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- (72) Inventors JOHN FISHBEIN, RAYMOND HENRY WILLIAM
BELL, ANTHONY JAMES CLARK and PETER
MERRIMAN



(54) POLYURETHANE FOAMS

(71) We, DUNLOP HOLDINGS LIMITED (formerly The Dunlop Company Limited), a British Company, of Dunlop House, Ryder Street, St. James's, London, S.W.1, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to flexible polyurethane foams, particularly to flame-retardant polyurethane foams, and to methods of making them.

Conventional polyurethane foams, particularly those derived from polyethers, have little inherent flame retardance, and in view of the widespread use of polyurethane foams in mattresses, cushions and other upholstery there exists a demand for flame-retardant products. Previous proposals for reducing the inflammability of flexible polyurethane foams have included the incorporation in the foam-forming reaction mixture of certain conventional flame retardants, for instance halogenated alkyl phosphates. However, these materials have either tended to be lost by evaporation during the foam-forming reaction or, if of sufficient molecular weight to preclude substantial loss by evaporation they have, because of their relatively high density, tended to concentrate in the lower regions of foam products during manufacture, especially where manufacture is by a continuous, free-rise method producing a foam loaf. Consequently, in order to ensure that sufficient flame retardant is included in the upper regions of the loaf it has been necessary to incorporate in the foam-forming reaction mixture an amount

of such conventional flame retardant substantially in excess of that which would be required if the retardant could be distributed evenly throughout the foam loaf. Furthermore, there is a marked tendency for certain types of polyurethane foam to shrink after being made, due to the formation of closed cells in the foam. Although this can be overcome by mechanically squeezing or crushing the foam as is well known to those skilled in the art, we have found that such shrinkage can be substantially obviated by the use of a polyether polyol derived from ethylene oxide, in which some at least of the oxyethylene groups in the polyol molecules are in non-terminal positions. Accordingly, the present invention provides a process for the production of a flexible flame-retardant polyurethane foam in which a polymeric polyol is reacted with a tolylene diisocyanate (T.D.I.) in a foam-forming reaction mixture having an isocyanate index of not more than 150 and which contains: (a) as a foam modifier a substance normally effective as a catalyst for the polymerisation of tolylene diisocyanate, and (b) an anti-ageing additive substantially to limit any deleterious effect of the foam modifier on ageing of the polyurethane foam, and (c) as an anti-shrinkage agent for the foam, from 2 to 40% by weight of the total polyol component of a poly (oxyalkylene) diol or triol derived from ethylene oxide and having a poly (oxyethylene) content of at least 20% by weight.

By "polymerisation of tolylene diisocyanate" above is meant in particular the polymerisation of three molecules of T.D.I. to produce a cyclic trimer usually of isocyanur-

[Price 33p]

ate or perhydrotriazine structure. It is not known for certain whether the foam modifier in the present invention does in fact result in the polymerisation of the T.D.I. in the reaction mixture, but it is believed that polymerisation does occur, at least where pure T.D.I. is initially present.

A particular advantage of the foams of this invention is that when subjected to flame they give off much less smoke than do conventional flame-retardant foams. This is a most valuable practical advantage because emission of noxious smoke and fumes when subjected to flame is one of the principal shortcomings of such conventional flame-retardant foams.

Substances which catalyse the polymerisation of T.D.I. include the following:—

alkali and alkaline earth metal salts of organic and weak inorganic acids, for example salts of carboxylic acids such as sodium and potassium acetate; other metal salts of carboxylic acids, for example lead heptane carboxylate (lead octoate) and calcium naphthenate; alkoxides or phenoxides of alkali or alkaline earth metals, for example sodium methoxide and sodium phenate; quaternary ammonium bases, for example tetramethyl- and tetraethyl- ammonium hydroxide; and certain tertiary amines, for instance tetramethylguanidine.

Substances of particular interest are alkaline substances, for instance alkali metal hydroxides and alkali metal salts or derivatives of weak organic or inorganic acids. By "weak" acids is meant, for example, monocarboxylic acids such as acetic acid, hydroxy aromatic compounds such as the phenols, for instance phenol itself (C_6H_5OH), and boric acid. Thus, suitable modifiers are, for example, sodium phenate, sodium acetate, potassium acetate, sodium tetraborate (borax), sodium sesquicarbonate, sodium peroxide and sodium carbonate. Of course, the particular substance or substances used as foam modifier in the process of the present invention should be such that there is no undesirable effect on the foam-forming reaction.

The foam modifiers of particular interest in the process of the present invention are basic substances, preferably readily soluble in water, and it is to such foam modifiers that the following description particularly relates.

The amount of the foam modifier incorporated depends upon the particular modified used and the nature of the components of the foam-forming reaction mixture. Although larger amounts can be used, it is not, in general, necessary to use an amount greater than 1% by weight of the polyol component, and the preferred amount is 0.05—1%, especially 0.2—0.5%. However, where the foam modifier is a tertiary amine the preferred amount is somewhat greater, and amounts of up to 5% or even more may be found neces-

sary for good results. The foam modifier, where water-soluble, is conveniently incorporated as a solution in water, for example in the water component of the foam-forming reaction mixture.

The polyol used in the production of the flame retardant foams of this invention is normally a polyether polyol having a high reactivity, though polyesters can be used. Suitable polyether polyols are those having a substantial proportion of primary hydroxyl end groups, usually referred to as "ethylene oxide-tipped polyols". However, other polyols can be used, and good results have been obtained using triols ("non-tipped polyols") such as those sold under the Registered Trade Mark Voranol CP.3720 and Propylan P.305. Suitable ethylene oxide-tipped polyols are those in which the primary hydroxyl groups comprise 20, 30 or 40% to 70% (for example 50—60%) of the total number of hydroxyl groups in that polyol. Where the polyol is a triol a suitable molecular weight is in the range 3000—6000.

A suitable polymeric polyol is one obtained by reacting a substance having a plurality of active hydrogen atoms with an alkylene oxide (for instance propylene oxide or a mixture of propylene oxide and ethylene oxide), and subsequently reacting the product thus obtained with ethylene oxide so as to introduce the terminal primary hydroxyl groups. Polyether polyols of this type are commercially available under the Registered Trade Mark Desmophen 3900 (which is a polyether triol of very high activity having a mean molecular weight of 4500—5100 and an hydroxyl number of 33—37), and Propylan M.12 described below with reference to the Examples.

The flame retardant foams of the invention can be, for example, foams of density up to 64 kg/m³, especially having densities in the range 16—64 kg/m³.

The anti-shrinkage polyols, which can be diols or triols, contain at least 20% (preferably from 20—80% and especially 40—70%) by weight of oxyethylene groups. Examples of suitable anti-shrinkage polyols are the commercial products G.978 and Propylan G.3650 of Lankro Chemicals Limited, and Pluronic L—35 (Registered Trade Mark) of Wyandotte. The anti-shrinkage polyol is effective in substantially obviating the formation of closed cells if it is used in an amount of from 2—40 (for example 4—15) % by weight of the total polyol component of the foam-forming reaction mixture. Care should be taken in the amount of the anti-shrinkage polyol used because too much leads to collapse of the foam. The anti-shrinkage polyol is conveniently a poly(oxyethylene) poly(oxypropylene) polyol whose poly(oxypropylene) content has a molecular weight in the range 500—2000, for instance 800—1500. It can, for example,

be a triol of molecular weight in the range 2000—3500. Where it has primary hydroxyl terminal groups they can comprise, for example, 35—45% of the terminal groups. The anti-shrinkage polyol can be a substance consisting substantially of oxyethylene groups. Polyethylene glycols of low molecular weight, for example in the range 300—800 have been found suitable. Other suitable subsidiary polyols are shown in our co-pending application No. 18603/71 (Serial No. 1,339,442).

The anti-shrinkage polyol is preferably fed to the mixer for the foam-forming reaction mixture as a separate stream, though satisfactory results have been obtained where it has been previously blended with the major polyol and the blend fed to the mixer.

It has further been found according to the present invention that the ageing properties of the polyurethane foams can be improved, especially where the foam modifier is a substance containing an alkali metal, for instance sodium or potassium salts of phenols, or inorganic or carboxylic acids, or alkali metal hydroxides, or other basic substance, if there is incorporated in the polyurethane foam-forming reaction a neutralising anti-ageing additive, for instance a labile halogen-containing substance. Suitable anti-ageing additives are halogenated aliphatic phosphate esters, such as chloro- and bromo- derivatives of trialkyl orthophosphates, for example compounds of the formula R_3PO where R is an halogenated—preferably polyhalogenated—alkyl group of 2, 3 or 4 carbon atoms. Examples of suitable anti-aging additives are tri-*beta*-chloroethyl phosphate, tri-*beta*-dichloropropyl phosphate, and tri-*beta*-dibromopropyl phosphate (T.B.P.P.) which is particularly effective. Although some of these compounds are themselves flame retardants and they contribute towards the flame-retardant of the foams, their effect in this direction is only minor and the flame-retardance of the foams is due in the main to the use of the foam modifier. The amount of anti-ageing additive to be used depends of course upon the particular inhibitor and also the type of foam in which it is to be used. However, in general an amount of 0.5—4 parts (especially 1.5—3 parts) per hundred parts of the polyol component has been found to be effective. Such amounts are much less than the amounts in which, for example T.B.P.P. is conventionally used as a flame retardant additive—usually about 15—20 parts per hundred of polyol. Where an organic bromo compound is used as the additive, it has been found that effective amounts are those corresponding to an amount of up to 0.25% (for example 0.05—0.1%) by weight of bromine per 100 parts of polyol component. Where the additive is a chloro compound the effective amounts are those corresponding to an amount of up to 0.5% (for example 0.1—0.2%) by weight

per 100 parts of polyol component.

The anti-ageing additives are in general covalent organic compounds which contain labile halogen atom or atoms. Such compounds can lose their labile halogen (for example, as a result of interaction between the halogen and alkali metal ions). The additives should be such that neither they, nor the residual substance left after loss of the labile halogen, have an undesirable effect on the reactions in the foam-forming reaction mixture. It is thought that the preferred additives, referred to above, probably do not lose their halogen until the early stages of the foam forming reaction are complete, but that they then lose their halogen (perhaps due to the exothermic heat produced in the reaction) which can then combine with alkali metal ions in the reaction mixture and thereby preclude their interference with the reaction mechanism or deleterious effect on the foam product.

Small amounts of amine catalysts may be used in the process of the invention, though it has not been found essential to use them where the polyol is an ethylene-oxide tipped polyol; but they are more necessary when using non-tipped polyols. Examples of tertiary amines which can be used are, for example, dimethyl ethanolamine, N-methyl and N-ethyl morpholines, triethylamine, and triethylene diamine (also known as 1,4-diazobicyclo 2,2,2-octane).

Under certain circumstances, for example when harder foams are required, cross-linking agents may be employed. Examples of suitable cross-linking agents are hydroxy amines, for example triethanolamine and tetrakis N-beta-hydroxypropylethylene diamine (sold under the Registered Trade Mark Quadrol); low molecular weight polyols, such as tetrols, hydroxyethers, for example trihydroxypropyl glycerol, and ortho-dichloro methylene bis-aniline.

In general the polyisocyanate and polyol components can be used in amounts such that the isocyanate index is of a normal value, for example in the range 100—110. However, the isocyanate index value must not exceed 150.

The T.D.I. can be in a substantially pure state. Where T.D.I. is referred to herein it can contain one or more isomers thereof. For example, it can be tolylene-2,4-diisocyanate, tolylene-2,6-diisocyanate, or a mixture thereof, for instance in the proportions 65:35 (65:38 T.D.I.) or, preferably 80:20 T.D.I.) by weight.

The T.D.I. can be, for example, crude T.D.I. or T.D.I. in polymeric form.

Crude T.D.I. is the product obtained by reacting the appropriate diamino-toluene with phosgene without any substantial purification. It is believed to contain material of polyurea and polybiuret structure. Where a mixture of 2,4- and 2,6-diamino-toluene

is used, the crude T.D.I. contains the corresponding 2,4- and 2,6 - diisocyanates.

Polymeric T.D.I. is normally of uretdione or isocyanurate structure. It can be obtained from pure T.D.I. in a separate preliminary reaction using polymerisation techniques well-known in the art and using catalysts referred to herein.

It has been found that the use in the process of the invention of large quantities of polysiloxane - oxyalkylene block copolymers should be avoided as they can detract from the flame-retardant properties of the polyurethane foams obtained. If a polysiloxane-oxyalkylene block copolymer is used it should preferably be in an amount less than 0.1% and preferably not more than 0.05%. However, small proportions of a polydimethyl siloxane as used in the Examples below is not objectionable, for example up to 0.1% by weight of the weight of the polyol component. Even larger quantities can be used if desired, and satisfactory foams have been obtained using amounts as follows:

Viscosity of silicone	Amounts (parts per 100 of polyol)
2 centistokes	0.5—4
5 "	0.025—0.25
10 "	0.05—0.1

The polyurethane foams of the invention can be obtained in moulded form by a cold-cure moulding method, that is, a method in which the foam-forming reaction mixture is moulded and allowed to cure without the application of heat.

Moreover, the foams of the invention are suitable for use in flame lamination to textile and other substrates.

Although it is not intended that the present invention should be construed with reference to any particular theory, it is thought that the foam modifier has the effect of producing a polyurethane foam having a structure different from that obtained in the absence of the foam modifier such that when subjected to flame the foam tends to collapse and thereby presents a reduced surface area to the flame. This view is supported by observation of what happens to a foam of the invention when subjected to a flame. For example, when a lighted match is placed on a block of the form the portion subjected to the heat of the flame readily melts or decomposes and "retracts" away from the flame but without any sustained burning.

The invention is illustrated by the following Examples, in which flexible flame-retardant polyurethane foams are obtained by the one-shot or single stage method.

The meanings of various Trade Names used in the Examples are as follows: Propylan M.12 is the Trade Name of a polyether polyol sold by Lankro Chemicals Limited, and

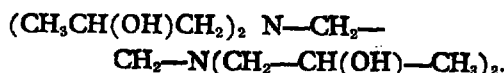
which is believed to be a poly(oxypropylene) poly(oxyethylene) triol having the following characteristics:—

Molecular Weight	about 5000
Hydroxyl No.	35—37
Poly(oxyethylene) content about 12—13% by weight	70

It has a high proportion of primary hydroxyl end groups.

G.978 is an abbreviation for "Development Polyol G.978" sold by Lankro Chemicals Limited. It is used in the Examples as an anti-shrinkage agent, and is believed to consist essentially of a poly(oxyethylene) poly(oxypropylene) triol based on a glycerol "starter" and having a molecular weight of about 2,800, a hydroxyl number of 53—59 and a poly(oxyethylene) content of about 64% by weight. The proportion of primary hydroxyl groups : secondary hydroxyl groups in this polyol is believed to be in the ratio 40 : 60.

It will be seen that in Example 3 the polyol component contained a third polyol (as a cross-linking agent) referred to as "Quadrol" which is believed to consist essentially of the compound:



In the Examples the silicone MS.200/5 is a commercial silicone oil having a viscosity of 5 centistokes and believed to be a dimethyl siloxane homopolymer, and the *tris* - dibromopropyl phosphate (T.B.P.P.) anti-ageing additive was used in the form of the commercial product Bromkal P.67. The T.D.I., except where stated otherwise, was 80:20 T.D.I. The hardness values were obtained under the test of BS.3667. Reference in the Examples simply to "catalyst" is to the foam modifier.

EXAMPLE 1.

A flexible, free-rise polyurethane foam obtained using the following formulation:—

Propylane M.12	Polyol Component	90
G978		10
Water		3
Sodium phenate		0.4
T.B.P.P		2
Silicone MS.200/5		0.05
T.D.I.		36.5

In this Example, and in the other Examples, the amounts of the ingredients are shown in parts by weight.

The procedure used to make the foam was as follows.

First, the silicone was dispersed in 2.5

parts of the Propylan M.12 polyol so as to provide a 2% solution; and the sodium phenate was dissolved in all of the water component. The remainder of the polyol component was then mixed with the T.B.P.P. and the polyol dispersion of the silicone by high speed stirring for 20 seconds. The aqueous solution of the sodium phenate was then added to the mixture and the whole was stirred for a further 15 seconds. Then the T.D.I. was added and the string was continued for a further 8 seconds, at the end of which time the resulting foam-forming reaction mixture started to "cream" and was immediately poured into an open mould.

The rise of the foam was completed in 90 seconds, and the foam was tack-free at the end of about 15 minutes after the pouring. At this time the resulting polyurethane moulding was removed from the mould.

The foam had a density of 29.4 kg/m³ and a hardness of 6 kg. and did not shrink on cooling.

EXAMPLE 2.

A flexible, free-rise polyurethane foam was obtained using the following formulation and the procedure described in Example 1:

Propylan M.12	} Polyol Component	90
G.978		10
Water		4
Sodium phenate		0.3
Silicone MS.200/5		0.05
T.B.P.P.		2
T.D.I.		46.5

The foam had a density of 24 kg/m³ and a hardness of 7—8 kg. and did not shrink on cooling.

EXAMPLE 3.

A flexible, free-rise polyurethane foam was obtained using the following formulation and the procedure described in Example 1:

Propylan M.12	} Polyol Component	82.5
G.978		12.5
Quadrol		5.0
T.B.P.P.		2
Water		4
Silicone MS.200/5		0.05
Sodium phenate		0.25
T.D.I.		52.4

The foam had a density of 25.0 kg/m³ and a hardness of 13—15 kg. and did not shrink on cooling.

EXAMPLE 4.

A flexible, polyurethane foam cushion was obtained by a cold-moulding technique using the following formulation:—

Propylan M.12	} Polyol Component	95	55
G.978		5	
Water		3	
Sodium phenate		0.5	
Triethylamine		0.4	
Silicone MS.200/5		0.05	
T.B.P.P.		2	60
T.D.I.		36	

The foam-forming reaction mixture, obtained using the procedure of Example 1, the triethylamine being dissolved in the polyol, was dispensed into a metal mould which had been pre-heated to 50°C. A close-fitting lid was clamped into place on the mould by toggle clamps and the mould left for 10 minutes without any application of heat. The moulded product was then removed from the mould. It was found to have a density of 48 kg/m³ and did not shrink on cooling.

EXAMPLE 5.

A flexible, free-rise polyurethane foam was obtained using the following formulation and the procedure described in Example 1:

Propylan M.12	} Polyol Component	95	75
G.978		5	
Water		3	
Sodium phenate		0.4	
T.B.P.P.		2	80
T.D.I.		41.2	
Silicone MS.200/5		0.05	

The foam had a density of 29 kg/m³ and a hardness of 10 kg. and did not shrink on cooling.

The foams of the Examples were all found to have excellent flame-retardance. When tested under the conditions of ASTM D 1692 67T the following results were obtained:

	EXAMPLE			
	1	2	4	5
Mean extent burned (mm)	14	29	13	22
Burning time (seconds)	10	22	13	24
Burning rate (mm/second)	1.4	1.32	1.0	0.91

5 Besides their excellent flame-retardance, the foams of these Examples were found to have high resilience—more than 50% as measured by the falling ball rebound test—and to show a relatively linear load-deflection relation.

obtained using the procedure of Example 1 10
and the following formulations:

In the Examples, PROPAMINE A is N,N - dimethylethanolamine, having the formula



EXAMPLES 6—13.

Further flexible polyurethane foams were

The word PROPAMINE is a Registered Trade Mark.

Example No.	6	7	8	9	10	11	12	13
Catalyst	Sodium Hydroxide	Sodium Carbonate (anhydrous)	Sodium Stannate (Na ₂ SnO ₃ · 3H ₂ O)	Sodium Formate	Benzyl trimethyl ammonium phenoxide	Potassium Phenate		
(parts)	0.15	0.25	0.4	0.2	0.5	0.4	0.5	0.45
Propylan M.12	90	90	90	90	90	92.5	90	90
G.978	10	10	10	10	10	7.5	10	10
Water	4.5	4.5	4.5	4.5	4.5	4.5	3	3
T.B.P.P.	2	2	2	2	2	0.4	2	2
Silicone MS.200/5	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
T.D.I.	54	54	54	54	54	36.2	36.2	36.2
Propamine A	—	—	—	0.2	0.2	—	—	—
Foam Density (kg./m. ³)	21	21	21	31	31	30	30	30

The foam of each of Examples 6—13 was found to be self extinguishing when tested according to ASTM D 1692/67T. That test was used for the products of all the following Examples except if stated otherwise.

Example 6 was repeated using the G.978 in amounts of 7.5, 8.5, 9, 11, 12 and 13.5 parts, instead of the 10 parts used in that

Example. In each case the amount of Propylan M.12 used was such that the total weight of Propylan M.12 and G.978 was 100 parts. The foam products obtained in each case were self-extinguishing.

EXAMPLES 14—17.

Example 6 was repeated but using the following labile hydrogen compounds instead of the T.B.P.P.

Example 14: *tris* 2,3 - dichloropropyl phosphate (as the commercial product Fryol F.R.2—2 parts)

5 Example 15: *tris* β - chloroethyl phosphate (4 Parts)

Example 16: 1,2,3 - tribromo propane (1.2 parts)

Example 17: dibromo - neopentyl glycol (2 parts)

10 (In Example 17 the amount of T.D.I. was increased to 37.6 to take account of the hydroxyl groups in dibromo - neopentyl glycol).

15 The foam product of each of these Examples was self-extinguishing, and did not suffer deterioration on heat ageing for 16 hours at 140°C. However, in comparative Examples in which the halogen compound was omitted, the foam products had deteriorated so much at the end of 16 hours heat ageing that their relevant physical properties could not be measured.

EXAMPLES 18—20.

25 These Examples illustrate the use of anti-shrinkage agents other than the polyol G.978 to obviate shrinkage of flexible foam products.

The procedure and formulation of Example 6 was repeated except that the following amounts of anti-shrinking agents were used instead of the G.978. In each case the total amount of Propylan M.12 and anti-shrinkage agent was 100 parts.

30 Example 18 Polyol R.161: 10—11.5 (for example 11.5) parts

35 Example 19 Polyol 1138: 7—9 (for example 7) parts

Example 20 Polyethylene glycol (PEG 600); 10—11.5 (for example 11) parts

40 Polyol R.161 and Polyol DP 1138 are respectively polyether triols sold by Union Carbide Corporation and Lankro Chemicals Limited. They have molecular weights in the range 2500—3500 and poly(oxyethylene) contents of about 65% and 79% by weight.

45 The foam products obtained were self-extinguishing.

EXAMPLE 21.

50 This describes the production of a flexible polyurethane foam moulding by the cold cure technique using a typical formulation of the present invention.

Propylan M.12 (288 g.) was blended with 12 g. of polyol G.978, 9 g. sodium carbonate solution (20 g Na₂CO₃ in 280 g. water), 55 0.9 g. Dabco 33LV*, 0.69 g. silicone MS. 200/5 and 3.0 g. 98% pure triethanolamine. The blend was mixed with a high speed stirrer for 10 seconds, 30 g. trichlorofluoromethane was added and stirring continued for a further 10 seconds.

*The word DABCO is a Registered Trade Mark.

114 g. of T.D.I. was then added and further stirred for 10 seconds. The mixture was then poured into a mould having a surface temperature of 58°C. The mould lid was clamped into place and the moulding left to cure without the application of heat for 10 minutes. The moulding obtained was of good appearance, its density was 37 kg/m³ and the foam was self-extinguishing.

EXAMPLE 22.

This Example illustrates the use of sodium salts of halogenated acetic acids as catalyst. Using the procedure of Example 1 flexible, free-rise foams were obtained from the following formulation.

Propylan M.12	Polyol Component	85.5	
G.978		12.5	
Polyol EDP.500		2	
Water		4.5	
Sodium monochloro acetate (S.M.C.A.)		0.4	80
Propamine A		0.4	
T.B.P.P.		2	
Silicone MS.200/5		0.05	
T.D.I.		63	

The foam density was 21.9 kg/m³ and the burned length was 22 mm.

The polyol EDP.500 is a low molecular weight cross-linking tetrol, believed to contain ethylene diamine as starter nucleus and having a molecular weight about 500.

EXAMPLES 23 AND 24.

Example 22 was repeated except that instead of the S.M.C.A. was used respectively 0.52 part sodium dichloroacetate and 0.64 part sodium trichloroacetate. The flexible foam products obtained were as follows:

Example 23—density 21.8 kg/m³ burned length 26 mm.

Example 24—density 21.9 kg/m³; burned length 22 mm.

EXAMPLE 25.

Example 22 was repeated but using tetramethyl guanidine (0.3 part) as catalyst instead of the S.M.C.A., and 0.3 part of Dabco 33 LV instead of the Propamine A. The flexible foam obtained was self-extinguishing.

EXAMPLE 26.

Tetramethylammonium hydroxide was used as catalyst in the following formulation to produce a flexible foam.

Propylan M.12	95	
G.978	5	
Water	4.5	
T.D.I.	61.5	
Silicone MS.200/5	0.05	115
(CH ₃) ₄ N. OH	0.34	
T.B.P.P.	1	

The foam obtained was self-extinguishing. In a comparative Example without T.B.P.P. the foam, though self-extinguishing, lost its flame retardant properties after heat ageing at 140°C. for 4½ hours.

5 In the following Examples, Daltogard WP is triphenyl phosphite.

EXAMPLE 27.

10 This Example illustrates the use of co-catalysts with the T.D.I. polymerisation-type catalyst. A flexible foam was obtained from the following:

	Proplan M.12	92.5
	G.978	7.5
15	T.D.I. (135 index)	66.5
	Water	4.5
	T.B.P.P.	2
	Daltogard WP	1
	NaOH	0.15
20	Propamine A	0.2
	Silicone MS.200/5	0.05

The foam product was self-extinguishing, mean extent burned being 43 mm.

EXAMPLE 28.

25 Example 27 was repeated but using 0.2 part of N,N - dimethylbenzylamine in place of the Propamine A. The product was self-extinguishing, mean extent burned being 54 mm.

EXAMPLE 29.

30 Isophorone diisocyanate (IDI) was used in conjunction with the T.D.I. to provide a flexible foam.

	Proplan M.12	90
35	G.978	10
	T.D.I.	53.3
	Isophorone DI	15
	Water	4.5
	T.B.P.P.	1
40	Na ₂ CO ₃	0.2
	Propamine A	0.2
	Silicone MS.200/5	0.05

The product was self-extinguishing, mean extent burned being 39 mm.

EXAMPLE 30.

45 A crude M.D.I. sold under the Trade Mark Isonate 143—L, and believed to be a carbodiimide-modified M.D.I. was used in conjunction with T.D.I.

Propylan M.12	95	50
G.978	5	
T.D.I.	45.5	
} NCO index 135 {		
M.D.I.	30	
Water	4.5	
T.B.P.P.	2	
Daltogard WP	1	55
Na ₂ CO ₃	0.2	
Propamine A	0.2	
Silicone MS.200/5	0.05	

The foam product was self-extinguishing, mean extent burned being 17 mm. 60

EXAMPLES 31—40.

Ten further flexible foams were obtained using various catalysts in the following formulations. Comparative foams using the same formulations but without T.B.P.P. and Daltogard WP were also produced. 65

On hot oven ageing at 140°C. it was found that the comparative foams had substantially lost their flame-retardance after 5 hours, and after 16 hours they had deteriorated so much that their relevant physical properties could not be measured. On the other hand, the foams of the invention had retained their flame-retardance, and their physical properties were only little worse than before ageing. 70
Indeed, their tensile strength and elongation at break were better. 75

Example No.	31	32	33	34	35	36	37	38	39	40
Catalyst	Sodium Tungstate	Sodium Molybdate	Sodium Acetate	Sodium Bicarbonate	Sodium sesquicarbonate	Lithium Hydroxide	Potassium Acetate	Potassium Hydroxide	Sodium Silicate	Ni(O) (bipyridyl) ₂
No. of parts of catalyst	0.8	0.8	0.6	0.2	0.2	0.42	0.6	0.2	0.4	0.4
Propylan M.12	90	90	90	90	90	90	90	90	90	95
G.978	10	10	10	10	10	10	10	10	10	5
Water	4.5	4.5	4.5	4.5	4.5	4.32	4.5	4.5	4.5	3
T.B.P.P.	2	2	2	2	2	2	2	2	2	2
Daltogard WP	1	1	1	1	1	1	1	1	1	1
MS.200/5	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
T.D.I.	61.5	61.5	61.5	66.5	66.5	61.5	61.5	61.5	61.5	43.4
Mean Extent burned mm. (BS 4735)	54.8	75	42.3	28.8	17.5	47.4	53.7	32.5	76.2	

The sodium sesquicarbonate was used in the form of an aqueous solution prepared by dissolving equimolar amounts of sodium carbonate and sodium bicarbonate in water; this solution was used directly in the foam formulation without isolating the sesquicarbonate.

All the foam products had densities in the range 19–25 kg/m³.

In Example 40 there was used 0.6 part of N-ethyl morpholine.



WHAT WE CLAIM IS:

1. A process for the production of a flexible flame-retardant polyurethane foam, in which a polymeric polyol is reacted with a tolylene diisocyanate (T.D.I.) in a foam-forming reaction mixture having an isocyanate index of not more than 150 and which contains: (a) as a foam modifier a substance normally effective as a catalyst for the polymerisation of tolylene diisocyanate, and (b) an anti-ageing additive substantially to limit any deleterious effect of the foam modifier on ageing of the polyurethane foam, and (c) as an anti-shrinkage agent for the foam, from 2 to 40% by weight by weight of the total polyol component of a poly(oxyalkylene) diol or triol derived from ethylene oxide and having a poly(oxyethylene) content of at 20% by weight.

2. A process according to Claim 1, in which said additive is a labile halogen-containing substance.

3. A process according to Claim 2, in which said additive is a halogenated aliphatic phosphate ester.

4. A process according to Claim 3, in which the ester is a chloro- or bromo-derivative of a trialkyl orthophosphate.

5. A process according to Claim 4, in which said additive is *tris* 2,3 - dibromopropyl orthophosphate.

6. A process according to any of the preceding claims, in which the amount of said additive is 0.5—4% by weight of the polyol component.

7. A process according to any of the preceding claims, in which the foam modifier is a basic substance.

8. A process according to Claim 7, in which the foam modifier is an alkali metal hydroxide.

9. A process according to Claim 7, in which the foam modifier is an alkali metal salt of a weak inorganic acid (as hereinafter defined).

10. A process according to Claim 9, in which the foam modifier is sodium carbonate.

11. A process according to Claim 7, in which the foam modifier is an alkali metal salt of an organic acid.

12. A process according to Claim 7, in which the foam modifier is in an amount of 0.05—1% by weight of the polyol component.

13. A process according to any of the preceding claims, in which the T.D.I. is crude T.D.I.

14. A process according to any of Claims 1—12, in which the T.D.I. is in polymeric form.

15. A process according to any of the preceding claims, in which the polymeric polyol comprises one having a substantial proportion of primary hydroxyl groups.

16. A process according to Claim 15, in which the polymeric polyol is a triol and the primary hydroxyl groups comprise 40—70% of the total number of hydroxyl groups.

17. A process according to any of the preceding claims, in which the polymeric polyol is a poly(oxyethylene) poly(oxypropylene) triol having a poly(oxyethylene) content of up to 20% by weight.

18. A process according to any one of the preceding claims, in which the anti-shrinkage polyol (c) is a poly(oxyethylene) poly(oxypropylene) polyol.

19. A process according to Claim 18, in which the polyol (c) is a triol having a molecular weight in the range 2000—3500.

20. A process according to Claim 18 or 19, in which the polyol (c) has a poly(oxyethylene) content of 40—70% by weight.

21. A process according to any of Claims 18 to 20, in which 35—45% of the hydroxyl groups of the polyol are primary hydroxyl groups.

22. A process according to any one of Claims 1 to 17, in which the polyol is a poly(oxyethylene) polyol.

23. A process according to Claim 22, in which the polyol is a polyethylene glycol.

24. A process according to any one of Claims 1 to 23, in which the polyol is in an amount of 4—15% by weight of the total polyol component of the foam-forming reaction mixture.

25. A process according to any one of the preceding claims, in which the reaction mixture contains no catalyst for the foam-forming reactions other than the foam modifier.

26. A process according to any one of the preceding claims, in which the foam-forming reaction mixture is fed into a mould where it is converted into moulded product without the application of external heat.

27. A process according to Claim 1, substantially as described herein.

28. A process for the production of a flexible flame-retardant foam, substantially as described in any of Examples 7 to 17.

29. A process for the production of a flexible flame-retardant foam, substantially as described in any of Examples 21 to 40.

30. A flexible flame-retardant polyurethane foam, obtained by the process of any of the preceding claims.

R. I. G. McKAY,

Agent for the Applicants.