

FILLED BUTYL RUBBER IONOMER COMPOUNDS

Field

The present invention relates to polymers, especially elastomeric compounds comprising butyl rubber ionomer as an additive.

5 Background

Poly(isobutylene-co-isoprene) or IIR, is a synthetic elastomer commonly known as butyl rubber (or Butyl polymer) which has been prepared since the 1940's through the random cationic copolymerization of isobutylene with small amounts of isoprene (usually not more than 2.5 mol %). As a result of its molecular structure, IIR possesses superior
10 air impermeability, a high loss modulus, oxidative stability and extended fatigue resistance.

Halogenation of butyl rubber produces reactive allylic halide functionality within the elastomer. Conventional butyl rubber halogenation processes are described in, for example, Ullmann's Encyclopedia of Industrial Chemistry (Fifth, Completely Revised
15 Edition, Volume A231 Editors Elvers, et al.) and/or "Rubber Technology" (Third Edition) by Maurice Morton, Chapter 10 (Van Nostrand Reinhold Company © 1987), particularly pp. 297-300.

The development of halogenated butyl rubber (halobutyl) has greatly extended the usefulness of butyl by providing much higher curing rates and enabling co-vulcanization
20 with general purpose rubbers such as natural rubber and styrene-butadiene rubber (SBR). Butyl rubber and halobutyl rubber are high value polymers, as their unique combination of properties (excellent impermeability, good flex, good weatherability, co-vulcanization with high unsaturation rubbers, in the case of halobutyl) make them preferred materials for various applications, such as their use in making tire inner tubes
25 and tire inner liners.

The presence of allylic halide functionalities allows for nucleophilic alkylation reactions. It has been shown that treatment of brominated butyl rubber (BIIR) with nitrogen and/or phosphorus based nucleophiles, in the solid state, leads to the generation of IIR-based ionomers with interesting physical and chemical properties (see: Parent, J.
30 S.; Liskova, A.; Whitney, R. A; Resendes, R. Journal of Polymer Science, Part A: Polymer Chemistry 43, 5671-5679, 2005; Parent, J. S.; Liskova, A.; Resendes, R. Polymer 45, 8091-8096, 2004 ; Parent, J. S. ; Penciu, A. ; Guillen- Castellanos, S. A.; Liskova, A.;

Whitney, R. A. Macromolecules 37, 7477-7483, 2004). The ionomer functionality is generated from the reaction of a nitrogen or phosphorus based nucleophile and the allylic halide sites in the halogenated butyl rubber to produce an ammonium or phosphonium ionic group respectively.

5 Like other rubbers, for most applications, butyl rubber must be compounded and vulcanized (chemically cross-linked) to yield useful, durable end use products. Grades of butyl rubber have been developed to meet specific processing and property needs, and a range of molecular weights, unsaturation, and cure rates. Both the end use attributes and the processing equipment are important in determining the right grade of butyl rubber to
10 use in a specific application.

 It would therefore be desirable to have butyl rubber ionomer compositions which exhibit better dynamic properties and physical properties.

Summary

 There is provided an elastomeric compound comprising a cured blend of a butyl
15 rubber ionomer, at least one elastomer co-curable with the butyl rubber ionomer and a filler.

 There is provided a process for producing an elastomeric compound comprising: blending a butyl rubber ionomer, at least one elastomer co-curable with the butyl rubber ionomer and a filler; and, curing the blend.

20 There is provided an article of manufacture comprising an elastomeric compound of the present invention.

 The elastomeric compound has improved physical and/or dynamic properties results from blending the co-curable elastomer with the butyl rubber ionomer in a filled, cured compound. Most notably, improvements in one or more of green strength, flex
25 fatigue, adhesion, traction, damping and tear strength may result. It has been surprisingly found that the inclusion of a butyl rubber ionomer as a partial replacement in a formulation with a co-curable elastomer results in compounds with beneficial physical and dynamic properties (e.g. crack growth resistance) without significantly sacrificing other properties.

30 Further features will be described or will become apparent in the course of the following detailed description.

Detailed Description

The butyl rubber ionomer may be prepared from a halogenated butyl rubber polymer. The halogenated butyl rubber polymer may be prepared from a butyl rubber polymer. The butyl rubber polymer may be a copolymer derived from at least one
5 isoolefin monomer and at least one multiolefin monomer and/or β -pinene, and optionally one or more further copolymerizable monomers.

Suitable isoolefin monomers include hydrocarbon monomers having 4 to 16 carbon atoms. In one embodiment, isoolefins have from 4-7 carbon atoms. Examples of suitable isoolefins include isobutene (isobutylene), 2-methyl-1-butene, 3-methyl-1-butene,
10 2-methyl-2-butene, 4-methyl-1-pentene, 4-methyl-1-pentene and mixtures thereof. A preferred isoolefin monomer is isobutene (isobutylene).

Multiolefin monomers copolymerizable with the isoolefin monomers may include dienes, for example conjugated dienes. Particular examples of multiolefin monomers include those having in the range of from 4-14 carbon atoms. Examples of suitable
15 multiolefin monomers include isoprene, butadiene, 2-methylbutadiene, 2,4-dimethylbutadiene, piperyline, 3-methyl-1,3-pentadiene, 2,4-hexadiene, 2-neopentylbutadiene, 2-methyl-1,5-hexadiene, 2,5-dimethyl-2,4-hexadiene, 2-methyl-1,4-pentadiene, 4-butyl-1,3-pentadiene, 2,3-dimethyl-1,3-pentadiene, 2,3-dibutyl-1,3-pentadiene, 2-ethyl-1,3-pentadiene, 2-ethyl-1,3-butadiene, 2-methyl-1,6-heptadiene,
20 cyclopentadiene, methylcyclopentadiene, cyclohexadiene, 1-vinyl-cyclohexadiene and mixtures thereof. A particularly preferred conjugated diene is isoprene. β -pinene may also be used instead of or in addition to the multiolefin monomer. Herein multiolefin/ β -pinene monomers refers to the presence or use of one or more multiolefin monomers and/or β -pinene monomer.

25 The butyl rubber polymer may optionally include one or more additional copolymerizable monomers along with the isoolefin and multiolefin/ β -pinene monomers. Additional copolymerizable monomers include monomers copolymerizable with the isoolefin and/or multiolefin/ β -pinene monomers. Suitable copolymerizable monomers include, for example, styrenic monomers, such as alkyl-substituted vinyl aromatic co-
30 monomers, including but not limited to a C₁-C₄ alkyl substituted styrene. Specific examples of copolymerizable monomers include, for example, α -methyl styrene, *p*-methyl styrene, chlorostyrene, cyclopentadiene and methylcyclopentadiene. In one embodiment, the butyl rubber polymer may comprise random copolymers of isobutylene, isoprene and *p*-methyl styrene.

The butyl rubber polymers are formed from a mixture of monomers described herein. In one embodiment, the monomer mixture comprises from about 80% to about 99% by weight of an isoolefin monomer and from about 1% to 20% by weight of a multiolefin/ β -pinene monomer. In another embodiment, the monomer mixture comprises
5 from about 85% to about 99% by weight of an isoolefin monomer and from about 1% to 15% by weight of a multiolefin/ β -pinene monomer. In certain embodiments, three monomers may be employed. In these embodiments, the monomer mixture may comprise about 80% to about 99% by weight of isoolefin monomer, from about 0.5% to about 5% by weight of a multiolefin/ β -pinene monomer, and from about 0.5% to about
10 15% by weight a third monomer copolymerizable with the isoolefin and/or multiolefin/ β -pinene monomers. In one embodiment, the monomer mixture comprises from about 68% to about 99% by weight of an isoolefin monomer, from about 0.5% to about 7% by weight of a multiolefin/ β -pinene monomer and from about 0.5% to about 25% by weight of a third monomer copolymerizable with the isoolefin and/or multiolefin/ β -pinene monomers.

15 The butyl rubber polymer may be prepared by any suitable method, of which several are known in the art. For example, the polymerization of monomers may be performed in the presence of $AlCl_3$ and a proton source and/or cationogen capable of initiating the polymerization process. A proton source includes any compound that will produce a proton when added to $AlCl_3$ or a composition containing $AlCl_3$. Protons may be
20 generated from the reaction of $AlCl_3$ with proton sources such as water, alcohol or phenol to produce the proton and the corresponding by-product. Such reaction may be preferred in the event that the reaction of the proton source is faster with the protonated additive as compared with its reaction with the monomers. Other proton generating reactants include thiols, carboxylic acids, and the like. The most preferred proton source is water. The
25 preferred ratio of $AlCl_3$ to water is between 5:1 to 100:1 by weight. It may be advantageous to further introduce $AlCl_3$ derivable catalyst systems, diethylaluminium chloride, ethylaluminium chloride, titanium tetrachloride, stannous tetrachloride, boron trifluoride, boron trichloride, or methylalumoxane. Inert solvents or diluents known to the person skilled in the art for butyl polymerization may be considered as the solvents or
30 diluents (reaction medium). These include alkanes, chloroalkanes, cycloalkanes or aromatics, which are frequently also mono- or polysubstituted with halogens. Hexane/chloroalkane mixtures, methyl chloride, dichloromethane or the mixtures thereof may be preferred. Chloroalkanes are preferably used. The monomers are generally polymerized cationically, preferably at temperatures in the range from $-120^\circ C$ to $+20^\circ C$,
35 preferably in the range from $-100^\circ C$ to $-20^\circ C$, and pressures in the range from 0.1 to 4 bar.

The butyl polymer may also be produced via a solution process as outlined in WO2011089083 A1 and references therein. A C6 solvent is a particularly preferred choice for use in a solution process. C6 solvents suitable for use in the present invention preferably have a boiling point of between 50°C and 69°C. Examples of preferred C6 solvents include n-hexane or hexane isomers, such as 2-methyl pentane or 3-methyl pentane, or mixtures of n-hexane and such isomers as well as cyclohexane.

The butyl rubber polymer may comprise at least 0.5 mol% repeating units derived from the multiolefin/ β -pinene monomers. In some embodiments, the repeating units derived from the multiolefin/ β -pinene monomers may be present in the butyl rubber polymer in an amount of at least 0.75 mol%, or at least 1.0 mol%, or at least 1.5 mol%, or at least 2.0 mol%, or at least 2.5 mol%, or at least 3.0 mol%, or at least 3.5 mol%, or at least 4.0 mol%, or at least 5.0 mol%, or at least 6.0 mol%, or at least 7.0 mol%. In one embodiment, the butyl rubber polymer may comprise from 0.5 to 2.2 mol% of the multiolefin/ β -pinene monomers. In another embodiment, the butyl rubber polymer may comprise higher multiolefin/ β -pinene monomer content, e.g. 3.0 mol% or greater. The preparation of suitable high multiolefin/ β -pinene butyl rubber polymers is described in Canadian Patent Application 2,418,884, which is incorporated herein by reference.

In one embodiment, the halogenated butyl rubber polymer may be obtained by first preparing a butyl rubber polymer from a monomer mixture comprising one or more isoolefins, and one or more multiolefins and/or β -pinene, followed by subjecting the resulting copolymer to a halogenation process to form the halogenated butyl rubber polymer. Halogenation can be performed according to the process known by those skilled in the art, for example, the procedures described in Rubber Technology, 3rd Ed., Edited by Maurice Morton, Kluwer Academic Publishers, pp. 297-300 and further documents cited therein. Halogenation may involve bromination and/or chlorination. Brominated butyl rubber polymers may be of particular note. For example, a brominated butyl rubber comprising isobutylene and less than 2.2 mole percent isoprene is commercially available from LANXESS Deutschland GmbH and sold under the name BB2030™.

In the halogenated butyl rubber polymers one or more of the repeating units derived from the multiolefin monomers comprise an allylic halogen moiety. During halogenation, some or all of the multiolefin and/or β -pinene content of the copolymer is converted to units comprising allylic halides. These allylic halide sites in the halobutyl rubber polymer result in repeating units derived from the multiolefin monomers and/or β -pinene originally present in the butyl rubber polymer. The total allylic halide content of the halogenated butyl rubber polymer cannot exceed the starting multiolefin and/or β -pinene

content of the parent butyl rubber polymer, however residual allylic halides and/or residual multiolefins may be present. The allylic halide sites allow for reacting with and attaching one or more nucleophiles to the halobutyl rubber polymer. The halogenated butyl rubber polymer may have a total allylic halide content from 0.05 to 2.0 mol%. The

5 halogenated butyl rubber polymer may also contain residual multiolefin levels ranging from 2 to 10 mol %.

The butyl rubber ionomers may be obtained by reacting a halogenated butyl rubber polymer with a nucleophile having no pendant vinyl group, a nucleophile comprising a pendant vinyl group or a mixture thereof. The halogenated rubber polymer

10 may be reacted first with a nucleophile having no pendant vinyl group and then with a nucleophile having a pendant vinyl group.

Nucleophiles suitable for the preparation of the butyl rubber ionomers may contain at least one neutral phosphorus or nitrogen center, which possess a lone pair of electrons, the lone pair being both electronically and sterically accessible for participation

15 in nucleophilic substitution reactions. The butyl rubber ionomers obtained from such nucleophiles would comprise phosphorus-based or nitrogen-based ionic moieties.

In one embodiment, the allylic halide sites of the halogenated butyl rubber polymers are reacted with nucleophiles (with or without a pendant vinyl group) having of formula (I):



wherein,

A is a nitrogen or phosphorus; and,

R₁, R₂ and R₃ are independently: a vinyl group, a linear or branched C₁-C₁₈ alkyl group; a linear or branched C₁-C₁₈ alkyl group comprising one or more hetero atoms

25 selected from the group consisting of O, N, S, B, Si and P; C₆-C₁₀ aryl group; C₃-C₆ heteroaryl group; C₃-C₆ cycloalkyl group; C₃-C₆ heterocycloalkyl group; or combinations thereof. If the nucleophile has a pendant vinyl group, the vinyl group may be one of R₁, R₂ or R₃ or could be pendant from one or more of the R₁, R₂ or R₃ groups. Two or all three of the R₁, R₂ and R₃ moieties may be fused together.

Suitable nucleophiles include, but are not limited to trimethylamine, triethylamine, triisopropylamine, tri-n-butylamine, trimethylphosphine, triethylphosphine, triisopropylphosphine, tri-n-butylphosphine, triphenylphosphine, diphenylphosphinostyrene, allyldiphenylphosphine, diallylphenylphosphine, diphenylvinylphosphine, triallylphosphine, 2-dimethylaminoethanol, 1-dimethylamino-2-propanol, 2-(isopropylamino)ethanol, 3-dimethylamino-1-propanol, N-methyldiethanolamine, 2-(diethylamino)ethanol, 2-dimethylamino-2-methyl-1-propanol, 2-[2-(dimethylamino)ethoxy]ethanol, 4-(dimethylamino)-1-butanol, N-ethyldiethanolamine, triethanolamine, 3-diethylamino-1-propanol, 3-(diethylamino)-1,2-propanediol, 2-[(2-(dimethylamino)ethyl)methylamino]ethanol, 4-diethylamino-2-butyne-1-ol, 2-(diisopropylamino)ethanol, N-butyldiethanolamine, N-tert-butyldiethanolamine, 2-(methylphenylamino)ethanol, 3-(dimethylamino)benzyl alcohol, 2-[4-(dimethylamino)phenyl]ethanol, 2-(N-ethylanilino)ethanol, N-benzyl-N-methylethanolamine, N-phenyldiethanolamine, 2-(dibutylamino)ethanol, 2-(N-ethyl-N-m-toluidino)ethanol, 2,2'-(4-methylphenylimino)-diethanol, tris[2-(2-methoxyethoxy)ethyl]amine, 3-(dibenzylamino)-1-propanol, N-vinyl caprolactam, N-vinyl phthalimide, 9-vinyl carbazole, N-[3-(dimethylamino)propyl]methacrylamide or mixtures thereof.

The reaction between the nucleophile and the halogenated butyl rubber polymer may be carried out at a temperature in a range of from about 60°C to about 250°C. In one embodiment, the reaction between the nucleophile and the halogenated butyl rubber polymer may be carried out at a temperature about 80°C to about 200°C. In another embodiment, the reaction between the nucleophile and the halogenated butyl rubber polymer may be carried out at a temperature about 100°C to about 160°C. The reaction may be carried out for a time in a range of from about 0.5 to 90 minutes, preferably from 1 to 60 minutes, more preferably from 5 to 30 minutes. The amount of nucleophile reacted with the halogenated butyl rubber polymer may be in the range of from 0.01 to 5 molar equivalents, more preferably about 0.1 to 2 molar equivalents, even more preferably about 0.5 to 1 molar equivalents, based on the total molar amount of allylic halide present in the halogenated butyl rubber polymer. The resulting butyl rubber ionomer preferably possesses from about 0.01 to 10 mol%, more preferably from about 0.1 to 5.0 mol%, even more preferably from about 0.5 to 0.8 mol% of ionomeric moieties. The resulting butyl rubber ionomer may be a mixture of the polymer-bound ionomeric moiety and allylic halide such that the total molar amount of ionomeric moiety and allylic halide functionality are present in an amount not exceeding the original allylic halide content.

The at least one elastomer is co-curable with the butyl rubber ionomer. Such elastomers include, for example, elastomers comprising one or more units of unsaturation. The one or more units of unsaturation are preferably carbon-carbon double bonds, such as in olefins and/or dienes. Diene elastomers are of particular note. The co-curable elastomer may be a butyl rubber elastomer, a non-butyl rubber elastomer or a mixture thereof. Some examples of butyl rubber elastomers include butyl rubber (IIR), bromobutyl rubber (BIIR), chlorobutyl rubber (CIIR), and mixtures thereof. Some examples of particular non-butyl rubber elastomers include isobutylene-methylstyrene (BIMS) rubber (commercially available under the trade name Exxpro™), ethylene propylene rubber (EPR), ethylene propylene diene monomer (EPDM) rubber, butadiene rubber (BR), solution styrene butadiene rubber (sSBR), emulsion styrene butadiene rubber (eSBR), acrylonitrile butadiene rubber (NBR), hydrogenated acrylonitrile butadiene rubber (HNBR), natural rubber (NR), epoxidized natural rubber (ENR), polyurethane (PU), polyisoprene rubber, polyacrylic or polyacrylate (ACM), chloroprene (CR), chlorosulphonylpolyethylene or chlorosulphonatedpolyethylene (CSM), ethylene acrylic (AEM), thermoplastic polyester urethane (AU), thermoplastic polyether urethane (EU), epichlorohydrin (ECO), fluoroethylene propylene-perfluoroalkoxy (FEP or PFA), tetrafluoroethylene/propylene (FEP or TFE/P), perfluoroelastomer (FFKM/FFPM), fluoroelastomer or fluorocarbon (FKM/FPM), fluorosilicone (FVMQ), silicone (VMQ/PVMQ), polytetrafluoroethylene (PTFE), ethylene vinylacetate (EVA) rubber, ethylene acrylate rubber, polyurethane rubber, polyisobutylene (PIB), chlorinated polyethylene (CPE), polynorbornene rubber (PNB), polysulphide rubber (TR) and mixtures thereof. The co-curable elastomer is preferably a non-butyl rubber elastomer.

The elastomeric compound includes one or more fillers. The fillers may be non-mineral fillers, mineral fillers or mixtures thereof. Non-mineral fillers are preferred in some embodiments and include, for example, carbon blacks, rubber gels and mixtures thereof. Suitable carbon blacks are preferably prepared by lamp black, furnace black or gas black processes. Carbon blacks preferably have BET specific surface areas of 20 to 200 m²/g. Some specific examples of carbon blacks are SAF, ISAF, HAF, FEF and GPF carbon blacks. Rubber gels are preferably those based on polybutadiene, butadiene/styrene copolymers, butadiene/acrylonitrile copolymers or polychloroprene.

Suitable mineral fillers comprise, for example, silica, silicates, clay, bentonite, vermiculite, nontronite, beidelite, volkonskoite, hectorite, saponite, laponite, sauconite, magadiite, kenyaite, ledikite, gypsum, alumina, talc, glass, metal oxides (e.g. titanium dioxide, zinc oxide, magnesium oxide, aluminum oxide), metal carbonates (e.g.

magnesium carbonate, calcium carbonate, zinc carbonate), metal hydroxides (e.g. aluminum hydroxide, magnesium hydroxide) or mixtures thereof.

Dried amorphous silica particles suitable for use as mineral fillers may have a mean agglomerate particle size in the range of from 1 to 100 microns, or 10 to 50 microns, or 10 to 25 microns. In one embodiment, less than 10 percent by volume of the agglomerate particles may be below 5 microns. In one embodiment, less than 10 percent by volume of the agglomerate particles may be over 50 microns in size. Suitable amorphous dried silica may have, for example, a BET surface area, measured in accordance with DIN (Deutsche Industrie Norm) 66131, of between 50 and 450 square meters per gram. DBP absorption, as measured in accordance with DIN 53601, may be between 150 and 400 grams per 100 grams of silica. A drying loss, as measured according to DIN ISO 787/11, may be from 0 to 10 percent by weight. Suitable silica fillers are commercially sold under the names HiSil™ 210, HiSil™ 233 and HiSil™ 243 available from PPG Industries Inc. Also suitable are Vulkasil™ S and Vulkasil™ N, commercially available from Bayer AG.

High aspect ratio fillers useful in the present invention may include clays, talcs, micas, etc. with an aspect ratio of at least 1:3. The fillers may include acircular or nonisometric materials with a platy or needle-like structure. The aspect ratio is defined as the ratio of mean diameter of a circle of the same area as the face of the plate to the mean thickness of the plate. The aspect ratio for needle and fiber shaped fillers is the ratio of length to diameter. The high aspect ratio fillers may have an aspect ratio of at least 1:5, or at least 1:7, or in a range of 1:7 to 1:200. High aspect ratio fillers may have, for example, a mean particle size in the range of from 0.001 to 100 microns, or 0.005 to 50 microns, or 0.01 to 10 microns. Suitable high aspect ratio fillers may have a BET surface area, measured in accordance with DIN (Deutsche Industrie Norm) 66131, of between 5 and 200 square meters per gram. The high aspect ratio filler may comprise a nanoclay, such as, for example, an organically modified nanoclay. Examples of nanoclays include natural powdered smectite clays (e.g. sodium or calcium montmorillonite) or synthetic clays (e.g. hydrotalcite or laponite). In one embodiment, the high aspect filler may include organically modified montmorillonite nanoclays. The clays may be modified by substitution of the transition metal for an onium ion, as is known in the art, to provide surfactant functionality to the clay that aids in the dispersion of the clay within the generally hydrophobic polymer environment. In one embodiment, onium ions are phosphorus based (e.g. phosphonium ions) or nitrogen based (e.g. ammonium ions) and contain functional groups having from 2 to 20 carbon atoms. The clays may be provided,

for example, in nanometer scale particle sizes, such as, less than 25 µm by volume. The particle size may be in a range of from 1 to 50 µm, or 1 to 30 µm, or 2 to 20 µm. In addition to silica, the nanoclays may also contain some fraction of alumina. For example, the nanoclays may contain from 0.1 to 10 wt% alumina, or 0.5 to 5 wt% alumina, or 1 to 3 wt% alumina. Examples of commercially available organically modified nanoclays as high aspect ratio mineral fillers include, for example, those sold under the trade name Cloisite® clays 10A, 20A, 6A, 15A, 30B, or 25A.

The butyl rubber ionomer may be present in the blend in an amount of about 1-99 phr, or 1 to 90 phr or about 5-75 phr, or less than 50 phr, or about 1-50 phr, or about 1 phr to less than 50 phr, or about 10-50 phr, or about 5-30 phr, or about 15-30 phr. Fillers may be present in the blend in an amount of about 1-100 phr, or about 3-80 phr, or about 5-60 phr, or about 5-30 phr, or about 5-15 phr.

The elastomeric compound may be prepared by blending the butyl rubber ionomer, the co-curable elastomer and the filler, and then curing the blend.

Stabilizers, anti-oxidants, tackifiers, and/or other additives known to those of skill in the art may also be added to the blend in the usual way and in the normal amounts. Additionally, other additives may be added to the ionomer prior to blending with the co-curable elastomer.

Ingredients may be compounded together using conventional compounding techniques. Suitable compounding techniques include, for example, mixing the ingredients together using, for example, an internal mixer (e.g. a Banbury mixer), a miniature internal mixer (e.g. a Haake or Brabender mixer) or a two roll mill mixer. An extruder also provides good mixing, and permits shorter mixing times. It is possible to carry out the mixing in two or more stages, and the mixing can be done in different apparatuses, for example one stage in an internal mixer and one stage in an extruder. For further information on compounding techniques, see Encyclopedia of Polymer Science and Engineering, Vol. 4, p. 66 et seq. (Compounding). Other techniques, as known to those of skill in the art, are further suitable for compounding.

The choice of curing system suitable for use is not particularly restricted and is within the purview of a person skilled in the art. In certain embodiments, the curing system may be sulphur-based, peroxide-based, resin-based or ultraviolet (UV) light-based.

A sulfur-based curing system may comprise: (i) a metal oxide, (ii) elemental sulfur and (iii) at least one sulfur-based accelerator. The use of metal oxides as a component in the sulphur curing system is well known in the art. A suitable metal oxide is zinc oxide, which may be used in the amount of from about 1 to about 10 phr. In another
5 embodiment, the zinc oxide may be used in an amount of from about 2 to about 5 phr. Elemental sulfur, (component (ii)), is typically used in amounts of from about 0.2 to about 2 phr. Suitable sulfur-based accelerators (component (iii)) may be used in amounts of from about 0.5 to about 3 phr. Non-limiting examples of useful sulfur-based accelerators include thiuram sulfides (e.g. tetramethyl thiuram disulfide (TMTD)), thiocarbamates (e.g.
10 zinc dimethyl dithiocarbamate (ZDC)) and thiazyl or benzothiazyl compounds (e.g. mercaptobenzothiazyl disulfide (MBTS)). A sulphur based accelerator of particular note is mercaptobenzothiazyl disulfide.

Peroxide based curing systems may also be suitable, especially for butyl rubber ionomers comprising residual multiolefin content in excess of about 0.2 mol%. A
15 peroxide-based curing system may comprises a peroxide curing agent, for example, dicumyl peroxide, di-tert-butyl peroxide, benzoyl peroxide, 2,2'-bis(tert.-butylperoxy diisopropylbenzene (Vulcup® 40KE), benzoyl peroxide, 2,5-dimethyl-2,5-di(tert-butylperoxy)-hexyne-3, 2,5-dimethyl-2,5-di(benzoylperoxy)hexane, (2,5-bis(tert-butylperoxy)-2,5-dimethyl hexane and the like. One such peroxide curing agent
20 comprises dicumyl peroxide and is commercially available under the name DiCup 40C. Peroxide curing agents may be used in an amount of about 0.2-7 phr, or about 1-6 phr, or about 4 phr. Peroxide curing co-agents may also be used. Suitable peroxide curing co-agents include, for example, triallyl isocyanurate (TAIC) commercially available under the name DIAK 7 from DuPont, N,N'-m-phenylene dimaleimide known as HVA-2 from DuPont
25 or Dow), triallyl cyanurate (TAC) or liquid polybutadiene known as Ricon D 153 (supplied by Ricon Resins). Peroxide curing co-agents may be used in amounts equivalent to those of the peroxide curing agent, or less. The state of peroxide cured articles is enhanced with butyl polymers containing increased levels of unsaturation, for example a multiolefin content of at least 0.5 mol%.

30 The blend may be cured by resin cure system and, if required, an accelerator to activate the resin cure. Suitable resins include but are not limited to phenolic resins, alkylphenolic resins, alkylated phenols, halogenated alkyl phenolic resins and mixtures thereof.

In some cases, curing may be achieved by heating the blend at a suitable curing temperature in the presence of the curing system. The curing temperature may be about 80°C to about 250°C, or 100°C to about 200°C, or about 120°C to about 180°C.

5 Addition of butyl rubber ionomer as an additive to a co-curable elastomer may result in improvement in one or more of green strength of the uncured blend, flex fatigue ratio, adhesion, tear strength, damping, traction and crack growth resistance.

Crack growth resistance of elastomeric compounds of the present invention, as measured by DeMattia Flexion tester (ASTM D 813), may be over 1.2 times greater, over 1.3 times greater, over 1.4 times greater, over 1.5 times greater, over 1.6 times greater,
10 over 1.7 times greater, over 1.8 times greater, over 1.9 times greater, over 2 times greater, over 3 times greater, or even over 4 times greater, than crack growth resistance of a similar blend not containing the butyl rubber ionomer. Green strength of the uncured blend, as measured according to ASTM D6746 may be over 1.2 times greater, over 1.3 times greater, over 1.4 times greater, over 1.5 times greater, over 1.6 times greater, or
15 even over 1.7 times greater, than green strength of a similar blend not containing the butyl rubber ionomer. Adhesion may be over 1.2 times greater, over 1.3 times greater, over 1.4 times greater, or even over 1.5 times greater than the adhesion of a similar blend not containing the butyl rubber ionomer. Tear strength as measured by Die C Tear (ASTM D 624) at 23°C may be over 1.2 times greater, over 1.3 times greater, over 1.4
20 times greater, over 1.5 times greater, over 1.6 times greater, over 1.7 times greater, over 1.8 times greater, over 1.9 times greater, or even over 2 times greater than the tear strength of a similar blend not containing the butyl rubber ionomer.

The elastomeric blend may be shaped into a desired article prior to curing. Articles comprising the cured elastomeric compound include, for example, belts, hoses,
25 shoe soles, gaskets, o-rings, wires/cables, inner tubes, membranes, rollers, bladders (e.g. curing bladders), inner liners of tires, tire treads, shock absorbers, machinery mountings, balloons, balls, golf balls, protective clothing, medical tubing, storage tank linings, electrical insulation, bearings, pharmaceutical stoppers, pharmaceutical closures, seals for pump spray bottles and aerosol cans, engine mounts, body mounts, noise
30 vibration harshness compounds useful for reducing the transference of noise and vibration for both automotive and industrial applications, adhesives, sealants, a container, such as a bottle, tote, storage tank, etc.; a container closure or lid; a seal or sealant, such as a gasket or caulking; a material handling apparatus, such as an auger or conveyor belt; a cooling tower; a metal working apparatus, or any apparatus in contact with metal
35 working fluids; an engine component, such as fuel lines, fuel filters, fuel storage tanks,

gaskets, seals, etc.; a membrane, for fluid filtration or tank sealing, an air conditioning hose, diaphragms, and curing envelopes. Additional examples where the butyl ionomer blends may be used in articles or coatings include, but are not limited to, the following:

5 appliances, baby products, bathroom fixtures, bathroom safety, flooring, food storage, garden, kitchen fixtures, kitchen products, office products, pet products, sealants and grouts, spas, water filtration and storage, equipment, food preparation surfaces and equipments, shopping carts, surface applications, storage containers, footwear, protective wear, sporting gear, carts, dental equipment, door knobs, clothing, telephones, toys, catheterized fluids in hospitals, surfaces of vessels and pipes, coatings, food processing,

10 biomedical devices, filters, additives, computers, ship hulls, shower walls, tubing to minimize the problems of biofouling, pacemakers, implants, wound dressing, medical textiles, ice machines, water coolers, fruit juice dispensers, soft drink machines, piping, storage vessels, metering systems, valves, fittings, attachments, filter housings, linings, and barrier coatings.

15 *EXAMPLES*

Materials and Reagents:

BB2030 (LANXESS), RB301 (LANXESS), BR (LANXESS), EPDM (LANXESS), CR (LANXESS), HNBR (LANXESS), NR (H.A. Astlett), Vulkanox (LANXESS), Vulkacit (LANXESS), Bayprene 210 (LANXESS), Butyl 301 (LANXESS), sSBR (Nippon Zeon),

20 zinc oxide (St. Lawrence Chemical Company), carbon black (Cabot), SP1045 Resin (Schemectady Chemicals), triphenylphosphine (Alfa Aesar), dimethylaminoethanol (Sigma Aldrich), stearic acid (HM Royal), sulfur (L.V.Lomas Ltd), Struktol ZB147 (Struktol), Si-69 (Evonik), Ultrasil (Evonik), Sunolite (Chemtura) were all used as received from their respective suppliers.

25 *Compound testing equipment and procedures:*

Table 1

Equipment/Test Method	ASTM #
MDR 200 (Moving Dye Rheometer)	ASTM D 5289
Mooney Viscometer	ASTM D 1646
DeMattia Flexion tester	ASTM D 813
Alpha Technologies T2000	ASTM D 412 ASTM D 624 ASTM D 6746
DIN Abrasion	DIN 53 516
Compression Set	ASTM D395
Doli Flexometer	ASTM D623

Example 1: LANXESS BB2030™ was premixed with triphenylphosphine and then passed through a twin screw extruder at 160 °C. Analysis of the final product by ¹H NMR confirmed the presence of 0.2 mol% phosphonium ionic groups.

- 5 *Example 2:* LANXESS BB2030™ was premixed with triphenylphosphine and then passed through a twin screw extruder at 160 °C. Analysis of the final product by ¹H NMR confirmed the presence of 0.4 mol% phosphonium ionic groups.

- 10 *Example 3:* LANXESS BB2030™ was premixed with triphenylphosphine and then passed through a twin screw extruder at 160 °C. Analysis of the final product by ¹H NMR confirmed the presence of 0.6 mol% phosphonium ionic groups.

Example 4: LANXESS BB2030™ was premixed with triphenylphosphine and then passed through a twin screw extruder at 160 °C. Analysis of the final product by ¹H NMR confirmed the presence of 0.8 mol% phosphonium ionic groups.

- 15 *Example 5:* LANXESS BB2030™ was passed through a twin screw extruder at 160 °C where *N,N*-dimethylaminoethanol (DMAE) was added at a rate of 0.4 mL/min. Analysis of the final product by ¹H NMR confirmed the presence of 0.8 mol% ammonium ionic groups.

- 20 *Example 6:* LANXESS BB2030™ was passed through a twin screw extruder at 160 °C where *N,N*-dimethylaminoethanol (DMAE) was added at a rate of 0.2 mL/min. Analysis of the final product by ¹H NMR confirmed the presence of 0.4 mol% ammonium ionic groups.

- 25 *Example 7:* LANXESS BB2030™ (100 phr) was added to a Banbury mixer, followed by the addition of triphenylphosphine (3 phr, 0.6 molar equivalents based on allylic bromide content) and mixed for 6 minutes. The mixture was then passed through a single screw extruder heated to 100°C. The resulting properties are shown in Table 2. Comparison of Example 3 to Example 1 and Example 2 show a lower amount of residual TPP and TPP=O. Additionally, Example 2 and Example 3 demonstrate comparable ionic content, indicating the improved efficiency of the process outlined in Example 3 (84% conversion).

Examples 8-16:

- 30 Examples 8-17 were prepared according to the general formulation outlined in Table 2. Ingredient 1A was added at t = 0 min, followed by 1B at t = 1min and the mix dropped at 7 min. Cure package outlined in 2A was added on a room temperature mill.

The samples were then cured and their physical and dynamic properties were evaluated as shown in Table 3. As evident from Table 3, partial replacement of the halobutyl rubber (LANXESS BB2030) with the Example 7 results in improved green strength, adhesion, tear and flex fatigue properties.

5

Table 2

		phr
LANXESS Bromobutyl 2030	1A	0-100
Example 7	1A	100-0
Stearic Acid	1B	1
Resin SP 1068	1B	4
Sunpar 2280	1B	7
Carbon Black, N 660	1B	60
Sulfur	2A	0.5
Vulkacit DM/C	2A	1.3
Zinc Oxide	2A	3

Table 3

	8	9	10	11	12	13	14	15	16
LANXESS Bromobutyl 2030	100	95	90	85	80	75	100	30	50
Example 7	0	5	10	15	20	25	5	70	50
Green Strength (ambient temperature)									
Peak Stress (MPa)	0.27	0.33	0.35	0.35	0.45	0.48	0.31	n/a	n/a
Stress @ 100 (MPa)	0.27	0.33	0.35	0.35	0.39	0.38	0.3	n/a	n/a
Stress @ 300 (MPa)	0.21	0.24	0.28	0.3	0.4	0.41	0.24	n/a	n/a
M300/100	0.78	0.73	0.80	0.86	1.03	1.08	0.80	n/a	n/a
Unaged Tensile (ambient temperature)									
Ultimate Tensile (MPa)	10.9	11.1	11.1	11.7	11.8	11.5	11.3	13.6	12.8
Ultimate Elongation (%)	713	680	688	749	739	706	728	731	762
Stress @ 100 (MPa)	1.2	1.3	1.4	1.4	1.5	1.5	1.3	1.8	1.6
Stress @ 300 (MPa)	4.9	5.2	5.5	5.1	5.6	5.4	5.2	6.1	5.6
M300/100	4.1	3.9	3.9	3.8	3.7	3.6	4.0	3.5	3.4
Aged Tensile (aged 168h @ 100 °C, tested at ambient temperature)									
Chg. Ulti. Tens. (%)	97	97	94	91	90	92	96	n/a	90
Chg. Ulti. Elong. (%)	64	71	78	79	80	88	76	n/a	63
Change in M300/100 (%)	74	71	81	81	82	112	83	n/a	118

Adhesion									
Adhesive Strength (kNm)	6.3	18.7	15.0	14.9	9.9	10.5	12.7	n/a	n/a
Mill Shrinkage (50 °C)									
Compd Shrinkage (%)	21	20	20	21	22	23	24	n/a	n/a
DeMattia Flex Fatigue (ambient temperature)									
300% Crack Growth (Kcycles)	40	35	39	72	80	66	43	>250	>250
600% Crack Growth (Kcycles)	168	165	151	>250	236	225	138	>250	>250
Die C Tear (ambient temperature)									
Tear Strength (kN/m)	35	38	36	40	39	40	n/a	46	42

Examples 17-24:

- Examples 17-24 were prepared according to the general formulation outlined in Table 4. Ingredients 1A and 1B were added to the mixer, followed by 1C at t = 1 min.
- 5 Once the mix temperature reached 105°C, ingredients 1D were added. The batch was dropped at 140°C. Ingredient 2A was added on a room temperature mill. The samples were then cured and their physical and dynamic properties were evaluated as shown in Table 5. As evident from Table 5, partial replacement of the regular butyl (LANXESS RB301) with Example 1 or Example 3 resulted in higher modulus, improved permeability
- 10 and flex fatigue properties.

Table 4

		phr
LANXESS Butyl 301	1A	93.6-0
Example1	1A	0-93.6
Example 3	1A	0-46.8
Bayprene 210	1B	5
Carbon Black, N 330	1C	50
Stearic Acid	1D	0.5
Castor Oil	1D	5
Zinc Oxide	1D	5
Butyl 301 TYPE IE	1D	6.4
SP1045 Resin	2A	10

Table 5

	17	18	19	20	21	22	23	24
LANXESS Butyl 301	93.6	0	46.8	70.2	84.24	46.8	70.2	84.24

Example 1	0	93.6	46.8	23.4	9.36	0	0	0
Example 3	0	0	0	0	0	46.8	23.4	9.36
Unaged Tensile (ambient temperature)								
Ultimate Tensile (MPa)	13.5	13.29	13.3	12.56	14.11	8.38	12.77	13.59
Ultimate Elongation (%)	782	729	768	740	726	870	800	703
Stress @ 100 (MPa)	1.54	1.91	1.67	1.61	1.86	1.42	1.53	1.81
Stress @ 300 (MPa)	4.24	5.42	4.51	4.31	5.34	2.52	3.19	4.68
M300/100	2.75	2.84	2.70	2.68	2.87	1.77	2.08	2.59
Permeability (ambient temperature)								
Perm.(cc mm/[m ² day])	168	133	147	155	161	132	152	159
DeMattia Flex (ambient temperature)								
300% Crack Growth (Kc)	63	>250	>250	>250	>250	>250	>250	>250
600% Crack Growth (Kc)	136.7	>250	>250	>250	>250	>250	>250	>250

Examples 25-27:

Examples 25-27 were prepared according to the general formulation outlined in Table 6. At the beginning of the mix, half of 1A, then 1B and then the balance of 1A were added, followed by 1C at 30 sec and 1D at 90 sec and mixed for 390 sec. The following day, the mix was put back in the mixer and 2A ingredients added, then mixed for 180 sec. Finally, ingredients 2B were added on the mill. The samples were then cured and their physical and dynamic properties were evaluated as shown in Table 7. As evident from Table 7, full and partial replacement of the bromobutyl with the Example 4 in a blend with butadiene rubber (BR) and solution styrene-butadiene rubber (sSBR) resulted in improved adhesion at higher temperatures as well as improved flex fatigue properties.

Table 6

		phr
BR	1A	30
sSBR	1A	35
LANXESS Bromobutyl 2030	1A	0-35
Example 4	1A	0-35
Ultrasil VN3	1B,1C,1D	3 x 25
Carbon Black, N 234	1C	5
N,N-Dimethylethanolamine	1C	1.13
Silane Si -69	1C	3.5
Struktol ZB 47	1C	1.5
Triphenylphosphine	1C	0-2
Calsol 8240	1D	25
Stearic Acid	1D	1.5
Sunolite 160 Prills	1D	1.25

Vulkanox 4020	2A	1.5
Vulkanox HS/LG	2A	1
Sulfur	3A	1.5
Vulkacit CZ/EGC	3A	1.75
Vulkacit D/C	3A	2
Zinc Oxide	3A	2.5

Table 7

	25	26	27
LANXESS BB2030	35	0	17.5
Example 4	0	35	17.5
Dimethylaminoethanol	1.13	1.13	1.13
Triphenylphosphine	2	0	0
Mooney Viscosity (ML (1+8) @100 °C)			
Mooney Viscosity (MU)	58	87	75
MDR Characteristics (160 °C)			
M _H (dN.m)	25	23	28
M _L (dN.m)	4	5	6
Delta M _H -M _L (dN.m)	21	17.1	21.3
Stress Strain (unaged, ambient temperature)			
Hardness Shore A2 (pts.)	55	56	59
Ultimate Tensile (MPa)	13.8	15.4	15.1
Ultimate Elongation (%)	343	494	403
Stress @ 100 (MPa)	2.1	1.8	2.1
Stress @ 300 (MPa)	11.4	8.1	10.5
M300/100	5.4	4.5	5
Die C Tear (ambient temperature)			
Tear Strength (kN/m)	37	36	39
Rubber Adhesion			
Pirelli (23°C, kN/m)	20	21	11
Pirelli (100°C, kN/m)	8	12	12
Zwick Rebound			
Resilience @ 0°C (%)	4.2	6.3	5.6
Resilience @ 23°C (%)	24.8	22.1	21.8
Resilience @ 100°C (%)	44.1	45.7	48.4
DeMattia Flex (2mm punched, unaged)			
Crack Growth 300% (Kc)	3.7	6	6.3
Crack Growth 600% (Kc)	13	22.5	21
DIN Abrasion			
Volume Loss (mm³)	132	158	130

Examples 28-35:

Examples 28-34 were prepared the same way as Examples 25-27 as outlined above. The samples were then cured and their physical and dynamic properties were evaluated as shown in Table 8. As evident from Table 8, full and partial replacement of the bromobutyl with Example 5 or Example 6 in a blend with BR and sSBR resulted in improved adhesion at higher temperatures as well as improved flex fatigue properties.

Table 8

	26	27	28	29	30	31	32	33	34
LANXESS BB2030	35	0	17.5	0	17.5	0	17.5	0	17.5
Example 5	0	35	17.5	35	17.5	0	0	0	0
Example 6	0	0	0	0	0	35	17.5	35	17.5
Dimethylaminoethanol	1.13	0	0	0	0	0	0	0	0
Triphenylphosphine	2	0	0	2	2	0	0	2	2
Mooney Viscosity (ML (1+8) @ 100 °C)									
Mooney Viscosity (MU)	58	102	77	101	73	73	69	72	68
MDR Characteristics (160 °C)									
MH (dN.m)	25	23.9	26.2	23.3	24.7	26.8	24.7	25.5	24.2
ML (dN.m)	4.1	6.8	6.2	6.7	5.5	6.2	5.2	6	5.3
Delta MH-ML (dN.m)	21	17.2	20	16.6	19.1	20.5	19.4	19.5	18.9
Stress Strain (ambient temperature)									
Hardness Shore A2 (pts.)	55	58	60	57	56	57	55	55	53
Ultimate Tensile (MPa)	13.8	15.6	14.6	15.1	16.3	14.4	13.9	13.6	14.1
Ultimate Elongation (%)	343	428	394	425	404	364	354	321	342
Stress @ 100 (MPa)	2.1	2.1	2.2	2	2.2	2.2	2.1	2.3	2.1
Stress @ 300 (MPa)	11.4	9.5	10.3	9.2	10.8	11.4	11	12.2	12
M300/100	5.4	4.5	4.7	4.6	4.9	5.2	5.2	5.3	5.7
Die C Tear (ambient temperature)									
Tear Strength (kN/m)	37	35	36	35	34	34.2	35	35	34.7
Rubber Adhesion (ambient temperature)									
Pirelli (23°C, kN/m)	20	9	11	25	10	19	20	24	22
Pirelli (100°C, kN/m)	8	11	11	20	12	10	11	9	7
Zwick Rebound									
Resilience @ 0°C (%)	4.2	4.8	4.5	3.6	3.7	12.3	12.3	11	11.1
Resilience @ 23°C (%)	24.8	20.4	20.7	22.2	22.8	21.9	22.5	22.7	23.3
Resilience @ 100°C (%)	44.1	47	46.1	46.1	46.3	53.5	52.8	52.5	52.5
Dimattia Flex (2mm punched, ambient temperature)									
Crack Growth 300%	3.7	5.9	5.5	5.5	6	7.7	4.8	4.2	4.4

(Kc)									
Crack Growth 600% (Kc)	13	52.2	42.2	27.5	35.6	37.9	21.9	17.8	17.9
DIN Abrasion (ambient temperature)									
Volume Loss (mm ³)	132	136	121	142	114	134	121	120	109

Examples 35-42:

Examples 35-42 were prepared according to the general formulation outlined in Table 9. The elastomer(s) 1A were added to the mixer, at 30 sec 1B was added and at 90 sec 1C was added. Curatives (2A) were added on the mill. The samples were then cured and their physical and dynamic properties were evaluated as shown in Table 10. As evident from Table 10, partial replacement of the EPDM with Example 7 resulted in improved tear strength and improved flex fatigue properties.

Table 9

		phr
EPDM	1A	100-50
Example 7	1A	0-50
LANXESS BB2030	1A	0-50
Process Aid	1B	2
Carbon Black, N 330	1B	70
Antioxidant	1C	1
Oil	1C	15
Peroxide	2A	5
Coagent	2A	3

10

Table 10

	35	36	37	38	39	40	41	42
EPDM	100	90	80	70	95	50	95	80
Example 7	0	10	20	30	5	50	0	0
LANXESS BB2030	0	0	0	0	0	0	5	20
MDR Cure Characteristics (170 °C)								
MH (dN.m)	39.5	30.0	26.1	21.8	34.7	n/a	35.5	30.4
ML (dN.m)	4.0	4.1	4.2	4.0	4.0	n/a	3.9	4.0
Delta MH-ML (dN.m)	35.6	25.9	21.9	17.8	30.7	n/a	31.6	26.4
t' 90 (min)	7.0	6.2	6.9	8.2	6.3	n/a	6.1	6.0
Compound Mooney Viscosity (ML (1+8) @ 100 °C)								
Mooney Viscosity (MU)	99.8	106.4	110.1	110.6	102.5	n/a	98.1	96.5
Unaged Stress Strain (ambient temperature)								
Hardness Shore A2 (pts.)	71	71	68	70	70	n/a	71	71
Ultimate Tensile (MPa)	20.75	17.34	15.40	14.80	18.19	n/a	19.45	16.70

Ultimate Elongation (%)	410	502	547	605	427	n/a	449	481
Stress @ 100 (MPa)	2.78	2.24	2.12	2.01	2.38	n/a	2.48	2.26
Stress @ 300 (MPa)	14.14	8.54	7.04	6.22	10.94	n/a	11.53	8.95
M300/100	5.09	3.81	3.32	3.09	4.60	n/a	4.65	3.96
Die C Tear Strength (ambient temperature)								
Tear Strength (kN/m)	33.5	37.2	38.6	40.4	34.0	n/a	33.4	33.0
Compression Set (aged 22h @ 150 °C)								
Compression Set (%)	27	36	43	55	30	n/a	28	38
Demattia Flex Test (ambient temperature)								
Crack Growth 600% (Kc)	7.8	>250	>250	>250	15.1	n/a	24.4	27
Crack Growth 300% (Kc)	2.1	5	>250	>250	2.8	n/a	3.2	4.1

Examples 43-51:

Examples 43-49 were prepared according to the general formulation outlined in Table 11. The elastomer(s) 1A were added to the mixer, at 150 sec 1B was added and at 210 sec 1C was added. Curatives (2A) were added on the mill. The samples were then cured and their physical and dynamic properties were evaluated as shown in Table 12. As evident from Table 12, partial replacement of the BR and bromobutyl with Example 4 or Example 5 resulted in improved modulus and abrasion resistance.

Table 11

		phr
NBR	1A	20
BR	1A	66-40
LANXESS Bromobutyl 2030	1A	14-0
Example 4	1A	0-40
Example 5	1A	0-40
Ultrasil	1A	40
Antioxidant	1A	0.7
Process Aides (Wax, aliphatic hydrocarbon resin, PEG)	1B	5.1
Stearic Acid	1C	0.5
Accelerator	2A	2.15
Sulphur	2A	1.65
Zinc Oxide	2A	4

10

Table 12

	43	44	45	46	47	48	49
BR	66	66	50	40	66	50	40
NBR	20	20	20	20	20	20	20
LANXESS Bromobutyl 2030	14						

Example 5		14	30	40			
Example 4					14	30	40
MDR Cure Characteristics (160 °C)							
MH (dN.m)	31.9	33.71	33.1	31.21	31.86	27.62	25.17
ML (dN.m)	7.71	9.03	9.42	9.8	8.67	7.55	7.43
Delta MH-ML (dN.m)	24.19	24.68	23.68	21.41	23.19	20.07	17.74
t' 90 (min)	10.08	8.67	7.43	7.14	5.75	2.96	2.26
Mooney Viscosity ML (1+8) @ 100 °C)							
Mooney Viscosity (MU)	90	110	117	145	131	150	110
Stress Strain (ambient temperature)							
Hardness Shore A2 (pts.)	57	60	60	60	59	61	60
Ultimate Tensile (MPa)	10.46	11.1	12.42	13.4	11.99	11.86	10.04
Ultimate Elongation (%)	669	592	535	538	675	601	475
Stress @ 100 (MPa)	1.24	1.37	1.64	1.62	1.31	1.77	1.72
Stress @ 300 (MPa)	3.26	4.14	5.35	5.14	3.64	5.13	5.72
M300/100	2.6	3.0	3.3	3.2	2.8	2.9	3.3
DIN Abrasion (ambient temperature)							
Abrasion Volume Loss (mm ³)	60	46	53	65	50	57	59

Examples 50-57:

Examples 50-57 were prepared according to the general formulation outlined in Table 13. The amounts are phr. The elastomer(s) 1A were added to the mixer, at 60 sec 1B was added and at 90 sec 1C was added. Curatives (2A) were added on the mill. The samples were then cured and their physical and dynamic properties were evaluated as shown in Table 14. As evident from Table 14, partial replacement of the RB301 with Example 7 resulted in improved modulus and damping.

Table 13

		phr
LANXESS Butyl 301	1A	100-0
Example 7	1A	0-100
Stearic Acid	1A	1
Marklube 160 Prills	1A	2
Zinc Oxide	1B	5
Carbon Black, N 550	1B	45
Sunpar 2280	1C	26
DPPT	2A	1.5
Vulkacit DM/C (MBTS)	2A	1
Sulfur	2A	1.5
TMTD	2A	1.5

Table 14

	50	51	52	53	54	55	56	57
LANXESS Butyl 301	100	99	95	90	75	50	40	0
Example 7	0	1	5	10	25	50	60	100
Compound Mooney Viscosity								
Mooney Viscosity (MU)	38	40	43	40	41	43	49	46
MDR Cure Characteristics								
Delta MH-ML (dN.m)	12.9	12.6	12.82	11.68	10.61	8.97	8.31	6.55
ts 2 (min)	5.01	4.4	4.74	4.39	3.93	3.4	3.27	3
t' 90 (min)	17.63	15.5	17.5	17.19	17.46	20.24	17.4	16.53
Unaged Stress Strain (ambient temperature)								
Hardness Shore A2 (pts.)	53	52	52	47	44	42	42	43
Ultimate Tensile (MPa)	12.2	11.24	11.7	13	13.8	12.7	12.8	12.3
Ultimate Elongation (%)	675	644	631	694	736	734	680	902
Stress @ 100 (MPa)	1.1	1.7	1.2	1.1	1.1	1	1.3	0.9
Stress @ 300 (MPa)	3.5	4.4	4.1	4.2	4.2	3.8	4.2	2.9
M300/100	3.18	2.6	3.42	3.82	3.82	3.80	3.23	3.22
Stress Strain (aged 22 hrs @ 70°C, measured at ambient temperature)								
Hardness Shore A2 (pts.)	52.2	50.2	49.5	49.1	43.4	41.5	48.6	43.1
Ultimate Tensile (MPa)	11.6	8.2	11.8	12.7	13.5	13.4	10.9	11.6
Ultimate Elongation (%)	715	423	599	662	722	733	585	857
Stress @ 100 (MPa)	1.2	1.87	1.2	1.2	1.1	1.1	1.5	0.9
Stress @ 200 (MPa)	2.4	3.62	2.6	2.6	2.5	2.5	3.4	1.8
Stress @ 300 (MPa)	3.6	5.20	4.2	4.2	4.3	4.1	5.1	3.1
M300/100	3.00	2.8	3.50	3.50	3.91	3.73	3.4	3.44
Compression Set								
Compression Set (%)	26	22	24	25	23	24	25	33
Damping								
tan d @ 1 Hz	0.15	0.17	0.15	0.15	0.14	0.16	0.17	0.15
tan d @ 5 Hz	0.19	0.21	0.22	0.22	0.22	0.22	0.22	0.21
tan d @ 10 Hz	0.24	0.25	0.25	0.26	0.26	0.27	0.27	0.26
tan d @ 50 Hz	0.40	0.4	0.42	0.44	0.48	0.50	0.47	0.46
tan d @ 70 Hz	0.43	0.45	0.48	0.5	0.54	0.56	0.53	0.43

Examples 58-62:

- 5 Examples 58-62 were prepared according to the general formulation outlined in Table 15. The elastomer(s) 1A were added to the mixer, at 30 sec 1B was added and at 60 sec 1C was added. Curatives (2A) were added on the mill. The samples were then

cured and their physical and dynamic properties were evaluated as shown in Table 16. As evident from Table 16, partial replacement of the BBX2 with Example 7 resulted in improved traction.

Table 15

LANXESS Bromobutyl X2	1A	100-50
Example 7	1A	0-50
Struktol 40 MS Flakes	1B	5
Stearic Acid	1C	1
Zeosil 1165 MP	1C	60
Silane Struktol SCA 985	1C	3.6
Carbowax 3350	1C	0.9
Spider Sulfur	2A	1.5
Zinc Oxide	2A	3
Vulkacit CZ/EGC	2A	1.75

5

Table 16

	58	59	60	61	62
LANXESS Bromobutyl X2	100	90	70	60	50
Example 7	0	10	30	40	50
MDR Cure Characteristics (160 °C)					
Delta MH-ML (dN.m)	20.66	18.07	17.02	15.75	13.89
t' 90 (min)	12.36	13.18	16.2	14.19	14.03
Compound Mooney Viscosity (ML (1+8) @ 100 °C)					
Mooney Viscosity (MU)	127.5	151.4	129.8	141.3	159.3
Stress Strain (ambient temperature)					
Hardness Shore A2 (pts.)	65	65	68	67	67
Ultimate Tensile (MPa)	22.94	23.65	15.88	17.26	18.27
Ultimate Elongation (%)	474.6	476.2	331.1	359.7	355.3
Stress @ 100 (MPa)	2.4	3.48	4.04	3.62	4.88
Stress @ 200 (MPa)	7.29	9.38	9.26	8.66	10.31
Stress @ 300 (MPa)	14.24	16.05	15.01	14.37	15.86
M300/M100	5.9	4.6	3.7	4.0	3.3
DIN Abrasion (ambient temperature)					
Abrasion Volume Loss (mm ³)	66	69	83	84	87
Traction					
tan d @ 1 Hz	0.17	0.18	0.16	0.17	0.17
tan d @ 5 Hz	0.23	0.24	0.24	0.24	0.25
tan d @ 10 Hz	0.30	0.29	0.33	0.33	0.35
tan d @ 50 Hz	0.48	0.48	0.50	0.52	0.55

tan d @ 70 Hz	0.5	0.58	0.59	0.62	0.67
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Examples 63-66:

Examples 63-66 were prepared according to the general formulation outlined in Table 17. The elastomer(s) 1A were added to the mixer, at 30 sec 1B was added and at 60 sec 1C was added. Curatives (2A) were added on the mill. The samples were then

5 cured and their physical and dynamic properties were evaluated as shown in Table 18. As evident from Table 18, partial replacement of the natural rubber with Example 7 resulted in improved tear strength, flex fatigue and damping.

Table 17

		phr
Natural Rubber SIR20	1A	70-100
Example 7	1A	0-30
Carbon Black, N 774	1B	50
6PPD	1C	1
Oil	1C	5
Stearic Acid	1C	1
Vulkanox HS/LG	1C	0.5
DPG	2A	1.5
Vulkacit Thiuram/C	2A	0.5
Vulkacit CZ/EGC	2A	3
Zinc Oxide	2A	3
Sulfur	2A	0.3

10

Table 18

Example	63	64	65	66
Natural Rubber SIR20	100	90	80	70
Example 7	0	10	20	30
Compound Mooney Viscosity (ML(1+4+4) @ 100 °C)				
Mooney Viscosity (MU)	34	42	48	66
Compound Mooney Scorch (ML @ 125 °C)				
t Value t35 (min)	9	9	8	8
t Value t05 (min)	7	7	6	3
MDR Cure Characteristics (160 °C)				
M _H (dN.m)	18	16	14	12
M _L (dN.m)	2	2	3	3
Delta M _H -M _L (dN.m)	17	14	12	9
t' 90 (min)	3	3	4	5
Stress Strain (ambient temperature)				

Hardness Shore A2 (pts.)	52	52	51	52
Ultimate Tensile	23.0	21.6	20.6	16.8
Ultimate Elongation (%)	550	611	640	607
Stress @ 100 (MPa)	1.7	1.6	1.5	1.6
Stress @ 200 (MPa)	4.4	3.6	3.3	3.3
Stress @ 300 (MPa)	8.2	6.2	5.5	5.3
Aged Stress Strain (168 h at 100 °C, measured at ambient temperature)				
Hardness Shore A2 (pts.)	54	53	53	51
Ultimate Tensile (MPa)	14.0	13.8	12.9	12.6
Ultimate Elongation (%)	371	443	458	481
Stress @ 100 (MPa)	2.3	2.2	2.2	2.0
Stress @ 200 (MPa)	5.7	5.0	4.7	4.1
Stress @ 300 (MPa)	10.2	8.0	7.2	6.3
Die C Tear (ambient temperature)				
Tear Strength (kN/m)	49	58	62	45
Aged Tear Strength - 168 h @ 100 °C (kN/m)	25	38	43	34
Compression Set -Method B (aged 70 h @ 100 °C, measured at ambient temp)				
Compression Set (%)	49	50	49	53
Demattia Flex Test (aged 168 h @ 100 °C, measured at ambient temperature)				
Crack Growth Aged 300% (kc)	38	55	81	82
Crack Growth Aged 600% (kc)	80	113	182	187
GABO				
tan delta @ 0.1 Hz	0.094	0.11	0.12	0.14
tan delta @ 1 Hz	0.14	0.15	0.16	0.15
tan delta @ 10 Hz	0.15	0.18	0.17	0.16

Examples 67-69:

- Examples 67-69 were prepared according to the general formulation outlined in Table 19. The elastomer(s) 1A were added to the mixer and at 60 sec 1B was added.
- 5 Curatives (2A) were added on the mill. The samples were then cured and their physical and dynamic properties were evaluated as shown in Table 20. As evident from Table 20, partial replacement of the CR with Example 7 resulted in improved flex fatigue.

Table 19

Example 7	1A	0-20
Baypren 116	1A	100-80
DOS	1B	10
Carbon Black N550	1B	65
Vulkanox 3100	1B	2
Rhenofit OCD	1B	3

Vulkanox Mb2	1B	0.3
Stearic Acid	1B	1
Magnesium Oxide	1B	4
Zinc Oxide	2A	5
Rhenogran TMTD-75	2A	1
Rhenogran ETU-80	2A	1

Table 20

Example	67	68	69
Example 7	0	10	20
Baypren 116	100	90	80
MDR Cure Characteristics (180 °C)			
MH (dN.m)	34	32	28
ML (dN.m)	3	4	4
Delta MH-ML (dN.m)	31	28	24
t' 90 (min)	5	3	3
Stress Strain (ambient temperature)			
Ultimate Tensile	20.3	17.0	13.9
Ultimate Elongation (%)	249	232	300
Stress @ 25 (MPa)	1.9	2.0	1.5
Stress @ 50 (MPa)	3.2	3.3	2.3
Stress @ 100 (MPa)	7.4	7.3	4.6
Aged Stress Strain (air - 72 h at 100 °C, measured at ambient temp)			
Ultimate Tensile (MPa)	21.5	16.7	14.0
Ultimate Elongation (%)	216	192	226
Stress @ 25 (MPa)	2.6	2.7	2.1
Stress @ 50 (MPa)	4.5	4.6	3.2
Stress @ 100 (MPa)	9.8	9.7	6.4
Aged Stress Strain (air - 168 h at 100 °C, measured at ambient temp)			
Ultimate Tensile (MPa)	19.2	15.5	15.1
Ultimate Elongation (%)	189	170	216
Stress @ 25 (MPa)	3.0	3.1	2.5
Stress @ 50 (MPa)	5.2	5.2	4.1
Stress @ 100 (MPa)	10.8	10.4	8.3
Aged Stress Strain (IRM 901 oil - 168 h at 100 °C, measured at ambient temp)			
Ultimate Tensile (MPa)	20.8	17.3	15.3
Ultimate Elongation (%)	202	180	220
Stress @ 25 (Mpa)	2.3	1.8	1.2
Stress @ 50 (Mpa)	4.2	3.7	2.4
Stress @ 100 (Mpa)	9.7	9.1	6.1

Die C Tear (measured at ambient temperature)			
Tear Strength (kN/m)	34	32	33
Compression Set -Method B (ambient temperature)			
Compression Set (%) (aged 22 h @ 100 °C)	21	25	28
Compression Set (%) (aged 70 h @ 100 °C)	33	41	42
Demattia Flex Test (aged 168 h @ 100 °C, measured at ambient temp)			
Crack Growth Aged 600% (kc)	100	100	4000

Examples 70-72:

- Examples 70- 72 were prepared according to the general formulation outlined in Table 21. The elastomer(s) 1A were added to the mixer and at 60 sec 1B was added.
- 5 Curatives (2A) were added on the mill. The samples were then cured and their physical and dynamic properties were evaluated as shown in Table 22. As evident from Table 22, partial replacement of the HNBR with Example 7 resulted in improved flex fatigue.

Table 21

		phr
Example 7	1A	0-20
Therban 3406	1A	100-80
Carbon Black, N 550	1B	65
Zinc Oxide	1B	2
Rhenofit OCD	1B	1
Vulkanox ZMB	1B	1
Stearic Acid	1B	1
Magnesium Oxide	1B	2
Dicup 40C	2A	8
Rhenofit TAIC-72	2A	1.5

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Table 22

Example	70	71	72
Example 7	0	10	20
Therban 3406	100	90	80
MDR Cure Characteristics (180 °C)			
MH (dN.m)	45	41	39
ML (dN.m)	4	5	6
Delta MH-ML (dN.m)	41	36	33
t' 90 (min)	3	3	3
Stress Strain			

Ultimate Tensile	25.4	21.9	20.8
Ultimate Elongation (%)	275	264	246
Stress @ 25 (MPa)	1.9	1.9	1.9
Stress @ 50 (MPa)	3.2	3.2	3.2
Stress @ 100 (MPa)	8.5	8.3	8.4
Aged Stress Strain (air - 72 h at 100 °C)			
Ultimate Tensile (MPa)	26.2	23.7	20.6
Ultimate Elongation (%)	199	191	147
Stress @ 25 (MPa)	3.6	4.0	3.9
Stress @ 50 (MPa)	6.9	7.5	7.6
Stress @ 100 (MPa)	15.4	15.4	15.9
Aged Stress Strain (air - 168 h at 100 °C)			
Ultimate Tensile (MPa)	26	23	20
Ultimate Elongation (%)	193	183	159
Stress @ 25 (MPa)	4.0	4.0	4.1
Stress @ 50 (MPa)	7.6	7.6	7.8
Stress @ 100 (MPa)	15.9	15.6	15.8
Aged Stress Strain (IRM 901 oil - 168 h at 100 °C)			
Ultimate Tensile (MPa)	25.8	23.2	19.9
Ultimate Elongation (%)	243	201	173
Stress @ 25 (MPa)	1.9	1.8	1.4
Stress @ 50 (MPa)	3.4	3.5	3.1
Stress @ 100 (MPa)	9.4	10.3	9.9
Die C Tear			
Tear Strength (kN/m)	37	36	33
Compression Set -Method B			
Compression Set (%) (aged 22 h @ 150 °C)	20	19	24
Compression Set (%) (aged 70 h @ 100 °C)	28	30	31
Demattia Flex Test (aged 168 h @ 100 °C)			
Crack Growth Aged 600% (kc)	400	800	200

Examples 73-78:

- Examples 73-78 were prepared according to the general formulation outlined in Table 23. The elastomer(s) 1A were added to the mixer and at 60 sec 1B was added.
- 5 Curatives (2A) were added on the mill. The samples were then cured and their physical and dynamic properties were evaluated as shown in Table 24. As evident from Table 24, partial replacement of the regular butyl with Example 7 resulted in improved green strength, tack, tear strength and crack growth resistance.

Table 23

		phr
LANXESS Butyl 301	1A	100-70
LANXESS Bromobutyl 2030	1A	0-10
Example 7	1A	0-30
Zinc Oxide	1B	3
Stearic Acid	1B	1
Sunpar 2280	1B	25
Carbon Black, N 660	1B	70
Spider Sulfur	2A	1.25
Vulkacit DM/C	2A	0.5
Vulkacit Thiuram/C	2A	1.2

Table 24

Example	73	74	75	76	77	78
LANXESS BUTYL 301	100	90	90	80	80	70
LANXESS BROMOBUTYL 2030	0	10	0	10	0	0
Example 7	0	0	10	10	20	30
Compound Mooney Viscosity (ML(1+4+4) @ 100 °C)						
Mooney Viscosity (MU)	50	49	54	52	54	56
Compound Mooney Scorch (ML @ 125 °C)						
t Value t35 (min)	>30	>30	>30	>30	>30	>30
t Value t05 (min)	>30	>30	>30	>30	>30	>30
MDR Cure Characteristics (160 °C)						
M _H (dN.m)	15	14	14	13	13	12
M _L (dN.m)	2	2	2	2	2	2
Delta M _H -M _L (dN.m)	13	12	12	11	11	10
t' 90 (min)	4	4	4	4	4	4
Green Strength						
Peak Stress (MPa)	0.18	0.17	0.27	0.27	0.33	0.38
Stress Strain						
Hardness Shore A2 (pts.)	48	48	49	49	48	48
Ultimate Tensile	12.4	12.1	12.6	12.4	12.2	12.5
Ultimate Elongation (%)	672	639	654	671	653	653
Stress @ 100 (MPa)	1.4	1.4	1.6	1.5	1.6	1.6
Stress @ 200 (MPa)	2.8	3.1	3.5	3.2	3.7	3.7
Stress @ 300 (MPa)	4.2	5.0	5.3	5.0	5.6	5.7
Aged Stress Strain (168 h at 100 °C)						
Hardness Shore A2 (pts.)	56	55	58	59	54	56
Ultimate Tensile (MPa)	10.9	11.1	10.9	10.8	11.0	11.1
Ultimate Elongation (%)	540	515	488	533	519	527

Stress @ 100 (MPa)	2.1	2.2	2.6	2.4	2.3	2.4
Stress @ 200 (MPa)	4.3	4.7	5.2	4.9	4.9	5.2
Stress @ 300 (MPa)	6.1	6.6	7.0	6.7	7.0	7.1
Permanent Set						
Unaged Permanent Set (%)	12	12	14	13	12	10
Aged Perm. Set (168 h @ 100 °C; %)	12	12	12	12	12	13
Tel Tack						
Tack to self	38	36	41	46	45	52
Die C Tear						
Tear Strength (kN/m)	33	35	34	36	37	38
Aged Tear Strength - 168 h @ 100 °C (kN/m)	31	29	28	28	27	28
Permeability						
Permeability (cc mm/[m ² day])	319	329	326	319	319	322
Demattia Flex Test						
Crack Growth 300% (kc) - unaged	31	38	67	83	155	
Crack Growth 600% (kc) - unaged	95	105	186	188	250	

Examples 79-84:

Examples 79-84 were prepared according to the general formulation outlined in Table 25. Ingredients 1A were added to the mixer and at 90 sec 1B was added. Curatives (2A) were added on the mill. The samples were then cured and their physical and dynamic properties were evaluated as shown in Table 26. As evident from Table 26, partial replacement of the EPDM with Example 7 resulted in improved tack, hot tear and crack growth. Addition of ZnO (Examples 82-84) further improved tack and reduced increased heat rise noted in examples 80 and 81.

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Table 25

		phr
Keltan 4450	1A	100-80
Example 7	1A	0-20
Sunpar 2280	1A	15
Struktol 40	1A	2
Carbon Black, N 330	1A	70
Vulkanox HS/LG	1B	1
Zinc Oxide	1B	0-1
Trimethylolpropane Trimethacrylate	2A	3
Di-Cup 40C	2A	5
HVA-2	2A	1.0

Table 26

Example	79	80	81	82	83	84
Example 7	0	10	20	0	10	20
Keltan 4450	100	90	80	100	90	80
Zinc Oxide	0	0	0	1	1	1
Compound Mooney Viscosity (ML(1+4+4) @ 100 °C)						
Mooney Viscosity (MU)	97	108	111	100	109	112
MDR Cure Characteristics (170 °C)						
M _H (dN.m)	38	33	27	38	36	31
M _L (dN.m)	4	5	5	4	5	5
Delta M _H -M _L (dN.m)	34	28	23	38	32	26
t' 90 (min)	4	6	6	6	6	6
Stress Strain (ambient temperature)						
Hardness Shore A2 (pts.)	71	69	69	70	71	71
Ultimate Tensile	19.4	17.4	15.6	19.3	17.8	15.9
Ultimate Elongation (%)	429	494	567	428	455	494
Stress @ 100 (MPa)	1.3	1.3	1.3	1.4	1.4	1.4
Stress @ 200 (MPa)	1.7	1.7	1.6	1.7	1.8	1.8
Stress @ 300 (MPa)	2.6	2.4	2.2	2.6	2.7	2.9
Aged Stress Strain (168 h at 100 °C)						
Hardness Shore A2 (pts.)	70	71	71	71	72	72
Ultimate Tensile (MPa)	18.7	17.7	15.2	19.3	17.9	15.5
Ultimate Elongation (%)	430	482	508	438	453	476
Stress @ 100 (MPa)	1.6	1.5	1.5	1.5	1.5	1.5
Stress @ 200 (MPa)	1.9	1.9	1.9	1.8	2.0	2.0
Stress @ 300 (MPa)	2.9	2.7	2.7	2.7	2.8	2.9
Permanent Set (ambient temperature)						
Unaged Permanent Set (%)	12	12	14	13	12	10
Aged Perm. Set (168 h @ 100 °C; %)	12	12	12	12	12	13
Tel Tack (ambient temperature)						
Tack to self	38	36	41	46	45	52
Die C Tear (ambient temperature)						
Tear Strength (kN/m)	40	41	41	38	39	42
Aged Tear Strength -@ RT - 168 h @ 100 °C (kN/m)	40	41	41	38	39	42
Aged Tear Strength @ 100 C - aged 168 h @ 100 °C (kN/m)	22	41	40	21	41	40
Demattia Flex Test (ambient temperature)						
Crack Growth 300% (kc) - unaged	4.3	8	29	4.1	3	6.7
Crack Growth 600% (kc) - unaged	38.7	37	>250	16.7	12.3	51
Crack Growth 300% (kc)– aged 100C for 168h	4	7	9.7	3.5	3.3	4.7
Crack Growth 600% (kc) - aged 100C for 168h	18.1	25.5	114	15.3	12.9	23.3
Doli Fexometer (ambient temperature)						
Heat Rise (°C)	60	64	68	60	61	60

Permanent Set (%)	3.7	5.4	8.6	3.6	4.2	4.6
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Examples 85-89:

- Examples 85-89 were prepared according to the general formulation outlined in Table 27. The elastomer(s) 1A were added to the mixer and at 60 sec 1B was added.
- 5 Curatives (2A) were added on the mill. The samples were then cured and their physical and dynamic properties were evaluated as shown in Table 28. As evident from Table 28, partial replacement of the CIIR with Example 7 resulted in improved adhesion to carcass and flex fatigue resistance. Additionally, replacement of the NR with Example 7 resulted in a compound with improved impermeability, flex fatigue resistance and comparable
- 10 adhesion.

Table 27

		phr
LANXESS Chlorobutyl 1240	1A	100-60
Example 7	1A	0-20
Natural Rubber	1A	0-40
Stearic Acid	1B	1
Resin SP1068 pellets	1B	4
Rhenosin 145A	1B	7
Sunpar 2280	1B	7
Carbon Black, N 660	1B	60
Sulfur	2A	0.5
Vulkacit DM/C	2A	1.3
Zinc Oxide	2A	3

Table 28

Example	85	86	87	88	89
LANXESS Chlorobutyl 1240	100	80	60	90	80
Example 7	0	0	0	10	20
SMR CV60 Natural Rubber	0	20	40	0	0
Stress Strain (ambient temperature)					
Ultimate Tensile	10.1	10.6	11.4	10.1	10.2
Ultimate Elongation	831	673	608	834	786
Stress @ 100 (MPa)	1.4	1.6	1.7	1.5	1.7
Stress @ 200 (MPa)	3.0	3.2	3.4	2.9	3.3

Stress @ 300 (MPa)	4.6	4.8	5.3	4.3	4.9
Die C Tear (ambient temperature)					
Tear Strength	38	35	33	38	40
Rubber Adhesion To Carcass (ambient temperature)					
Adhesive Strength	8.7	6.9	13.6	15.3	16.8
Tel Tak (ambient temperature)					
Tack to Carcass	25	48	47	23	28
Tack to Self	63	53	49	49	61
Permeability To Gases (ambient temperature)					
Permeability	171	322	400	186	171
Compound Mooney Viscosity (ML 1+8 @ 100 °C)					
Mooney Viscosity	60	53	47	60	63
Compound Mooney Scorch (ML @ 138 °C)					
t Value t05 (min)	7	14	13	10	12
t Value t35 (min)	9	22	19	14	16
DeMattia Flex Fatigue (aged 7 days @ 100 °C, 2 mm punch)					
300 % Crack Growth	100	50	50	100	150
600 % Crack Growth	210	150	200	>250	>250

Examples 90-91:

- Examples 90-91 were prepared according to the general formulation outlined in Table 29. The elastomer(s) 1A were added to the mixer and at 60 sec 1B was added.
- 5 Curatives (2A) were added on the mill. The samples were then cured and their physical and dynamic properties were evaluated as shown in Table 30. As evident from Table 30, partial replacement of the BBX2 with Example 7 resulted in improved green strength and flex fatigue.

Table 29

		phr
LANXESS Bromobutyl X2	1A	100-80
Example 7	1A	0-20
Stearic Acid	1B	1
Resin SP 1068	1B	4
Sunpar 2280	1B	7
Carbon Black, N 660	1B	60
Spider Sulfur	2A	0.5
Vulkacit DM/C	2A	1.3
Zinc Oxide	2A	3

Table 30

Example	90	91
LANXESS BROMOBUTYL X2	100	80
Example 7	0	20
Compound Mooney Viscosity (ML(1+4+4) @ 100 °C)		
Mooney Viscosity (MU)	68	70
Compound Mooney Scorch (ML @ 125 °C)		
t Value t35 (min)	11	13
t Value t05 (min)	8	9
MDR Cure Characteristics (160 °C)		
M _H (dN.m)	11	11
M _L (dN.m)	4	4
Delta M _H -M _L (dN.m)	7	7
t' 90 (min)	8	12
Green Strength		
Peak Stress (MPa)	0.33	0.78
Stress Strain		
Hardness Shore A2 (pts.)	52	55
Ultimate Tensile	12.1	11.7
Ultimate Elongation (%)	642	706
Stress @ 100 (MPa)	1.5	1.8
Stress @ 200 (MPa)	3.8	4.2
Stress @ 300 (MPa)	6.6	6.5
Aged Stress Strain (100 °C for 168 h)		
Hardness Shore A2 (pts.)	58	59
Ultimate Tensile (MPa)	11.1	11.0
Ultimate Elongation (%)	452	546
Stress @ 100 (MPa)	3.0	2.9
Stress @ 200 (MPa)	6.7	6.1
Stress @ 300 (MPa)	9.4	8.2
Permeability		
Permeability (cc mm/[m ² day])	187	179
Demattia Flex Test (aged 168 h @ 100 °C)		
Crack Growth Aged 300% (kc)	30	52
Crack Growth Aged 600% (kc)	109	183

Examples 92-95:

- Examples 92-95 were prepared according to the general formulation outlined in Table 31. The elastomer(s) 1A were added to the mixer and at 60 sec 1B was added. Curatives (2A) were added on the mill. The samples were then cured and their physical and dynamic properties were evaluated as shown in Table 32. As evident from Table 32,

partial replacement of the XIIR with Example 7 resulted in improved green strength, permeability, adhesion, and flex fatigue.

Table 31

LANXESS Chlorobutyl 1240	1A	0-80
LANXESS Bromobutyl 2030	1A	0-80
Natural Rubber	1A	20
Example 7	1A	0
Stearic Acid	1B	1
Resin SP 1068 Pellets	1B	4
Oil	1B	7
Carbon Black, N 660	1B	60
Spider Sulfur	2A	0.5
Vulkacit DM/C (MBTS)	2A	1.3
Zinc Oxide	2A	3

5

Table 32

Example	92	93	94	95
LANXESS Chlorobutyl 1240	0	0	80	60
LANXESS Bromobutyl 2030	80	60	0	0
Example 7	0	20	0	20
Compound Mooney Viscosity (ML(1+4+4) @ 100 °C)				
Mooney Viscosity (MU)	54	54	57	58
Compound Mooney Scorch (ML @ 125 °C)				
t Value t35 (min)	9	9	17	13
t Value t05 (min)	16	15	>30	19
MDR Cure Characteristics (160 °C)				
M _H (dN.m)	13	11	14	12
M _L (dN.m)	3	3	3	3
Delta M _H -M _L (dN.m)	11	9	11	9
t' 90 (min)	8	8	9	10
Green Strength				
Peak Stress (MPa)	0.25	0.35	0.27	0.37
Stress Strain				
Hardness Shore A2 (pts.)	56	56	57	56
Ultimate Tensile	12.4	11.4	12.3	11.3
Ultimate Elongation (%)	558	636	499	614
Stress @ 100 (MPa)	1.9	1.9	2.4	1.9
Stress @ 200 (MPa)	4.5	2.0	5.3	4.2
Stress @ 300 (MPa)	7.4	6.1	8.3	6.5
Aged Stress Strain (100 °C for 168 h)				

Hardness Shore A2 (pts.)	63	62	66	62
Ultimate Tensile (MPa)	10.6	9.5	11.0	10.1
Ultimate Elongation (%)	350	433	328	396
Stress @ 100 (MPa)	3.7	3.0	3.7	3.2
Stress @ 200 (MPa)	6.8	5.8	7.2	6.5
Stress @ 300 (MPa)	9.6	7.8	10.4	8.9
Permeability				
Permeability (cc mm/[m ² day])	344	315	352	300
Demattia Flex Test (aged 168 h @ 100 °C)				
Crack Growth Aged 300% (kc)	62	72	10	63
Crack Growth Aged 600% (kc)	>250	>250	51	173
Adhesion to Carcass				
Adhesion at Ambient Temperature (kNm)	9	11	6	7
Adhesion at 100 °C (kNm)	3	5	2	2
Die C Tear				
Unaged Tear Strength (kN/m)	34	41	33	37
Aged Tear Strength(100 °C for 168 h; kNm)	29	34	27	30
Doli Flexometer				
Permanent Set (%)	6	7	4	5
Heat Build-up (°C)	42	44	39	40
Mill Shrinkage				
Shrinkage @ 50 °C (%)	23	26	26	26
Shrinkage @ 90 °C (%)	11	13	15	12

Examples 96-100:

Examples 96-100 were prepared according to the general formulation outlined in Table 33. The elastomer(s) 1A were added to the mixer, at 30 sec 1B was added, at 75 sec 1C was added and at 120 sec 1D was added. Curatives (2A) were added on the mill. The samples were then cured and their physical and dynamic properties were evaluated as shown in Table 34. As evident from Table 34, partial replacement of the regular butyl with Example 7 resulted in improved flex fatigue.

Table 33

		phr
LANXESS Butyl 301	1A	89-69
Example 7	1A	0-20
LANXESS Bayprene 210	1A	5
Stearic Acid	1B	1
Carbon Black, N 330	1B	10
Acetylene Carbon Black	1C	40
Castor Oil	1D	5

Rhein Chemie WBC-41P	2A	21.4
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Table 34

Example	96	97	98	99	100
LANXESS BUTYL 301	89	84	79	74	69
Example 7	0	5	10	15	20
Compound Mooney Viscosity (ML(1+4+4) @ 100 °C)					
Mooney Viscosity (MU)	76	83	86	82	86
MDR Cure Characteristics (160 °C)					
M _H (dN.m)	17	16	16	14	14
M _L (dN.m)	3	4	4	4	4
Delta M _H -M _L (dN.m)	14	12	12	10	10
t' 90 (min)	13	14	17	17	18
Stress Strain					
Hardness Shore A2 (pts.)	58	60	62	62	62
Ultimate Tensile	12.9	12.1	12.4	11.9	12.1
Ultimate Elongation (%)	669	679	668	693	697
Stress @ 100 (MPa)	1.7	2.0	2.0	1.9	2.0
Stress @ 200 (MPa)	3.44	3.74	3.92	3.49	3.8
Stress @ 300 (MPa)	5.54	5.68	5.94	5.2	5.61
Aged Stress Strain (180 °C for 24 h)					
Hardness Shore A2 (pts.)	78	82	79	76	79
Ultimate Tensile (MPa)	10.0	9.6	10.0	8.1	8.9
Ultimate Elongation (%)	290	309	325	292	299
Stress @ 100 (MPa)	4.2	4.3	4.3	4.2	4.4
Stress @ 200 (MPa)	7.4	7.3	7.2	6.6	7.1
Stress @ 300 (MPa)	n/a	9.5	9.4	n/a	n/a
Demattia Flex Test (aged 168 h @ 100 °C)					
Crack Growth Aged 300% (kc)	0.3	0.5	0.5	1	1.5
Crack Growth Aged 600% (kc)	1.0	1.75	2.0	7.0	8.0
Die C Tear					
Unaged Tear Strength (kN/m)	35	36	35	36	36
Aged Tear Strength(180 °C for 24 h; kNm)	28	29	30	30	29

5 Examples 101-103:

Examples 101-103 were prepared according to the general formulation outlined in Table 35. The elastomer(s) 1A were added to the mixer, at 60 sec 1B was added, and at 240 sec 1C was added.. Curatives (2A) were added on the mill. The samples were then

cured and their physical and dynamic properties were evaluated as shown in Table 36. As evident from Table 36, partial replacement of the bromobutyl with Example 7 resulted in improved flex fatigue, higher tack, higher green strength and improved impermeability.

Table 35

		phr
LANXESS X_Butyl BB2030	1A	60-80
SMR CV60 Natural Rubber	1A	20
Example 7	1A	0-20
Stearic Acid	1B	1
Resin SP 1068	1B	4
Polyfil DL	1B	30
Sunpar 2280	1B	7
Carbon Black N660	1B	45
Spider Sulphur	2A	0.5
Vulkacit DM/C (MBTS)	2A	1.3
Zinc Oxide	2A	3

5

Table 36

Example	101	102	103
LANXESS BB2030	80	70	60
Example 7	0	10	20
Mooney			
Mooney Scorch (125 °C)	8	9	9
Mooney Viscosity (ML 1+4 @ 100 °C)	48	48	51
MDR Cure Characteristics (160 °C)			
M _H (dN.m)	11	10	9
M _L (dN.m)	2	2	3
Delta M _H -M _L (dN.m)	9	8	7
t' 90 (min)	9	9	8
Green Strength			
Peak Stress (MPa)	0.25	0.35	0.38
Stress Strain			
Hardness Shore A2 (pts.)	54	55	56
Ultimate Tensile	12.0	12.0	11.7
Ultimate Elongation (%)	647	689	676
Stress @ 100 (MPa)	1.7	1.8	2.0
Stress @ 300 (MPa)	5.3	4.9	5.1
Aged Stress Strain (100 °C for 168h)			
Hardness Shore A2 (pts.)	61	62	61
Ultimate Tensile (MPa)	9.5	9.2	9.1

Ultimate Elongation (%)	479	548	554
Stress @ 100 (MPa)	2.8	3.0	2.9
Stress @ 300 (MPa)	6.4	6.3	6.1
Demattia Flex Test (aged 168 h @ 100 °C)			
300% Crack Growth (kc)	70	80	200
Permeability			
(cc mm/[m ² day])	274	246	235
Die C tear			
Unaged Tear Strength (kN/m)	31	33	34
Aged Tear Strength(100 °C for 168 h; kNm)	29	31	33
Tack			
Self (psi)	41	51	60
Carcass (psi)	36	38	40
Adhesion			
Carcass (kNm)	14	15	15
Mill Shrinkage			
50 C after 2h (%)	23	22	21
50 C after 24 h (%)	25	27	27
90 C after 2h (%)	14	13	11
90 C after 24 h (%)	17	17	14

Examples 104-106:

Examples 104-106 were prepared according to the general formulation outlined in Table 37. The elastomer(s) 1A were added to the mixer, at 60 sec 1B was added, and at 5 240 sec 1C was added.. Curatives (2A) were added on the mill. The samples were then cured and their physical and dynamic properties were evaluated as shown in Table 38. As evident from Table 38, partial replacement of the chlorobutyl with Example 7 resulted in improved flex fatigue, higher green strength and improved impermeability.

10

Table 37

		phr
LANXESS X_Butyl CB1240	1A	60-80
SMR CV60 Natural Rubber	1A	20
Example 7	1A	0-20
Stearic Acid	1B	1
Resin SP 1068	1B	4
Calcium Carbonate	1B	40
Sunpar 2280	1B	7
Carbon Black N660	1B	60

Spider Sulphur	2A	0.5
Vulkacit DM/C (MBTS)	2A	1.3
Zinc Oxide	2A	3

Table 38

Example	104	105	106
LANXESS CB1240	80	70	60
Example 7	0	10	20
Mooney			
Mooney Scorch (125 °C)	18	14	13
Mooney Viscosity (ML 1+4 @ 100 °C)	54	55	56
MDR Cure Characteristics (160 °C)			
M _H (dN.m)	14	13	12
M _L (dN.m)	2	3	3
Delta M _H -M _L (dN.m)	23	10	9
t' 90 (min)	14	13	13
Green Strength			
Peak Stress (MPa)	0.26	0.36	0.42
Stress Strain			
Hardness Shore A2 (pts.)	55	55	56
Ultimate Tensile	10.2	10.4	9.7
Ultimate Elongation (%)	503	566	636
Stress @ 100 (MPa)	1.8	1.6	1.5
Stress @ 300 (MPa)	5.9	5.2	4.6
Aged Stress Strain (100 °C for 168h)			
Hardness Shore A2 (pts.)	65	61	61
Ultimate Tensile (MPa)	9.2	8.8	8.6
Ultimate Elongation (%)	358	400	435
Stress @ 100 (MPa)	2.9	2.6	2.5
Stress @ 300 (MPa)	8.0	7.1	6.6
Demattia Flex Test (aged 168 h @ 100 °C)			
300% Crack Growth (kcycles)	3	5	10
600% Crack Growth (kcycles)	12	22	41
Permeability			
(cc mm/[m ² day])	325	292	286
Die C tear			
Unaged Tear Strength (kN/m)	29	29	35
Aged Tear Strength(100 °C for 168 h; kNm)	25	25	26
Mill Shrinkage			
90 C after 2h (%)	11	10	10
90 C after 24 h (%)	12	13	13

Examples 107-109:

Examples 107-109 were prepared according to the general formulation outlined in Table 38. The elastomer(s) 1A were added to the mixer, at 60 sec 1B was added, and at 240 sec 1C was added.. Curatives (2A) were added on the mill. The samples were then cured and their physical and dynamic properties were evaluated as shown in Table 40. As evident from Table 40, partial replacement of the chlorobutyl with Example 7 resulted in improved flex fatigue and higher green strength.

Table 39

		phr
X Butyl TM CB 1240	1A	50-70
SMR CV60 Natural Rubber	1A	30
Example 7	1A	0-20
Carbon Black N774	1B	70
Stearic Acid	1B	2
Vulkanox HS/LG	1B	1.5
Zinc Oxide	1B	5
Escorez 1102	1B	10
Sunpar 2280	1B	5
Vulkacit Merkapt MG/C (MBT)	2A	0.2
Vulkacit DM/C (MBTS)	2A	1
Sulphur	2A	1.5
Vultac TB710	2A	1

10

Table 38

Example	107	108	109
LANXESS CB1240	70	60	30
Example 7	0	10	20
Mooney			
Mooney Viscosity (ML 1+4 @ 100 °C)	44	43	42
MDR Cure Characteristics (180 °C)			
M _H (dN.m)	11	9	8
M _L (dN.m)	1	1	1
Delta M _H -M _L (dN.m)	10	8	7
t' 90 (min)	3	2	2
Green Strength			
Peak Stress (MPa)	0.21	0.30	0.47
Stress Strain			

Hardness Shore A2 (pts.)	61	58	57
Ultimate Tensile	10.4	11.5	11.2
Ultimate Elongation (%)	291	519	566
Stress @ 100 (MPa)	3.1	2.3	2.3
Stress @ 300 (MPa)	n/a	7.7	6.5
Aged Stress Strain (100 °C for 168h)			
Hardness Shore A2 (pts.)	65	61	59
Ultimate Tensile (MPa)	10.5	10.2	10.2
Ultimate Elongation (%)	200	293	337
Stress @ 100 (MPa)	5.8	4.2	3.5
Stress @ 300 (MPa)	n/a	n/a	9.4
Demattia Flex Test (aged 168 h @ 100 °C)			
300% Crack Growth (kcycles)	0.5	1	3
600% Crack Growth (kcycles)	0.8	4	12
Die C tear			
Unaged Tear Strength (kN/m)	27	30	32
Aged Tear Strength(100 °C for 168 h; kNm)	22	223	26
Mill Shrinkage			
90 C after 2h (%)			
90 C after 24 h (%)			

Examples 110-113:

Examples 110-113 were prepared according to the general formulation outlined in Table 40. 1A were added to the mixer, followed by 1B and then 1C. Curatives (2A) were added on the mill. The samples were then cured and their physical and dynamic properties were evaluated as shown in Table 41. As evident from Table 41, partial replacement of the EPDM with Example 7 resulted in improved flex fatigue.

Table 40

		phr
Sunpar 2280	1A	150
Carbon Black N550	1A	220
Keltan 4450	1B	80-100
X_Butyl™ I4565P	1B	0-20
Carbowax 3350	1C	2
Stearic Acid	1C	2
Calcium Carbonate	1C	50-80
ZOCO 104	2A	5
Perkacit TBzTD	2A	4

Sulphur	2A	1.5
Vulkacit Merkapto MG/C (MBT)	2A	3

Table 41

Example	110	111	112	113
Keltan 4450	100	80	100	80
Example 7	0	20	0	20
Calcium Carbonate	50	50	80	80
Mooney				
Mooney Scorch (138 C)	5	4	4	5
Mooney Viscosity (ML 1+4 @ 100 °C)	56	56	66	57
MDR Cure Characteristics (160 °C)				
M _H (dN.m)	14	14	17	14
M _L (dN.m)	2	2	2	2
Delta M _H -M _L (dN.m)	12	12	15	12
t' 90 (min)	13	15	16	15
Stress Strain				
Ultimate Tensile	7.8	5.4	6.6	5.4
Ultimate Elongation (%)	296	300	291	343
Stress @ 100 (MPa)	3.4	2.5	3.4	2.5
Demattia Flex Test (unaged)				
300% Crack Growth (kcycles)	0.6	1	0.1	0.8
600% Crack Growth (kcycles)	3.7	4	1.7	4.4

All documents cited herein are incorporated herein by reference.

- 5 The novel features will become apparent to those of skill in the art upon examination of the description. It should be understood, however, that the scope of the claims should not be limited by the embodiments, but should be given the broadest interpretation consistent with the wording of the claims and the specification as a whole.

Claims:

1. An elastomeric compound comprising a cured blend of a butyl rubber ionomer, at least one elastomer co-curable with the butyl rubber ionomer and a filler.
2. The elastomeric compound according to claim 1, wherein the co-curable elastomer comprises one or more units of unsaturation.
3. The elastomeric compound according to claim 1, wherein the co-curable elastomer comprises butyl rubber, bromobutyl rubber, chlorobutyl rubber, isobutylene-methylstyrene copolymer, ethylene propylene rubber, ethylene propylene diene monomer rubber, butadiene rubber, solution styrene butadiene rubber, emulsion styrene butadiene rubber, acrylonitrile butadiene rubber, hydrogenated acrylonitrile butadiene rubber, natural rubber, epoxidized natural rubber, polyurethane, polyisoprene rubber, polyacrylic, polyacrylate, chloroprene, chlorosulphonylpolyethylene, chlorosulphonatedpolyethylene, ethylene acrylic, thermoplastic polyester urethane, thermoplastic polyether urethane, epichlorohydrin, fluoroethylene propylene-perfluoroalkoxy, tetrafluoroethylene/propylene, perfluoroelastomer, fluoroelastomer or fluorocarbon, fluorosilicone, silicone, polytetrafluoroethylene, ethylene vinylacetate rubber, ethylene acrylate rubber, polyurethane rubber, polyisobutylene, chlorinated polyethylene, polynorbornene rubber, polysulphide rubber or mixtures thereof.
4. The elastomeric compound according to any one of claims 1 to 3 comprising two co-curable elastomers.
5. The elastomeric compound according to any one of claims 1 to 4, wherein the butyl rubber ionomer is present in an amount of 1-50 phr.
6. The elastomeric compound according to any one of claims 1 to 5, wherein the butyl rubber ionomer comprises phosphorus-based or nitrogen-based ionic moieties.
7. The elastomeric compound according to any one of claims 1 to 6, wherein the filler comprises carbon black, mineral filler or mixtures thereof.
8. The elastomeric compound according to claim 7, wherein the mineral filler comprises silica or a high aspect ratio filler.
9. The elastomeric compound according to any one of claims 1 to 8, having a crack growth resistance as measured by ASTM D 813 over 1.2 times greater than crack growth

resistance of a cured blend comprising the co-curable elastomer and the filler but not the butyl rubber ionomer.

10. The elastomeric compound according to any one of claims 1 to 9, having a damping as measured by $\tan \delta$ @ 70 Hz at least 1.1 times greater than damping of a
5 cured blend comprising the co-curable elastomer and the filler but not the butyl rubber ionomer.

11. The elastomeric compound according to any one of claims 1 to 10, having a traction at least 1.1 times greater than traction of a cured blend comprising the co-curable elastomer and the filler but not the butyl rubber ionomer.

10 12. A process for producing an elastomeric compound comprising: blending a butyl rubber ionomer, at least one elastomer co-curable with the butyl rubber ionomer and a filler; and, curing the blend.

13. The process according to claim 12, wherein the blend is cured with a sulfur-based cure system, a peroxide-based cure system or a resin-based cure system.

15 14. The process according to any one of claims 12 to 13, wherein the butyl rubber ionomer is blended in an amount of less than 50 phr.

15. The process according to any one of claims 12 to 14, wherein the butyl rubber ionomer comprises phosphorus-based or nitrogen-based ionic moieties

16. The process according to any one of claims 12 to 15, wherein the filler comprises
20 carbon black, mineral filler or mixtures thereof.

17. An article of manufacture comprising an elastomeric compound as defined in any one of claims 1 to 11.

18. The article of manufacture according to claim 17 which is a belt, a hose, a shoe sole, a gasket, an o-ring, a wire, a cable, an inner tube, a membrane, a roller, a bladder,
25 an inner liner of a tire, a tire tread, a shock absorber, a machinery mounting, a balloon, a ball, a golf ball, protective clothing, medical tubing, a storage tank lining, electrical insulation, a bearing, a pharmaceutical stopper, an adhesive, a sealant, a container, a container closure or lid, a seal, a material handling apparatus, a cooling tower, a metal working apparatus, an apparatus in contact with metal working fluids or an engine
30 component.