

(19)



Europäisches Patentamt
European Patent Office
Office européen des brevets



(11) Publication number:

0 242 227 B1

(12)

EUROPEAN PATENT SPECIFICATION

(45) Date of publication of patent specification: **10.02.93** (51) Int. Cl.⁵: **G21F 1/10**

(21) Application number: **87303420.1**

(22) Date of filing: **16.04.87**

(54) **Elastomeric neutron protection material.**

(30) Priority: **17.04.86 DE 3612971**

(43) Date of publication of application:
21.10.87 Bulletin 87/43

(45) Publication of the grant of the patent:
10.02.93 Bulletin 93/06

(84) Designated Contracting States:
CH FR GB IT LI

(56) References cited:
EP-A- 0 041 155
DE-A- 3 238 831
FR-A- 2 534 058
US-A- 4 072 702

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Description

The invention relates to an elastomeric neutron protection material for decelerating fast neutrons, comprising an elastomeric material having a high hydrogen content and being preferably combined with an absorber material, e.g., boron, for decelerating slow electrons.

Known elastomeric neutron protection materials of the kind indicated are silicone elastomer-based (German disclosure Letter 28 22 494) or polyurethane-based (German disclosure Letter 32 38 831) and offer important advantages over polyethylene and polypropylene, or even simpler protection materials like water, paraffin and the like, with respect to mechanical and chemical properties, particularly temperature resistivity, toughness, resilient deformability, workability, and chemical durability. The hydrogen content, which is the determining factor for the neutron decelerating capability, however, is considerably less than in polyethylene and polypropylene (14.3 weight percent), polyamide (11.6 weight percent) or water (11.1 weight percent), and amounts to about a maximum of 5 to 7 weight percent. Further consideration of other known neutron protection materials (German disclosure Letter 32 38 831) shows that protection materials were not available which combine in themselves good mechanical and chemical properties with a high hydrogen content similar to that of polyethylene.

In accordance with the invention, there is provided a material which comprises a polymeric reaction product of a reaction between a) at least one polybutadiene-based polyol and b) at least one aliphatic diisocyanate, the reaction product having a hydrogen content of at least 8 weight percent, said protection material having a total hydrogen content of from 10 to 12.5 weight percent.

This composition thus provides an elastomeric neutron protection material which exhibits good mechanical, chemical, and physical properties, particularly easy workability, chemical durability, and temperature resistivity, with a particularly high hydrogen content.

Elastomeric neutron protection materials in accordance with the invention can be simply prepared like known polyurethanes and have, similar to the latter, very favorable mechanical, chemical and physical properties; the hydrogen content, however, is considerably higher

10 to 12.5 weight percent, which is up to double the hydrogen content of known neutron protection materials having comparable elastomeric properties. In any case, a hydrogen content of more than 8 weight percent is desired and readily obtainable.

Of the mechanical properties, the following should be particularly emphasized:

- flexibility at low temperatures (glass transition temperature about -60°C ;
- low shrinkage rate;
- low vapor permeability;
- castable; possibility to manufacture structural parts of high volume; filler materials, particularly of an abrasive nature, e.g., boron carbide powder, can be simple intermixed;
- interlinked, thus not exhibiting cold flow;
- good adhesion and cohesion; better compatibility with usual layered systems, for instance if further layers or a protection lacquer is applied.

Of the chemical properties, the following should be particularly emphasized;

- good durability against hydrolysis;
- good durability against alkali and acids;
- good durability of coloration against light;
- good durability against oxygen;
- sprayable (even with a high content of filler materials).

The neutron protection materials according to the invention can be easily combined with absorber materials, particularly boron or boron-containing substances for absorbing slow neutrons. For instance, an absorber material, such as boron carbide or boron nitride, can be provided as a filler material in finely divided form. Then, the neutron protection material will form a shield against slow as well as against fast neutrons. The absorber material can also be provided in chemically bonded form; for instance, the polyols can be partly or totally provided in the form of organic boron compounds, e.g., diol boric acid ester.

It should be understood that the neutron protection material according to the invention can also be combined with other radiation protection materials, for example with heavy metals or heavy metal compounds, for example in finely divided form as filler material, in order to achieve an additional protection against ionizing radiation.

The preparation of the neutron protection materials in accordance with the invention basically may be performed in the same manner as the preparation of known polyurethanes, and with the use of corresponding catalysts. If the two components are brought to reaction, the OH radicals of the polyol react with the NCO radicals of the isocyanate.

The favorable properties of the neutron protection materials according to the invention are based essentially due on the fact that polybutadiene-based polyol have a hydrogen content similar to that of polyethylene and result in reaction products which have a high elasticity and a high durability against shock loads. The aliphatic diisocyanates used in accordance with the invention have higher hydrogen contents
5 than the usually employed aromatic diisocyanates and result in reaction products having a high temperature resistivity. For crosslinking, particularly trifunctional crosslinking agents can be employed which offer advantages because of their high reactivity; such crosslinking agents are not applicable with aromatic isocyanates. Particularly well suited are crosslinking agents from the group nitrolo tripropanol, triethanolamine and nitrotributanol.

10 It should be understood that all batch components used in the preparation of the neutron protection material according to the invention are selected with a view to obtaining as high a hydrogen content as possible. Batch components which contain hydrogen only in small amounts, or not at all, should be used in amounts as small as possible in order to avoid unnecessary reduction of the hydrogen content of the final product.

15 The invention will be subsequently described by means of embodiment examples. In the tables, all contents are shown, in both weight percents and in parts by weight (parts by weight are in parenthesis).

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Table 1

Example No.

5	Batch Components - Amounts shown in parts by weight (in parenthesis) and in weight percent	1	2	3	4
10	Poly BD R45 HT Polybutadiene resin having terminal hydroxy radicals (ARCO Chemical Company)	(80.00) 53.42	(80.00) 48.18	-	-
15	Nisso G1000 1,2-polybutadiene resin having terminal OH radicals (NIPPO SODA CO. LTD)	-	-	(80.00) 32.90	(80.00) 50.11
20	Trimethyl hexane diol (VEBA)	(20.00) 13.36	(20.00) 12.04	(10.00) 4.11	(10.00) 6.26
	Triethanol amine (MERCK)	-	(5.00) 3.01	(10.00) 4.11	(10.00) 6.26
25	IRGANOX 1076 Antioxydant (CIBA-GEIGY)	(0.80) 0.53	(0.80) 0.48	(0.80) 0.33	(0.80) 0.50
30	Molecular sieve ZEOLITH-L-PASTE Sodium aluminum silicate (BAYER)	(8.40) 5.61	(8.40) 5.06	(8.40) 3.45	(8.40) 5.26
35	Defoaming agent Silicon oil (WACKER CHEMIE)	(0.05) 0.03	(0.05) 0.03	(0.05) 0.02	(0.05) 0.03
	Dibutyl tin dilaureate 10% (Barlocher)	(0.20) 0.13	(0.20) 0.12	(0.60) 0.25	(0.60) 0.38
40	Isophoron diisocyanate (VEBA)	(40.30) 26.92	(51.60) 31.08	-	(49.80) 31.19
	Aliphatic diisocyanate DDI (General Mills, Inc.)	-	-	(133.30) 54.82	-
45		(149.75) 100.00	(166.05) 100.00	(243.15) 100.00	(159.65) 100.00
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Example No.

Mechanical Properties	1	2	3	4
Tensile strength (N/mm ²)	11.40	12.20	1.80	12.2
Elongation at break (%)	625.40	229.00	219.30	162.70
Tear strength (N/mm ²)	3.10	4.40	0.50	6.30
Shore A hardness	67	82	39	85
Hydrogen content (weight %)	10.10	10.10	12.3	11.30

Table 2

With Absorber Material		
	Example No.	
Batch Components	5	
	Parts by Weight	Weight Percent
Shellsol T (Shell)	(8.800)	8.38
Bentone 34	(0.800)	0.76
Ethanol	(0.400)	0.38
B ₄ C Powder	(71.650)	68.25
Zeolith-L-Paste	(3.100)	2.95
Poly BD R45 NT	(12.100)	11.52
Trimethyl hexane diol	(3.000)	2.86
Irganox 1076	(0.120)	0.11
Dibutyl tin dilaureate (10%)	(0.030)	0.03
Isophoron diisocyanate	(5)	4.76
	(105.00)	100.00
Mechanical Properties Adhesion to steel (MPa)	8.3	8.3

Claims

1. An elastomeric neutron protection material capable of decelerating fast neutrons, comprising an elastomeric polymeric reaction product of a reaction between:
 - a) at least one polybutadiene-based polyol; and
 - b) at least one aliphatic diisocyanate; the product having a hydrogen content of at least 8 weight percent, said protection material having a total hydrogen content of from 10 to 12.5 weight percent.
2. The protection material according to claim 1 wherein said material has a tensile strength of from 11 to 12.5 N/mm².
3. The protection material according to any preceding claim wherein said material has an elongation at break of from 100 to 800%.

4. The protection material according to any preceding claim wherein said material has a tear strength of from 3 to 7 N/mm².
- 5 5. The protection material according to any preceding claim wherein said material has a Shore A hardness of from 60 to 90.
6. The protection material according to any preceding claim further including an absorber material capable of decelerating slow neutrons.
- 10 7. The protection material of claim 6 wherein said absorber material comprises boron.
8. The protection material of any preceding claim further containing an absorption layer comprising an absorber material capable of decelerating slow neutrons.
- 15 9. The protection material of claim 8 wherein said absorber material comprises boron.
10. A process for preparing the protection material according to any preceding claim comprising reacting said polyol and said isocyanate in the presence of a crosslinking agent to form a polymeric reaction product.
- 20 11. The process according to claim 10 wherein said crosslinking agent is trifunctional and selected from the group consisting of nitrilo tripropanol, triethanol amine, and nitro tributanol.

Patentansprüche

- 25 1. Elastomeres Neutronenschutzmaterial, das zum Bremsen schneller Neutronen in der Lage ist, umfassend ein elastomeres, polymeres Reaktionsprodukt einer Reaktion zwischen:
 - a) mindestens einem Polyol auf der Basis von Polybutadien und
 - b) mindestens einem aliphatischen Diisocyanat, wobei das Produkt einen Wasserstoffgehalt von
- 30 mindestens 8 Gewichtsprozent und das Schutzmaterial einen Gesamtwasserstoffgehalt von 10 bis 12,5 Gewichtsprozent aufweist.
2. Schutzmaterial nach Anspruch 1, bei welchem das Material eine Zugfestigkeit von 11 bis 12,5 N/mm² hat.
- 35 3. Schutzmaterial nach einem der vorstehenden Ansprüche, bei welchem das Material eine Zerreidehnung von 100 bis 800 % hat.
- 40 4. Schutzmaterial nach einem der vorstehenden Ansprüche, bei welchem das Material eine Zerreifestigkeit von 3 bis 7 N/mm² hat.
5. Schutzmaterial nach einem der vorstehenden Ansprüche, bei welchem das Material eine Shore-Hrte A von 60 bis 90 hat.
- 45 6. Schutzmaterial nach einem der vorstehenden Ansprüche, ferner umfassend ein Absorbermaterial, das zum Bremsen langsamer Neutronen in der Lage ist.
7. Schutzmaterial nach Anspruch 6, bei welchem das Absorbermaterial Bor umfat.
- 50 8. Schutzmaterial nach einem der vorstehenden Ansprüche, ferner umfassend eine Absorptionsschicht, die ein zum Bremsen langsamer Neutronen fhiges Absorbermaterial aufweist.
9. Schutzmaterial nach Anspruch 8, bei welchem das Absorbermaterial Bor umfat.
- 55 10. Verfahren zur Herstellung des Schutzmaterials nach einem der vorstehenden Ansprüche, umfassend das Umsetzen des Polyols und des Isocyanats in Gegenwart eines Netzmittels zur Bildung eines polymeren Reaktionsprodukts

11. Verfahren nach Anspruch 10, bei welchem das Netzmittel dreifunktional ist und aus der Gruppe ausgewählt wird, bestehend aus Nitrilotripropanol, Triethanolamin und Nitrotributanol.

Revendications

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1. Matériau élastomère de protection neutronique capable de freiner des neutrons rapides, comprenant un produit de réaction polymère élastomère d'une réaction entre :

- a) au moins un polyol à base de polybutadiène ; et
b) au moins un diisocyanate aliphatique ; le produit ayant une teneur en hydrogène d'au moins 8 % en poids, ledit matériau de protection ayant une teneur totale en hydrogène de 10 à 12,5 % en poids.

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2. Matériau de protection selon la revendication 1, ledit matériau ayant une résistance à la rupture par traction de 11 à 12,5 N/mm².

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3. Matériau de protection selon une quelconque des revendications précédentes, ledit matériau ayant un allongement à la rupture de 100 à 800 %.

4. Matériau de protection selon une quelconque des revendications précédentes, ledit matériau ayant une résistance au déchirement de 3 à 7 N/mm².

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5. Matériau de protection selon une quelconque des revendications précédentes, ledit matériau ayant une dureté Shore A de 60 à 90.

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6. Matériau de protection selon une quelconque des revendications précédentes, contenant en outre un matériau absorbant capable de freiner des neutrons lents.

7. Matériau de protection selon la revendication 6, ledit matériau absorbant contenant du bore.

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8. Matériau de protection selon une quelconque des revendications précédentes, contenant en outre une couche absorbante comprenant un matériau absorbant capable de freiner des neutrons lents.

9. Matériau de protection selon la revendication 8, dans lequel ledit matériau absorbant contient du bore.

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10. Procédé de préparation du matériau de protection selon une quelconque des revendications précédentes, comprenant la réaction dudit polyol et dudit isocyanate en présence d'un agent de réticulation pour former un produit de réaction polymère.

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11. Procédé selon la revendication 10, dans lequel ledit agent de réticulation est trifonctionnel et choisi dans le groupe comprenant le nitrilotripropanol, la triéthanolamine et le nitrotributanol.

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