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(54) **SOLVENTLESS LIQUID ISOPRENE COMPOUNDS**

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(57) **ABSTRACT**

In one embodiment, this invention relates to a solventless liquid isoprene compound. The compound includes a liquid isoprene rubber. The compound also includes a curing agent selected from sulfur and/or sulfur donors. The curing agent is present in an amount of at least about 3% by weight of the compound. The compound contains substantially no solvent. In another embodiment, this invention relates to a solventless liquid isoprene compound. The compound includes a liquid isoprene rubber. The compound also includes a nonsulfur curing agent. The curing agent is present in an amount of at least about 5% by weight of the compound. The compound contains substantially no solvent.

SOLVENTLESS LIQUID ISOPRENE COMPOUNDS

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims the benefit of U.S. provisional application Ser. No. 60/342,239, filed Dec. 21, 2001.

BACKGROUND OF THE INVENTION

[0002] This invention relates in general to elastomeric compositions, and in particular to compounds made with a liquid isoprene rubber.

[0003] Liquid isoprene rubbers are conventionally used in a minor amount as a plasticizer or processing aid in combination with a solid elastomer in preparing a rubber compound. It has not previously been thought to use a liquid isoprene rubber as the base elastomer for making a compound, and then to cure the liquid isoprene rubber.

[0004] Rubber compounds are conventionally made by mixing the elastomer(s) and other chemicals together in an organic solvent, or in an aqueous solvent to prepare an emulsion. It has not previously been thought to prepare a liquid isoprene rubber compound without the use of a solvent, and there has been no suggestion how to prepare the compound in a solventless process. Such a process is contrary to the conventional thinking.

SUMMARY OF THE INVENTION

[0005] In one embodiment, this invention relates to a solventless liquid isoprene compound. The compound includes a liquid isoprene rubber. The compound also includes a curing agent selected from sulfur and/or sulfur donors. The curing agent is present in an amount of at least about 3% by weight of the compound. The compound contains substantially no solvent.

[0006] In another embodiment, this invention relates to a solventless liquid isoprene compound. The compound includes a liquid isoprene rubber. The compound also includes a nonsulfur curing agent. The curing agent is present in an amount of at least about 5% by weight of the compound. The compound contains substantially no solvent.

[0007] Various objects and advantages of this invention will become apparent to those skilled in the art from the following detailed description of the preferred embodiment.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0008] The liquid isoprene compounds of the invention use liquid isoprene rubbers as the base material for the compounds. Surprisingly, the compounds are made with substantially no solvent, e.g., not more than about 2% solvent. It has been discovered that liquid isoprene compounds having excellent properties can be made without solvent by using an increased amount of curing agent compared to conventional methods.

[0009] The solventless liquid isoprene compounds of the invention contain a liquid isoprene rubber, a curing agent, and optionally other curing chemicals and other compounding ingredients as described below.

The Liquid Isoprene Rubber

[0010] The liquid isoprene rubber can be any suitable type of liquid isoprene-containing rubber. One nonlimiting example is Claprene® L-1R-30, L-1R-50 or L-1R-503 manufactured by Kuraray Co., Ltd., Kashima, Japan. Preferably, the liquid isoprene rubber is present in an amount between about 40% and about 97% weight of the compound.

Optional Solid Elastomer

[0011] In some applications, it may be desirable to add to the compound a solid isoprene rubber having a Mooney value of not more than about 75. A low Mooney isoprene rubber can be added to improve the physical properties of the liquid isoprene rubber without substantial loss in its flowability and processability. Preferably, the amount of the solid isoprene rubber is not more than about 49% by weight of the total rubber.

The Curing Agent

[0012] The curing agent (vulcanizing agent) can be any type suitable for curing the liquid isoprene rubber. Some typical curing agents include sulfur, sulfur donors, and nonsulfur curing agents such as peroxides, metal oxides, difunctional resins, and amines. Sulfur donors include sulfur-containing chemicals such as tetramethylthiuram disulfide (TMTD), dipentamethylenethiuram hexasulfide (DPTH), bis(2,2'-benzothiazolyl)disulfide or benzothiazyldisulfide (MBTS), and dimorpholinyl disulfide (DTDM).

[0013] Any suitable type of sulfur can be used. A nonlimiting example of a suitable sulfur is Spider® brand sulfur manufactured by C. P. Hall, Chicago, Ill.

[0014] Any suitable type of peroxide curing agent can be used. Some nonlimiting is examples of peroxide curing agents are Varox® DBPH-50, a 50% 2,5-dimethyl-2,5-di(t-butyl-peroxyl) hexane manufactured by R.T. Vanderbilt Co., Norwalk, Conn.; Vul-Cup® 40KE manufactured by Hercules, Inc., Wilmington, Deleware; Cadox® TS-50 manufactured by Akzo Chemical, Chicago, Ill.; and MEK (methyl ethyl ketone) peroxides.

[0015] The liquid isoprene compounds contain an increased amount of curing agent compared to conventional rubber compounds. When the curing agent is a sulfur and/or a sulfur donor, the curing agent is usually present in an amount of at least about 3% by weight of the compound, and preferably between about 3% and about 10%. When the curing agent is a nonsulfur curing agent, the curing agent is usually present in an amount of at least about 5% by weight of the compound, and preferably between about 5% and about 12%.

Other Curing Chemicals

[0016] The compounds can also optionally include other curing chemicals, such as activators, crosslinking enhancers, accelerators, and/or retarders. Any suitable type of activator can be used. Some nonlimiting examples of activators are zinc oxide, stearic acid, combinations of zinc oxide and stearic acid, other metal oxides, other fatty acids, and phosphonium salts.

[0017] Any suitable type of crosslinking enhancer can be used. Some nonlimiting examples are TAIC (triallyl isocyanurate), which is manufactured by companies such as Nippon Kasei Chemical, Iwaki, Japan, and Aldrich Chemical Co., Milwaukee, Wis.; Ricon® 152, a homopolymer of butadiene

(MW 2,900), which is manufactured by Sartomer, Exton, Pa.; SR-351, trimethylol propane triacrylate, manufactured by Sartomer, Exton, Pa.; and B5405, which is 75% SR-350 (trimethylol propane trimethacrylate) and 25% inert filler acting as a carrier.

[0018] If desirable, any suitable type of accelerator can be used. Some nonlimiting examples of accelerators are hexamethylenetetramine, mercaptobenzothiazoles, sulfenamides, thiurams, dithiocarbamates, and guanidines. Also, any suitable type of retarder can optionally be used. Some nonlimiting examples of retarders are organic acids and anhydrides, cyclohexylthiophthalimide, and sulfenamide.

Other Compounding Ingredients

[0019] The compounds can also optionally include other compounding ingredients, such as fillers, bonding agents, antidegradants, process oils, plasticizers, coloring agents, or other desirable ingredients. Any suitable type of filler can be used. Some typical fillers are carbon black, silica, and clay. Nonlimiting examples of suitable fillers include Sterling® 6630 carbon black, manufactured by Cabot Corporation, Alpharetta, Ga.; FK140 or FK160 silica manufactured by Degussa AG, Dusseldorf, Germany; and CAB-O-SIL® TS-530, a hydrophobic fumed silica, manufactured by Cabot Corp.

[0020] Some nonlimiting examples of bonding agents useful in the compounds are resorcinol (1,3-dihydroxybenzene); and A-151, a vinyl triethoxy silane, which is manufactured by Huayuan Fine Chemicals, Wuhan, China.

[0021] Any suitable type of antidegradant can be used, such as antioxidants, antiozonants, and heat stabilizers. Some typical antioxidants are secondary amines, phenolics, and phosphites. A nonlimiting example of a suitable antioxidant is Naugard® 445 antioxidant, which is a 4,4'-di(alpha, alpha-dimethyl-benzyl)diphenylamine, manufactured by Uniroyal Chemical Co., Waterbury, Conn.

[0022] Any suitable type of process oil can be used, such as petroleum oils or vegetable oils. Some nonlimiting examples of process oils include Sunpar® 2280 paraffinic oil, manufactured by Nippon Sun Oil K.K., Japan; and Chevron ParaLux® Process Oil 6001R, a highly saturated white paraffinic process oil with very low aromatic content, manufactured by ChevronTexaco Corp., San Ramon, Calif. Also, any suitable type of plasticizer can be used, such as petroleum oils.

[0023] Optionally, a coloring agent can be added to the compounds. Some nonlimiting examples of coloring agents are man-made mineral pigments such as the Geode® series (e.g., Geode® V-11633 Kelly Green); and the NEOLOR® series of inorganic pigments (e.g., NEOLOR® Red S), both manufactured by Ferro Corp., Cleveland, Ohio.

Processing

[0024] The solventless liquid isoprene compounds can be processed in any suitable manner. Typically, the chemicals are mixed together using any suitable mixing equipment, such as planetary mixers (e.g., Ross mixers), internal mixers, two-roll mills, open roll mills or the like. The mixed compound is then applied, pressed, or molded depending on the particular use. Then, the compound is cured using any suitable time and temperature profile. Typically, the compound is cured at a temperature between about 300° F. and about 400° F. for a time between about 3 minutes and about 20 minutes. The compound can be further post cured if desired or necessary, e.g., for 2 to 14 days at 70° F. to 400° F.

Applications

[0025] The compounds of the invention can be used in many different applications. Advantageously, the compounds are flowable so that they can take the place of materials such as liquid silicones in many applications. Preferably, the compounds have a viscosity not more than about 50% greater than that of liquid silicones, more preferably not more than about 25% greater, and most preferably not more than about 10% greater, Unlike liquid silicones, the compounds are impermeable to fluids, so their use is beneficial in applications where it is desired to limit the flow of fluids, such as in engine seals to limit the flow of VOC's through the engine. The compounds are also easier to process than liquid silicones. The flowability of the compounds allows them to be applied instead of molded, which can save the costs typically associated with molding. Of course, the compounds can also be molded if desired, and their use is not limited to flowable applications.

[0026] Some nonlimiting examples of typical applications include use as sealing members (e.g., gaskets, O-rings, packings or the like) which can be used in many different applications, such as sealing with respect to engine oil, gear oil, transmission oil, or power steering fluid. For example, the compounds can be used for cure in place gasketing (CIPG), inject in place gasketing (IJPG), and form in place gasketing (FIPG). They can be applied robotically thereby resulting in a dispensed sealing bead.

[0027] The compounds are suitable for making thin seals such as thin layered gaskets, and for making intricate seals and gaskets. They can be used to fill intricate channels in a metal plate. A thin gasket can be injection molded onto a plastic or metal carrier.

[0028] The compounds can be used in liquid injection molding (LIM), transfer molding (TM), injection molding.

[0029] The compounds can be used to make rubber-coated metal (RCM) products and rubber-coated plastic products. The compounds cure and bond well to the metal and plastic.

[0030] The compounds can be used as a screen printing material. Because of their low viscosity, lower pressures are required during the forming process which allows for complicated manufacturing using pressure sensitive material as an integral part of the forming process.

[0031] The compounds can be used as a fabric coating in many different applications, e.g., as a coating on airbags or interior portions of airplanes. The compounds can be used as a repair material, e.g., to fill in little holes in bumpers.

[0032] Since the compounds are solventless, they can be easily applied by workers without the hazards of breathing in fumes. The compounds can be applied by any suitable method. The compounds can be applied and will cure at room temperature.

EXAMPLES

[0033] Some nonlimiting examples of compounds according to the invention were prepared as follows:

Liquid IsopreneRubber (IR 30)	100.0
Varox DBPH	8.0
ZnO	1.5

[0034]

IR 30	50	50	50
Silica	25	—	—
6630	—	25	25
Varox	4	4	4
ZnO	0.75	0.75	0.75
Pigment	0.5	—	—
Ricon 152	—	—	1.0

[0035]

IR 30	50.0	50
6630	15.0	25
Varox	4.0	2
ZnO	0.90	0.9
B5405	1.0	1.0

[0036]

IR 30	50	50
ZnO	0.9	0.9
Varox	2	2
FK 140	12	12
B5405	1	1
Blue Pigment	1	1
Rincon 152		2
TS-561		1.2

[0037] In accordance with the provisions of the patent statutes, the principle and mode of operation of this invention have been explained and illustrated in its preferred embodiment. However, it must be understood that this invention may be practiced otherwise than as specifically explained and illustrated without departing from its spirit or scope.

1. A solventless liquid isoprene compound comprising:

a liquid isoprene rubber, polymer molecules thereof having a backbone consisting of polyisoprene; and

a curing agent selected from the group consisting of sulfur, sulfur donors, and mixtures thereof, where the curing agent is present in an amount of at least about 3% by weight of the compound;

the compound containing substantially no solvent.

2. A compound according to claim 1 wherein the curing agent is present in an amount between about 3% and about 10% by weight of the compound.

3. A compound according to claim 1 wherein the liquid isoprene rubber is present in an amount of at least about 40% by weight of the compound.

4. A compound according to claim 1 additionally comprising a solid isoprene rubber having a Mooney value of not more than about 75, wherein the solid isoprene rubber is present in an amount of not more than about 49% by weight of the total rubber.

5. A compound according to claim 1 which is readily flowable between about 23° C. and about 150° C.

6. A flowable compound according to claim 1 which can be curable at room or elevated temperature.

7. A compound according to claim 1 which is used as a curing material for a sealing member.

8. A compound according to claim 1 which is used as a curing material for a gasket selected from the group consisting of in place gasketing (CIPG), inject in place gasketing (IJPG), and form in place gasketing (FIPG).

9. A compound according to claim 1 which is used as a molding material selected from the group consisting of liquid injection molding (LIM), transfer molding (TM), and injection molding.

10-16. (canceled)

17. A compound according to claim **10** which is used as a curing material for a sealing member.

18. A compound according to claim **10** which is used as a curing material for a gasket selected from the group consisting of in place gasketing (CIPG), inject in place gasketing (IJPG), and form in place gasketing (FIPG).

19. A compound according to claim **10** which is used as a molding material selected from the group consisting of liquid injection molding (LIM), transfer molding (TM), and injection molding.

20. (canceled)

21. A sealing member made by a process comprising curing the solventless liquid isoprene compound according to claim 1.

22. A sealing member according to claim 21, wherein the sealing member is a gasket.

23. A gasket according to claim 22, wherein the gasket is a cure in place gasket (CIPG), an inject in place gasket (IJPG), or a form in place gasket (FIPG).

24. A gasket according to claim 22, wherein the gasket is a gasket formed by liquid injection molding (LIM), a gasket formed by transfer molding (TM), or a gasket formed by injection molding.

25. A sealing member according to claim 21, wherein the sealing member is an O-ring.

26. A sealing member made by a process comprising curing the solventless liquid isoprene compound according to claim **10**.

27. A sealing member according to claim 26, wherein the nonsulfur curing agent is a peroxide curing agent.

28. A sealing member according to claim 26, wherein the sealing member is a gasket.

29. A gasket according to claim 28, wherein the gasket is a cure in place gasket (CIPG), an inject in place gasket (IJPG), or a form in place gasket (FIPG).

30. A gasket according to claim 28, wherein the gasket is a gasket formed by liquid injection molding (LIM), a gasket formed by transfer molding (TM), or a gasket formed by injection molding.

31. A sealing member according to claim 26, wherein the sealing member is an O-ring.

32. A process for making a sealing member, comprising shaping and curing the solventless liquid isoprene compound according to claim 1.

33. A process according to claim 32, comprising shaping and curing by a method selected from the group consisting of cure in place gasketing (CIPG), inject in place gasketing (IJPG), and form in place gasketing (FIPG).

34. A process according to claim 32, wherein the sealing member is shaped by a method selected from the group consisting of liquid injection molding (LIM), transfer molding (TM), and injection molding.

35. A process according to claim 32, comprising curing at a temperature between 300° F. and 400° F.

36. A process for making a sealing member comprising shaping and curing the solventless liquid isoprene compound according to claim **10**.

37. A process according to claim 36, comprising shaping and curing by a method selected from the group consisting of cure in place gasketing (CIPG), inject in place gasketing (IJPG), and form in place gasketing (FIPG).

38. A process according to claim 36, wherein the sealing member is shaped by a method selected from the group consisting of liquid injection molding (LIM), transfer molding (TM), and injection molding.

39. A process according to claim 36, comprising curing at a temperature between 300° F. and 400° F.

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