

[54] **THERMOPLASTIC IONOMER FOAMS**  
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3,852,096	12/1974	Lundberg et al. ....	260/31.8 M
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3,947,387	3/1976	Lundberg .....	260/2.5 R
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**Related U.S. Application Data**

[60] Division of Ser. No. 855,727, Nov. 29, 1977, Continuation-in-part of Ser. No. 839,172, Oct. 4, 1977.

[51] Int. Cl.<sup>2</sup> ..... **C08J 9/00**  
 [52] U.S. Cl. .... **521/93; 260/31.2 MR; 260/31.2 R; 260/32.4; 260/32.6 A; 260/33.6 AQ; 260/33.6 UA; 260/42.33; 260/42.35; 260/42.37; 260/42.38; 521/82; 521/91; 521/92; 521/94; 521/95; 521/97; 521/140; 521/150; 521/153; 521/905**  
 [58] Field of Search ..... **521/93, 140, 150, 94, 521/95**

**References Cited**

**U.S. PATENT DOCUMENTS**

3,396,136	8/1968	Dickerson .....	260/30.6 R
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3,847,854	11/1974	Canter et al. ....	260/23.7 M

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[57] **ABSTRACT**

This invention relates to a novel elastomeric foamed material which has been found to exhibit a variety of unusual and desirable features both in its physical properties and in its process of manufacture. These foamed compositions of a lightly sulfonated elastomeric gum contain a non-volatile polar plasticizer and preferably extenders such as oil and fillers. These elastomer foams exhibit an unusual profile of physical properties including extremely rapid production, melt reprocessability of fabricated articles, a novel memory characteristic, and high temperature reshaping of foamed objects while maintaining a good foam structure. These novel foams can be manufactured with relatively uniform cell structures and with small cell sizes at foam densities from near bulk density to less than 0.1g/cc.

**7 Claims, No Drawings**

## THERMOPLASTIC IONOMER FOAMS

### CROSS REFERENCE TO RELATED APPLICATION

This application is a continuation-in-part of copending application Ser. No. 839,172 filed Oct. 4, 1977. This is a division of application Ser. No. 855,727, filed 11/29/77.

### BACKGROUND OF THE INVENTION

#### 1. Field of the Invention

This invention relates to a novel elastomeric foamed material which has been found to exhibit a variety of unusual and desirable features both in its physical properties and in its process of manufacture. These foamed compositions of a lightly sulfonated elastomeric gum contain a non-volatile polar plasticizer and preferably extenders such as oil and fillers. These elastomer foams exhibit an unusual profile of physical properties including extremely rapid production, melt reprocessability of fabricated articles, a novel memory characteristic, and high temperature reshaping of foamed objects while maintaining a good foam structure. These novel foams can be manufactured with relatively uniform cell structures and with small cell sizes at foam densities near bulk density to less than 0.1g/cc.

#### 2. Description of the Prior Art

Foamed articles have represented one of the fastest growing markets in the polymer industry in the past 15 years. This growth is expected to continue, and it is claimed that the potential usage of foamed polymers could far exceed the ability of the polymer industry to supply the needed materials.

The market for flexible foams is currently dominated by chemically crosslinked polymers, for example, polyurethanes and sponge rubbers. The time required for curing these materials is costly; for example, vulcanized elastomer foams such as vulcanized EPDM can require as long as two hours or more to cure. Also, the resultant lack of reprocessability can be a major handicap since many foaming operations generate up to 25% scrap.

The present invention relates to unique and novel elastomer foams which have been found to possess several unexpected and useful characteristics. These novel foams contain a low concentration of sulfonate groups which are covalently appended to the elastomeric polymer backbone. These flexible ionomer foams are effectively crosslinked by the physical associations of sulfonate salt groups from different molecules. It has been found that in specified sulfonated elastomer systems these associations can provide a strong and tough material at use temperatures; yet at sufficiently elevated temperatures these associations can be disrupted to enable melt flow and melt fabrication. An important aspect of this material as specified in this invention is that it contains a non-volatile polar plasticizer which greatly improves the flow or processability of the material at processing temperature. The continued presence of the non-volatile polar plasticizer in the foam subsequent to the foaming process is crucial for many of the important characteristics of these novel foams such as the thermal reformability, the melt reprocessability and the memory characteristics which are described below. A major advantage in the production of elastomer lightly sulfonated thermoelastic foams is that no post cure is required. This can result in a large savings in production time, machinery and cost. Also, no precure

is required, and this can also make the foaming process less complicated and more efficient. These process advantages together with the virtues of melt reprocessability, thermal reformability, the memory characteristic, and the temperature insensitivity of the material during the foaming process make these foams extremely attractive candidates for a variety of flexible foam applications.

The preferred sulfonated elastomeric compositions of the present invention are derived from elastomeric polymers having a primarily hydrocarbon backbone with olefinic unsaturation, especially elastomeric polymers such as butyl and EPDM rubbers. Some processes for sulfonating such polymers are described in U.S. Pat. Nos. 3,642,728 and 3,836,511. Some methods for using polar additives to weaken the physical crosslinks at elevated temperature and improve processability in non-foamed articles of these lightly sulfonated polymers are included in U.S. Pat. No. 3,847,854.

U.S. Pat. No. 3,867,319 teaches a process for foaming an ionic polymer using a volatile polar plasticizer. A preferred method of foaming taught by that patent is dissolving of the ionic polymer in a solvent containing a volatile polar plasticizer and foaming by heating at atmospheric pressure in an oven. That patent differs from the instant invention in that a non-volatile polar plasticizer which is a high temperature flow improver is specified in the instant invention and, as mentioned above, the non-volatile polar plasticizer is required to obtain the unique set of characteristics of the flexible foams of the instant invention. In addition, the preferred method of foaming taught in U.S. Pat. No. 3,867,319 (which is described above) was found to be ineffective for producing satisfactory foams of the ionic elastomer materials considered here.

U.S. Pat. No. 3,947,387 claims novel ionic foams which are produced by using a volatile polar plasticizer. Again, such foams lack the essential ingredient of the non-volatile polar plasticizer which is critical to several of the most important characteristics of the foam of the instant invention.

U.S. Pat. No. 4,051,217, filed Nov. 17, 1971, describes a fabrication process for multiphased plastics which includes ionic plastic foams. That process deals only with ionomers derived from a plastic material and explicitly excludes elastomeric polymers; therefore that application does not bear on the instant invention which is concerned specifically with the novel characteristics of anionic elastomer foam.

The present invention differs from the ionic polymer systems disclosed in U.S. Pat. No. 3,322,734, herein incorporated by reference, in that the products of the present invention are preferably neutralized at least about 95%. The strong association of these fully neutralized ionic polymers of the present inventions are weakened at elevated temperatures by the addition of suitable plasticizing agents which disrupt the ionic domains and permit the foaming process. On the other than, U.S. Pat. No. 3,322,734 teaches that the acid form of the ionic polymer should not be completely neutralized—preferably the neutralization should be only 80% complete and in no case should exceed 90% of the stoichiometric equivalence. Thus, it is emphasized in U.S. Pat. No. 3,322,734 that incomplete neutralization of the acid moiety is essential in order that the resulting products be fabricated.

The foams described in the present instant invention may be characterized as follows:

(a) the foamed products of the present invention are tough, strong and rubbery at use temperature behaving in many ways like a chemically crosslinked elastomer;

(b) at sufficiently high temperatures the foamed products of the present invention which contain a non-volatile polar plasticizer can be made to have excellent melt rheological properties so these product, or used or scrap material can be readily melt reprocessed, thereby enabling reuse and refoaming of waste material;

(c) due to the unique ionic bonding in these systems and the incorporation of a non-volatile high temperature polar flow improver, it has been found that in an appropriate elevated temperature range these foams have the characteristic of being reformable into different shapes without substantially damaging the foam structure (see e.g., Example 7);

(d) when reshaped at slightly elevated temperatures and cooled, these flexible foams exhibit a novel memory effect;

(e) the production of these foams from the hulk material (containing a non-volatile polar plasticizer, foaming agents, flow improvers and compounding ingredients) exhibits several unusual and important characteristics such as insensitivity of the foam production to temperature changes over a wide temperature region, very rapid foam production because curing is not required, and excellent rheological melt properties;

(f) these thermoplastic elastomer foams can be rapidly produced by either high pressure compression molding or extrusion foaming; and

(g) rubbery foams of good cell uniformity and small cell size can be produced at densities from below 0.1g/cc up to near bulk density.

### SUMMARY OF THE INVENTION

The present invention relates to unique and novel sulfonated elastomeric foam articles and processes for foaming these articles, wherein a sulfonated elastomeric polymer composition is modified with a non-volatile polar plasticizer, foaming agents, and preferably other chemical additives, and is foamed to produce articles which exhibit a variety of unusual and desirable physical and rheological properties.

Accordingly, it is an object of our present invention to provide novel sulfonated elastomeric foam compositions having superior quality and unusual characteristics, wherein the compositions are formed from sulfonated elastomeric polymers, a non-volatile polar plasticizer and preferably selected chemical additives.

### GENERAL DESCRIPTION OF THE INVENTION

The present instant invention relates to improved sulfonated elastomeric foamed articles and foaming processes for forming these articles wherein the sulfonated elastomeric foams exhibit an unusual and useful profile of physical characteristics, and wherein simple and unusually rapid processes are used to produce or modify the foams.

The elastomeric polymers of the present invention are derived from synthetic and natural polymers having olefinic unsaturation sites, wherein the polymer has from about 0.1 to about 10.0 mole % olefinic unsaturation. The unsaturation sites can be in the polymer backbone, pendant therefrom or cyclic.

In particular, the unsaturated polymers of this present invention include low unsaturated polymers such as

butyl rubber, halo-butyl or EPDM terpolymers. Additionally, other unsaturated polymers contemplated are partially hydrogenated isoprene, partially hydrogenated polybutadiene, or an isoprene-styrene random copolymer.

The expression "Butyl rubber" as employed in the specification and claims is intended to include copolymers made from a polymerization reaction mixture having therein from 70 to 99.5% by weight of an isoolefin which has about 4 to 7 carbon atoms, e.g. isobutylene and about 0.5 to 30% by weight of a conjugated multiolefin having from about 4 to 14 carbon atoms, e.g. isobutylene and about 0.5 to 30% by weight of a conjugated multiolefin having from about 4 to 14 carbon atoms, e.g. isoprene. The resulting copolymer contains 85 to 99.8% by weight of combined isoolefin and 0.2 to 15% of combined multiolefin.

Butyl rubber generally has a Staudinger molecular weight of about 20,000 to about 500,000, preferably about 25,000 to about 400,000 especially about 100,000 to about 400,000 and a Wijs Iodine No. of about 0.5 to 50, preferably 1 to 15. The preparation of Butyl rubber is described in U.S. Pat. No. 2,356,128 which is incorporated herein by reference.

For the purpose of this invention, the Butyl rubber may have incorporated therein from about 92 to 10% of combined multiolefin; preferably about 0.5 to about 6%; more preferably about 1 to about 4%, e.g. 2%.

Illustrative of such a Butyl rubber is Exxon Butyl 218 (Exxon Chemical Co.), having a viscosity average molecular weight of about 450,000, a mole % unsaturation of about 1.5% and a Mooney viscosity of about 55 at 260° F. at 8 minutes.

Halogenated butyl rubber is commercially available and may be prepared by halogenating Butyl rubber in a solution containing between 1 to 60% by weight of Butyl rubber in a substantially inert C<sub>5</sub>-C<sub>8</sub> hydrocarbon solvent such as pentane, hexane, heptane, etc. and contacting this Butyl rubber cement with a halogen gas for a period of about 25 minutes, whereby halogenated Butyl rubber and a hydrogen halide are formed, the copolymer containing up to one halogen atom per double bond in the copolymer. The preparation of halogenated Butyl rubber is old in the art, see e.g. U.S. Pat. No. 3,099,644 which is incorporated herein by reference. This invention is not intended to be limited in any way by the manner in which Butyl rubber is halogenated, and both chlorinated and brominated Butyl rubber are suitable for use in this invention.

Illustrative of halogenated Butyl rubbers is Exxon Butyl HT-10-66 (a chlorinated Butyl rubber containing about 1.3 wt. % chlorine, having about 1.7 mole % unsaturation and a viscosity average molecular weight of about 357,000).

Low molecular weight Butyl rubbers, i.e. Butyl rubbers having a viscosity average molecular weight of about 5,000 to 85,000 and a mole % unsaturation of about 3 to about 4% may be sulfonated by the process of this invention. Preferably, these polymers have a viscosity average molecular weight of about 25,000 to about 60,000.

The term "EPDM" is used in the sense of its definition as found in ASTM D-1418-64 and is intended to mean a terpolymer containing ethylene and propylene in the backbone and a diene in the side chain. Illustrative methods for producing these terpolymers are found in U.S. Pat. No. 3,280,082, British Pat. No. 1,030,289 and French Pat. No. 1,386,600, which are incorporated



herein by reference. The preferred terpolymers contain about 40 to about 80 wt. % ethylene and about 2 to about 10 wt. % of a diene monomer, the balance of the polymer being propylene. More preferable, the polymer contains about 45 to about 75 wt. % diene monomer, e.g. 5.0 wt. %. The diene monomer is preferably a non-conjugated diene. The  $\overline{M}_n$  of the terpolymer is preferably about 10,000 to about 200,000; and more preferably about 15,000 to about 100,000; and most preferably about 20,000 to about 60,000. the Mooney viscosity of the terpolymer at (1+8) minutes at 212° F. is preferably 5 to 90, more preferably 10 to 60 and most preferably 15 to 50 e.g. 40. The  $\overline{M}_v$  of the EPDM is preferably below about 350,000 and more preferably below about 300,000; e.g. 270,000. The  $\overline{M}_w$  of the EPDM is preferably below about 500,000 and more preferably below about 350,000, e.g. 343,000.

Illustrative of these non-conjugated diene monomers which may be used in the EPDM terpolymer are 1,4-hexadiene, dicyclopentadiene, ethylidene norbornene, methylene norbornene, propylidene norbornene and methyl tetrahydroindene.

A typical EPDM is Vistalon 2504 (Exxon Chemical Co.) a terpolymer having a Mooney viscosity at (ML, 1+8, 212° F.) of about 40 and having 50 wt. % of ethylene, 45 wt. % of propylene, and 5.0 wt. % of 5-ethylidene-2-norbornene with an  $\overline{M}_n$  of about 47,000, an  $\overline{M}_v$  of about 145,000 and an  $\overline{M}_w$  of about 174,000. The Vistalon 2504 can be reprocessed through an extruder until a 20 Mooney value has been achieved.

Another EPDM terpolymer, Vistalon 2504-20 is derived from Vistalon 2504 (Exxon Chemical Co.) by a controlled extrusion process, wherein the resultant Mooney viscosity at 212° F. is about 20. The  $\overline{M}_n$  of Vistalon 2504-20 is about 26,000, the  $\overline{M}_v$  is about 90,000 and the  $\overline{M}_w$  is about 125,000.

Vistalon 3708 (Exxon Chemical Co.) is a terpolymer, having a Mooney viscosity (ML, 1+8, 260° F.) of about 45-55 and having about 65 wt. % of ethylene, about 3.3 wt. % of 5-ethylidene-2-norbornene; and about 31.7 wt. % of propylene with an  $\overline{M}_n$  of about 53,000, an  $\overline{M}_w$  of about 343,000 and an  $\overline{M}_v$  of about 27,000.

Vistalon 6505 (Exxon Chemical Co.) is a terpolymer having a Mooney viscosity (ML, 1+8, 260° F.) of about 45-55 and having about 53 wt. % of ethylene, about 9.0 wt. % of 5-ethylidene-2-norbornene and about 38 wt. % of propylene.

Nordel 1320 (DuPont) is another EPDM terpolymer having a Mooney viscosity (ML, 1+8, 212° F.) of about 25 and having about 53 wt. % of ethylene, about 3.5 wt. % of 1,4-hexadiene and about 43.5 wt. % of propylene.

In carrying out the present invention, an olefinically unsaturated polymer is sulfonated with a sulfonating agent according to, for example, the method of either U.S. Pat. No. 3,642,728 and 3,836,511, both of which are herein incorporated by reference.

It should be pointed out that neither the sulfonating agent nor the manner of sulfonation is critical, provided that the sulfonating method does not degrade the polymer backbone.

In the practice of this invention, the polymer to be sulfonated can be dissolved in a suitable solvent and reacted with the sulfonating agent. The solvent medium should be a neutral one for the rubber and the sulfonating agent. The solvent is preferably an aromatic hydrocarbon, an aliphatic hydrocarbon, or a halogenated aromatic hydrocarbon.

Sulfonation of the polymer is conducted at a temperature between -10° C. and +100° C. Sulfonation occurs, when the sulfonating agent is added to the polymer solution. The sulfonating agent is preferably dissolved in a suitable solvent. Reaction time at room temperature may be about 5 min. to about 60 min., more preferably about 30 min.

The acid form of the sulfonated elastomeric can be quenched with a liquid aliphatic alcohol.

The amount of desirable sulfonation depends on the particular application. Preferably, the elastomeric polymer is sulfonated at about 10 to about 100 meq.  $\text{SO}_3\text{H}/100\text{g}$  of polymer, more preferably at about 15 to about 50 meq.  $\text{SO}_3\text{H}/100\text{g}$  of polymer, and most preferably at about 20 to about 45 meq.  $\text{SO}_3\text{H}/100\text{g}$  of polymer. The meq. of  $\text{SO}_3\text{H}/100\text{g}$  of polymer was determined by dissolving the acid form of the sulfonated polymer in a mixed solvent of 95 parts of toluene and 5 parts of methanol at a concentration level of 50 grams per liter of solvent. The acid form is titrated with sodium ethoxide to an Alizarin Thymolphthalein endpoint. Sulfur analysis was done by Dietert Analysis.

Polymers containing unsaturation and sulfonic acid groups have been found to be somewhat deficient in thermostability. Therefore, it is desirable to neutralize the acid groups as part of the manufacturing of sulfonated elastomeric polymer. Neutralization further improves the physical properties of the sulfonated polymer. Thus, the acid form of the polymer lacks adequate physical properties and often the stability to be useful in the applications envisioned for the foamed products.

In preparing the ionomer it is not necessary to neutralize every sulfonic acid group. Preferably, enough base is added to theoretically neutralize at least about 95 of the sulfonic acid groups; more preferably at least about 98; and most preferably at least about 99.

The neutralizing agents of the present invention are metallic salts of carboxylic acids, wherein the metallic ion of the metallic salt is selected from the group consisting of Groups IA, IIA, IB, IIB, A1 or Pb of the Periodic Table of Elements and mixtures thereof. (see page B-3, "Handbook of Chemistry and Physics", Chemical Rubber Publishing Co., 47th Ed.). Suitable monovalent metal ions include  $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{Li}^+$ ,  $\text{Cs}^+$ ,  $\text{Ag}^+$ ,  $\text{Hg}^+$  and  $\text{Cu}^+$ . Suitable divalent metal ions include  $\text{Be}^{+2}$ ,  $\text{Mg}^{+2}$ ,  $\text{Ca}^{+2}$ ,  $\text{Sr}^{+2}$ ,  $\text{Ba}^{+2}$ ,  $\text{Cu}^{+2}$ ,  $\text{Cd}^{+2}$ ,  $\text{Hg}^{+2}$ ,  $\text{Sn}^{+2}$ ,  $\text{Fe}^{+2}$ ,  $\text{Pb}^{+2}$ ,  $\text{CO}^{+2}$ ,  $\text{Ni}^{+2}$  and  $\text{Zn}^{+2}$ . A preferred cation is  $\text{Zn}^{+2}$ .

Other neutralizing agents of this invention are metallic oxides, hydroxides, or  $\text{C}_1$  to  $\text{C}_{20}$  alkoxides,  $\text{C}_1$  to  $\text{C}_{20}$  alkanates and mixtures thereof, wherein the metallic ion is selected from the group consisting essentially of Groups IA, IIA, IB and IIB and mixtures thereof of the Periodic Table of Elements. Illustrative examples are lead oxide, zinc oxide, calcium oxide, magnesium oxide, ammonium hydroxide, sodium hydroxide, magnesium hydroxide, calcium hydroxide, or sodium ethoxide.

Still other useful neutralizing agents are primary, secondary and tertiary amines having up to 30 carbons.

The foam compositions of the present invention are formed from a blend of the neutralized sulfonated elastomeric polymer, a non-volatile polar plasticizer which is used to control the viscoelasticity of the elastomeric ionomer at processing temperatures, a foaming agent, and preferably oils and fillers. Selected crystalline polymers and lubricants may also be added in minor amounts. Other additives such as coloring agents and stabilizers which are known in the art can also be added,

if desired. The cell structure of the resultant foams depends in a complex way on a number of interdependent variables including the choice of non-volatile polar plasticizer, the amount of non-volatile polar plasticizer, the foaming agent, the sulfonated gum, and the various additives and their concentrations. In addition, the details of the particular foaming process can have a significant effect on cell structure, for example, whether extrusion, compression molding or some other foaming procedure is used, and the temperatures, heating times, or foaming rates employed. Some specific examples of some materials, techniques, and conditions which produce satisfactory foams are given later in this application.

A preferential polar plasticizer is used to help weaken the ionic associations of the neutralized sulfonate groups prior to, and during the foaming operation. This is necessitated by the fact that for most neutralized sulfonated elastomeric polymers, quite high temperatures are required to obtain appreciable flow rates; and, for some, this temperature is above the thermal decomposition temperature of the polymer. The preferential polar plasticizer, through the weakening of the ionic associations decreases, the melt viscosity of the neutralized sulfonated elastomeric polymer at elevated temperatures thereby making it readily processable.

By the proper selection of the preferential polar plasticizer, it is possible to obtain excellent physical properties for the plasticized, neutralized sulfonated elastomeric polymer. A preferred class of preferential plasticizers are metallic salts of fatty acids wherein the fatty acid has about C<sub>12</sub> to about C<sub>40</sub> carbon atoms, more preferably about C<sub>14</sub> to about C<sub>26</sub>, most preferably about C<sub>16</sub> to about C<sub>22</sub> carbon atoms and the metallic action is selected from the group consisting of zinc, antimony, lead or Groups IA, IIA, IB or IIB of the Periodic Table of Elements and mixtures thereof. Because with metal salts the cation might partially exchange with the cation of the neutralized sulfonated polymer, it is preferable (but not necessary) that the metal salt contain the same cation as the sulfonated polymer. A preferred plasticizer is zinc stearate, preferably in combination with a zinc neutralized sulfonated polymer. A less preferred class of preferential plasticizer is the aforementioned fatty acids alone or in combination with the aforementioned metallic salts of the fatty acids. Other preferential plasticizers which are preferred in the instant compositions include amides, ureas, amines or thioureas and mixtures thereof. The preferential plasticizers are incorporated into the compositions at about 0 to about 60 parts by weight per hundred parts of the metal neutralized sulfonated elastomeric polymer, more preferably at about 2 to about 40, and most preferably about 8 to about 30.

Polar plasticizers can be distinguished into two categories—volatile and non-volatile plasticizers. The major practical difference between the two types is that the non-volatile plasticizers remain with the final product while the volatile plasticizers are volatilized from the ionomer during or shortly after a processing operation.

The foams of this invention require the use of a non-volatile polar plasticizer to achieve several of their desirable and unusual properties. For example, the thermal reshaping process described earlier and also detailed in an example requires the presence of the non-volatile plasticizer; and the economically important characteristic of being able to melt reprocess scrap foam

or to refabricate used or discarded foam requires the presence of the nonvolatile plasticizers. At the elevated temperature at which foaming takes place (and also any thermal reshaping operations or reprocessing) the non-volatile polar plasticizer must be very effective in reducing the melt viscosity of the sulfonated elastomer to enable rapid and satisfactory foaming.

The foaming agents used in combination with the preferential polar plasticizer include chemical compounds that decompose at or below the temperature of foaming to liberate gases, and low boiling liquids which are converted into gaseous form by heating. The chemical foaming agents have been found to be particularly easy to use and generally give excellent results.

The blowing (foaming) agent may be a chemical blowing agent or a physical blowing agent or a combination of chemical and physical blowing agents. In the case of physical blowing agents a nucleating agent may be helpful for obtaining good cell structure. Chemical blowing agents are particularly effective as nucleating agents for physical blowing agents. If a physical blowing agent is used, the ionic elastomeric material must not be soluble in the physical blowing agent nor should the backbone polymer chain (in the absence of the ionic group) be soluble in the physical blowing agent. In the foaming process the polymer is heated under pressure and the foam structure is nucleated by rapid decrease in the pressure. Heating the polymer without utilizing a rapid decrease in pressure was not found to be very effective in producing foams of relatively uniform cell structure. The foaming of the elastomeric ionomer material differs from the foaming of thermoplastic ionomer materials such as lightly sulfonated polystyrene in that heating at atmospheric pressure is able to produce good quality foams of sulfonated polystyrene. Also, it is known that many sulfonated polystyrene foams using physical blowing agents did not require nucleating agents.

The foaming agents used in the process of the instant invention are well known in the art and include compounds which when incorporated in the polymer composition decompose at or below the temperature of foaming to liberate gases, and the low boiling liquids which are converted into gaseous form by heating.

Examples of foaming agents which decompose at specific temperatures to liberate gases include the following representative compounds for which the approximate temperature range of decomposition for the neat material is indicated in parenthesis: sodium bicarbonate (160°–200° C.), sodium bicarbonate and citric acid combination (0° C. to 200° C.), azobisformamide combination (160°–200° C.), azobisisobutyronitrile (90°–115° C.), diazominobenzene (90°–110° C.), N,N'-dimethyl-N,N'-dinitroisoterephthalamide (90°–105° C.), N,N'-dinitrosopentamethylenetetramine (130°–190° C.), toluene-4-sulfonyl hydrazide (100°–100° C.), 4,4'-oxybis (benzene sulfonyl hydrazide) (120°–140° C.), and similar compounds known in the art. (For example, see reference "Plastic Foams"; Vo. II, by C. J. Bennings, Wiley Interscience Publishers, 1969, Appendix A-II.

When chemical foaming agents are employed, generally from about 0.25 to about 5 parts per hundred by weight (based on 100 parts of the neutralized sulfonated elastomeric polymer) of the foaming agent will be used; more preferably about 0.5 to about 4.

If a low boiling liquid is used as a foaming agent, suitable liquids include butane, pentane, hexane, and

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