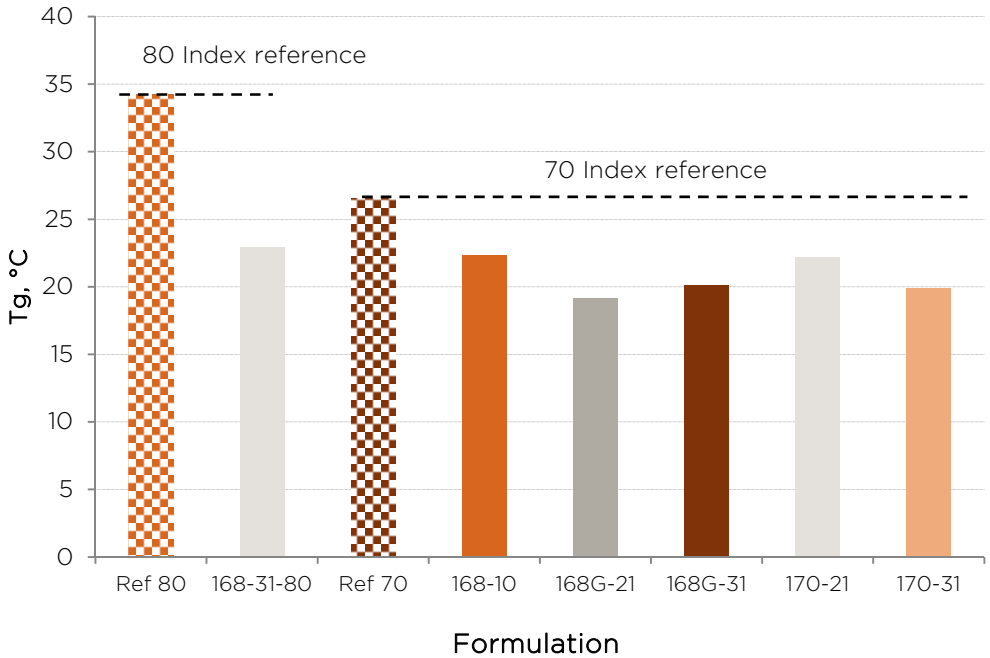

Figure 3: Glass transition temperature (T_g) as determined by DMA. All foams compare to the 70-index reference except 168-31-80, which compares to the 80-index reference.

Table 3: Viscoelastic foam formulations

Formulation	REF-70	168-10	168G-21	168G-31	170-21	170-31	Ref-80	168-31-80
Weight % TERRIN™ polyol based on total polyol	0	10	21	31	21	31	0	31
Isocyanate index	70	70	70	70	70	70	80	80
Polyol components								
POLY-G® 30-240	21	11	0	0	0	0	21	0
POLY-G® 76-120	21	21	21	11	21	11	21	11
POLY-G® 85-34	18	18	18	18	18	18	18	18
TERRIN™ 168™ polyol	0	10	0	0	0	0	0	31
TERRIN™ 168G™ polyol	0	0	21	31	0	0	0	0
TERRIN™ 170™ polyol	0	0	0	0	21	31	0	0
LUMULSE® POE 26	40	40	40	40	40	40	40	40
Chain extender, Water, Surfactant, Catalysts								
Diethylene glycol	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25
Water	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
TEGOSTAB® B 8871	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
DABCO® 33-LV	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
NIAX® A-1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Isocyanate								
MONDUR® MRS-2	49.08	47.94	46.67	47.38	46.5	47.38	56.09	54.15

POLY-G® is a registered trademark of Monument Chemical. LUMULSE® is a registered trademark of Lambent Technologies. TEGOSTAB® is a registered trademark of Evonik Industries. DABCO® is a registered trademark of Air Products and Chemicals. NIAX® is a registered trademark of Momentive. MONDUR® is a registered trademark of Bayer MaterialScience.

Table 4: Reaction profiles and properties of viscoelastic foams

Formulation	REF-70	168-10	168G-21	168G-31	170-21	170-31	Ref-80	168-31-80
Reaction profile								
Mix time, sec.	10	10	10	10	10	10	10	10
Cream time, sec.	24	30	29	34	31	28	29	19
Gel time, sec.	33	40	40	41	46	46	42	40
Rise time, sec.	86	115	114	110	105	104	110	115
Foam properties								
Free-rise density, pcf	2.76	3.19	3.61	4.05	3.76	3.83	2.88	2.99
Resilience, %	0.76	0	0	0.25	0.51	1.78	5.34	0.25
CFD @ 25%, psi	0.1	0.11	0.11	0.2	0.28	0.27	0.5	0.18
CFD @ 50%, psi	0.14	0.15	0.16	0.28	0.37	0.37	0.63	0.23
CFD @ 65%, psi	0.21	0.22	0.24	0.43	0.55	0.6	0.94	0.35
Tensile Strength, psi	7.4	8.17	7.92	18.64	22.94	14.89	16.11	18.41
Elongation at Break, %	255	233	289	283	252	200	163	283
Tear Strength, N/cm	4.05	3.41	3.69	5.49	5.47	6.56	7.03	5.46
Hysteresis, %	72.5	66.6	68.7	74.4	72.5	73.5	84.3	92.6
Recovery time, sec.	53	23	17	18	13	24	68	154
Dry Compression Set @ 50%, %	3.07	2.71	4.59	1.98	3.23	0.73	0.53	19.85
Wet Compression Set @ 50%, %	2.42	2.01	3.51	1.41	1.1	0.3	2.96	4.95
Burn Rate, mm/min	85.6	73.8	62.8	63.4	60.1	65	78.6	87.7

The formulations herein are not optimized and aren't intended to cover the entire range of possibilities but are meant to provide the experienced polyurethane formulator with ideas and starting points for viscoelastic foam formulations. The information set forth herein is furnished free of charge and is based on technical data that INVISTA believes to be reliable, provided that INVISTA makes no representation or warranty as to the completeness or accuracy thereof. It is intended for use by persons having technical skill, at their own discretion and risk, who will make their own determination as to its suitability for their purposes prior to use. As with any material, evaluation of any compound under end-use conditions prior to specification is essential. Nothing herein is to be taken as a license to operate under or a recommendation to infringe any patents. In no event will INVISTA be responsible for damages of any nature whatsoever resulting from the use of or reliance upon the information contained herein or the product to which the information refers.

www.TERRIN.INVISTA.com
For samples and further information please contact:
1.800.231.0998 | TERRIN@INVISTA.com

This Product Data Sheet contains selected information about a specific INVISTA product, or group of products, and particular uses of the same. It relates only to the identified product and any identified uses, and is based on information available as of the date hereof. Additional information may be needed to evaluate other uses of the product, including use of the product in combination with any materials or in any processes other than those specifically referenced. Information provided herein with respect to any hazards that may be associated with the product is not meant to suggest that use of the product in a given application will necessarily result in any exposure or risk to workers or the general public. This product data sheet does not contain a complete statement of, and does not constitute a representation, warranty or guaranty with regard to, a product's characteristics, uses, QUALITY, merchantability, FITNESS FOR A Particular PURPOSE, or the suitability, safety, efficacy, hazards or health effects of the product, whether used singularly or in combination with any other product, EXCEPT TO THE EXTENT REQUIRED BY THE RELEVANT LAW AND REGULATIONS. Purchasers and users of the product are responsible for determining that the product is suitable for the intended use and that their workers and the general public are advised of any risks resulting from such use. Nothing contained in this Product Data Sheet shall be construed to modify any of the commercial terms pursuant to which the product was sold by INVISTA including, but not limited to, terms and conditions addressing each party's respective rights and obligations with regard to warranties, remedies and indemnification.

If purchasers and users believe or have reason to believe that the Product Data Sheet or other information provided to them by INVISTA is inaccurate or in any way insufficient for any purpose, they should immediately notify INVISTA of the same, and of the basis for their belief (for example, studies, data, reports of incidents, etc.) so that INVISTA can determine whether modification or supplementation of the Product Data Sheet, or other measures, are appropriate. Failure of purchasers and users to timely provide such notice shall be deemed a waiver by purchasers and users of any and all claims, demands or causes of action, including causes of action based on an alleged failure to warn, for personal injury or damage to the environment or property arising from or attributable to the use of product.

This disclaimer shall be effective to the extent allowed by law. Should any provision be deemed to be ineffective or unenforceable, that provision shall be deemed severed from the disclaimer and the remaining provisions shall continue to have full force and effect.