BIIR/POE BLEND

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ABSTRACT: *Butyl rubber (polyisobutylene-co-isoprene (IIR)) is a very important commercial elastomer with many desirable physical properties, such as low air permeability and broad damping properties. The principal uses of this material are in the tire industry for the preparation of inner tubes and inner liners of passenger car tires. Despite these unique properties, there are some deficiencies associated with this polymer, mainly poor compatibility with other materials, including elastomer, plastics and carbon black. This poor compatibility greatly limits the application of butyl rubber in many application areas. In fact, the improvement of interfacial adhesion among butyl rubber has been an intense research area for some time. On other hand, polyolefin elastomers (POEs) are available with properties ranging from amorphous to crystalline, and low to very high molecular weight, providing superior elasticity, toughness and low temperature ductility and offer a unique combination of flexibility and toughness, making them a material of choice for a wide variety of applications. They are versatile polymers that offer excellent adhesion at high and low temperatures, outstanding processability, and superior levels of performance in packaging and other applications. Further advantages include optimize processing and end-use performance, excellent thermal stability and UV resistance. POE's cover a range of melt index and comonomer content (density) for use in several applications. The cost effectiveness of POE is limited by the combination of reduced flowability and/or softness requirements. The ability to extend POE with conventional process oils allows greater flexibility to compounder to tailor the performance of the product. Here retention of physical properties can be achieved by increased molecular weight of POE with addition of oil without compromising with processibility. Here the research is being made on the binary blend containing IIR and POE (IIR/POE blend). The work is to be done for testing an array of compounded butyl rubber with 10%, 15%, and 20% POE. It is to be expected that the IIR/POE blend will have dramatically better properties as POE levels rise. This development in the area of butyl rubber/POE blend may give the more advantageous characteristics of the presently available butyl compound without compromising the processibility characteristics of parent compound at moderate cost. Thus the modified form of butyl can have a set of more desirable properties and therefore it may be used more advantageously.*

Keywords— polymer blend, butyl rubber, BIIR, polyolefin elastomer (POE).

I INTRODUCTION:
1.1 INTRODUCTION TO BUTYL RUBBER
Butyl rubber introduced in 1942, is commercially produced by cationically copolymerizing isobutylene with small amounts of isoprene. The halogen-derivatives, chloro- and bromo- , were introduced in the early 1960's and have been commercially available then. The halogenated derivatives of butyl rubber provide greater vulcanization flexibility and enhanced cure compatibility with other, more unsaturated general-purpose elastomers. Butyl polymers are among the most widely used synthetic elastomers in the world, ranking third in total synthetic elastomers consumed. As specially elastomers, the butyl-based polymers have found their most important application in the tire industry although a host of other applications have evolved and continue to utilize their unique properties. There are two producers in the free world: Exxon Chemical Company, an affiliate of Exxon Corporation; and Polysar Ltd., of Canada. The polymer is also produced in the USSR for internal consumption. Commercial butyl-rubber grades poly(methylpropene-co-2-methyl-1,3-butadiene) or poly(isobutylene-co-isoprene), are prepared by copolymerizing small amounts of isoprene, 1 to 3 % of the monomer feed, with isobutylene, catalyzed by $AlCl_3$ dissolved in methyl chloride. The extremely rapid reaction is unique, proceeding via cationic polymerization at -100^0C to completion in less than a second. Monomer purity is important to achieve the desired polymer molecular weights. The methyl chloride diluents and monomer feed must be carefully dried.

1.2 HALOGENATION OF BUTYL
The concept to halogenations to provide more active functionality to the butyl molecule was first introduced by Goodrich researchers in 1954-56. Their work emphasized the attributes of the brominated derivative. Goodrich commercialized a brominated butyl in 1954 prepared from a bulk batch halogenations, withdrew it in 1969. In this same period, Exxon researchers originated the chlorobutyl product concept. Chlorobutyl was commercially introduced in 1961 by Exxon Chemical Company. Bromobutyl was again

commercially introduced by Polysar Limited of Canada in 1971 and by Exxon Co. in 1980. The introduction of chlorine to butyl molecule, in appropriately 1/1 molar ratio of chloride to double bond, achieved a broadening of vulcanization lattitude and rate, and enhanced covulcanization with general purpose, high unsaturation elastomers, while preserving the many unique attributes of the basic butyl molecule. Bromination in the same approximate molar ratio further enhanced cure properties and provided greater opportunity for increased covulcanization or adhesion, or both, to general purpose elastomers. These property enhencements were vital to the major applications for halobutyl tubeless tire innerliners. Thus halogenated butyls contributed the required level of covulcanizability and adhesion to the highly unsaturated tire elastomers to carry the advantages of butyl inner tubes forward through the development of the radial tubeless wire.

Production Description

The reaction of elemental bromine and chlorine with the isoprene residue in butyl rubber can be quite complicated. The "dark" reaction of a solution of butyl in a inert diluents with these halogens can result in the incorporation of up to about 3 gram atoms of halogen per mole of unsaturation originally present in the polymer. McNeil's study indicates that the overall halogenations occurs substantially as a series of consecutive reactions, each being slower than preceding one. The reported study by Van Tongerloo and Vukov, using the model compound 2,2,4,8,8 pentamethylonene-4, is revealing as to the presence of possible structures. Synthesis in the halogenated-butyls production facilities involves the "dark" reaction of solution of butyl in hexane with elemental helogens at conventional process temperatures (40-60^{0}C). The target is to produce a product in which no more than one halogen atom is introduced into the polymer per unsaturated site initially present, within the constraints of a final product weight percent halogen specification range. Under the above conditions, the reaction with chlorine is very fast, probably completed in 15 seconds or less, even at the low molar concentration of reactants employed. The bromine reaction is considerably slower, perhaps about 5 times that of chlorination. In both cases, thorough mixing is a prerequisite to meet the synthesis targets (i.e., to avoid multiple halogenation at a particular site). That these reactions lead primarily to substituted products has been well documented. These fast reactions are presumed to occur via an ionic mechanism. The halogen molecules are polarized at the olefinic sites, and undergo heterolytic scission and consequent reaction. This ionic reaction can be depicted as follows:
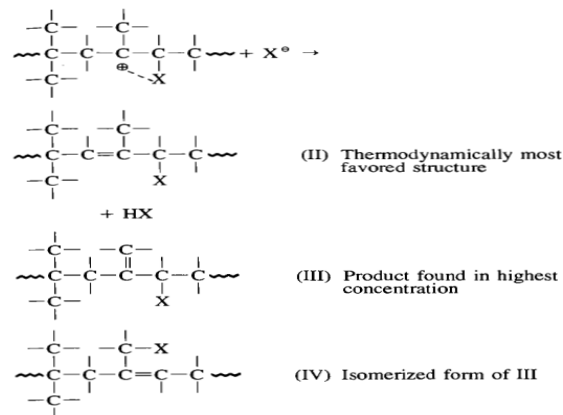Heterolosys and addition of halogen (X).
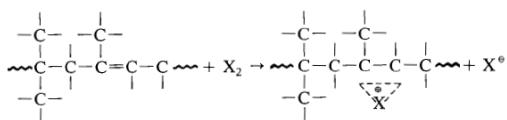

(I)

Proton abstraction by X$^-$
Apperantly the steric constraints imposed by the dimethyl-substituted carbon alpha to the in-chain charged carbon render III the kinetically favored structure by far. The structural features of commercial product can be accounted for to a level greater or equal 95% by the sometime summations of the concentration of structures I-IV with III dominant.

(II) Thermodynamically most favored structure

+ HX

(III) Product found in highest concentration

(IV) Isomerized form of III

Actual production is conducted in a hexane solvent and the process flow chart is shown in figure. Butyl rubber in solution is treated with chlorine or bromine in a series of high intensity mixing steps. Hydrogen chloride or hydrogenbromide is generated during the halogenations step, and must be neutralized, usually with a diluent aqueous caustic solution. After neutralization the caustic aqueous phase is separated and removed at the halogenated cement is then stabilized and antioxydent is added to protect the halogenated product during the polymer recovery and finishing step, which are much along similar lines as for butyl recovery.

Stabilization

As in all hydrocarbon polymers, the presence of antioxidant is required to protect those elastomers
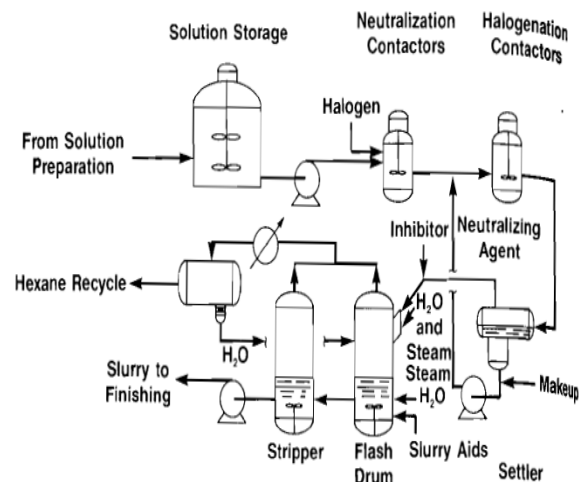
schematic flow plan of halogenated butyl rubber process

during finishing, storage and compounding. These are chosen on the basis of cost effectiveness, discoloration tendencies, FDA approval and compatibility with the overall process. These reactive halogens having been implanted in the polymer, the principle stabilization problem is how to preserve them until they can display their main thermal dihydrohalogenation and simultaneously crosslinking, the brominated product more readily than the chlorinated. The dihydrohalogenation is catalyzed by the evolved acid as well as by friedel crafts metal halide catalysts (e.g. $AlCl_3$). Useful stabilization must meet numerous criteria. The stabilizer or the package thereof must.

1. Prevent the accumulation of evolving HX and yield harmless by-products.
2. Not be it highly reactive with allylic halogens.
3. Have process compatibility.
4. For interact favorably or at least unfavorably with crosslinking systems to be employed.
5. Not introduced a health hazard.
6. Be economical within the forgoing constraints.

Many materials will satisfy one or more of these demands, but very few all of them. Experiment and experience have combined to teach that calcium stearate fulfill these objectives for chlorinated butyl. Brominated butyl, being less stable and more reactive, requires a combination of calcium stearate and an epoxidized vegetable oil.

Compounding Halobutyl

The following summarizes the influence of compounding ingredients on processing and vulcanizate properties of halobutyls:

Carbon Black: Carbon blacks affect the compound properties of halobutyl in a similar way as they affect the compound properties of other rubbers: particle size and structure determine the reinforcing power of the carbon black and hence the final properties of the halobutyl compounds.Increasing reinforcing strength, for example, from GPF (N660) to FEF (N550) to HAF (N347) raises the compound viscosity, hardness and cured modulus. Cured modulus increases with the carbon black level up to 80 phr. Tensile strength goes through a maximum at 50-60 phr carbon black level.

Mineral fillers: Mineral fillers vary not only in particle size but also in chemical composition. As a result, both cure behavior and physical properties of bromobutyl compound are affected by the mineral filler used, although to a lesser extent than chlorobutyl compounds. Generally the common mineral fillers may be used with halobutyl but highly alkaline ingredients and hygroscopic fillers should be avoided. Clays are semireinforcing. Acidic clays give very fast cures; therefore extra scorch retarders may be needed. Calcined clay is the preferred filler for pharmaceutical stopper compounds based on halobutyl. Talc is semireinforcing in halobutyl without a major effect on cure. Hydrated silicas even at moderate levels cause compound stiffness and slower cure

rate, so their use should be restricted. Silane-treated mineral fillers: one way to enhance the interaction between polymer and silicates, and hence to improve compound properties, is to small (1 phr) amounts of silanes. Particularly useful silanes are the mercapto- and amino- derivatives.

Plasticizers: Petroleum based process oils are the most commonly used plastisizers for halobutyl. They improve mixing and processing, soften stocks, improve flexibility at low temperatures and reduced cost. Paraffinic/napthanic oils are preferred for compatibility reasons. Other useful plasticizers are paraffin waxes and low molecular weight polyethylene. Adipates and sebacates improve flexibility at very low temperatures.

Process aids: Struktol 40 MS and Mineral Rubber not only improve the processing characteristics of halobuty1 compounds by improving filler dispersion, but they also enhance compatibility between halobuty1 and highly unsaturated rubbers.

Tackifying resins should be selected with care. Phenol-formaldehyde resins,even those here the reactive methylol groups have been deactivated, react with halobuty1 especially bromobuty1, causing a decrease in scorch time, while partially aromatic resins such as Koresin have an intermediate effect on scorch in bromobuty.

Stearates , stearic acid: it should be noted that zinc stearate (which can also be fomed via the zinc oxide and stearic acid reaction) is a strong dehydrohalogenation agent and a cure catalyst for halobutyl. Similar effects will be observed with other organic acids such as oleic acid or naphtenic acid. Alkaline stearates, on the other hand as calcium stearate, have a retarding action on the halobuty cure. Amine-type antioxidants/antiozonants such as Flectol H, mercaptobenzimidazole and especially p-phenylenediamines will react with halobutyl. They should preferably be added with the curatives, not in the masterbatch. Phenol derivative antioxidants are generally preferred.

Processing Halobutyl

The following recommended processing conditions are applicable to both chloro- and bromobutyl.

Mixing: The mixing is done in two stages. The first stage contains all the ingredients except for zinc oxide and accelerators. The batch weight should be 10-20% higherer than that used for comparable compound based on general-pupose rubbers. A typical mixing cycle and processing for halobutyl in a inner linear compound are as follows:

First stage

0 min: Halobutyl, carbon black, retarder

1.5 min: process aids, plasticizers,fillers,stearic aid…..

3.5 min: dump at 120-140^{0}C

Higher dump temperatures could result in scorching

Second stage

0 min: masterbatch + curatives

2 min: dump at 100^{0}C

Mill-mixing on a two roll mill is best accomplished with a roll speed ratio of 1.25/1 and roll temperature of 40^0C on the slow roll and 55^0C on the first roll.

The following sequence of addition is recommended: part of the rubber together with a small amount of a previous mix as a seed; ¼ fillers plus retarder; reminder of polymer; rest of filler is small increments; plasticizers at the end; acceleration below 150^0C.

Calendaring: Feed preparation can be done either by mill or by extruder halobutyl follows the cooler roll; therefore a temperature differential of 10^0C between calendar rolls is recommended. Strting roll temperature should be;

Cool roll   75-80^{0}C

Warm roll 85-90^{0}C

Normal calendaring speed for halobutyl compounds are between 20-30 meters/min. Rapid cooling of a calendar sheet is beneficial for optimal processibility (handling) and maximum tack retention.

Extrusion: Feed temperature should be 75-80^{0}C while the temperature of extrudate is around 100^0C. During calendaring an extrusion of halobutyl compounds, the most important problem is blister formation. The reason for the phenomenon is the low permeability of these polymers, which tend to retain entrapped air or moisture. Preventive action should be taken at the all stages of the process, for example; Ensure the stock well-mixed in a cool mixer to prevent porosity.

Avoid moisture at all stages. Keep all rolling banks on mills and calendar nips to a minimum

Molding: Halobutyl can be formulated to have a first-cure rate, goog mold flow and mold release characteristic, and can, therefore, demolded into highly intricate designs with conventional molding equipment. Entrapped air can be removed by bumping of the press during the early part of the molding cycle. Halobutyl is also very well suited for injection molding because of its easy flow and fast, reversion-resistant cures. Low molecular-weight polymer grades may be required for optimum flow and good scorch safety.

2. BROMOBUTYL (BIIR)
Structure and physical properties

Macromolecules of bromobutyl rubber consist of polyisobutylene blocks, statistically separated by saturated and unsaturated bromine-containing isoprenyl units. The structure of bromobutyl rubbermacromolecules is not clear yet, but, obviously the distribution of fragments in them is more complex, than in chlorobutyl rubbers. The reason is that 2-3 halogen atoms enter the reaction of butyl rubber brominationat one double C=C bond, and only 25-30 mass% of HBr is observed in the reaction products. This proves that substitution reaction is accompanied by addition. Incidentally, bromobutyl rubber Polycar Bromobutyl X-2 contains 90% of allyl bromine. The degree of unsaturation of the polymer after

bromination hardly decreases. No gel is formed. The reaction scheme of bromination of butyl rubber:
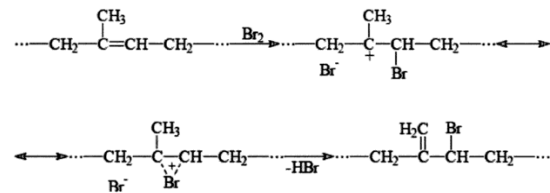
Bromination of the model compound *cis:-trans*-2,2,4,8,8-pentamethylnonene has displayed the presence of four structures in the products. Qntitatively the process shows poor reproduction and is quite sensitive to temperature, concentration of reagent, reaction condition, working condition of bromination and light. Analysis has displayed that in the product containing 1.33 of bromine equivalent, 70-90 % of substitutionproducts and 30-10 % addition productsof bromine atoms are present. In this case, the relation of structures below is 6:1.
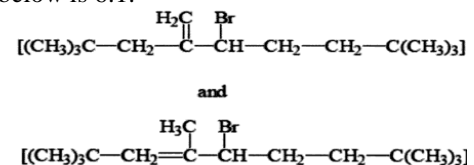

Endochains also participate in the composition of macromolecules. These endochains are formed atre-grouping of the exo-structure. Exo-endo-regrouping in bromobutyl rubber proceeds more easily, than in chlorobutyl rubber. The following structure is absent in the composition of macromolecules of bromobutyl rubber.
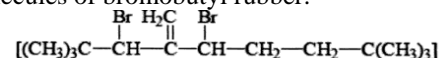
Experimental data indicate that there are probably two mechanisms of butyl rubber bromination – ionic and free radical ones.

Investigation of industrial bromobutyl rubberPolycar bromobutyl X-2has confirmed results of analysis of model compound. The following structures were identified.
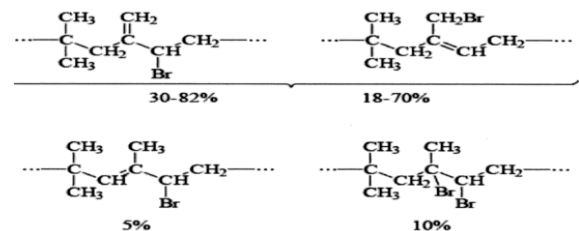
These polymers are differs by high stability. Consequently bromobutyl rubber is low heat aged: after exposure of rubber vulcanizate at 450 K for 22 hours, strength at elomgation is approximately20-fold greater thananalogous index for butyl rubber. Bromobutyl rubber is readily soluble in aliphatic and aromatic hydrocarbons. Introduction of bromine into butyl

rubber sharply improves its adhesive properties, much better than at chlorination of butyl rubber.

Chemical properties

The main chemical properties of bromobutyl rubbers are analogous to those of chlorobutyl rubber. The bromine atom in the rubber is more mobile than the chlorine atom.this produces high rate of vulcanization of bromobutyl rubber, which grows with the content of bonded bromine, in the presence of the same vulcanizing systems. Double bonds in bromobutyl rubber are more active than in butyl and chlorobutyl rubbers, which are confirmed by its ability to vulcanize by just sulfur in the absence of metal oxides and accelerators.

Bromobutyl vulcanization

Bromobutyl is very close in structure and properties to chlorobutyl. The approximately 2 wt% bromine present in bromobutyl is located on the isoprene units, in a similar way as the chlorine atoms in chlorobutyl. The main difference in bromo- and chlorobutyl is in higher reactivity of the C-Br bond compared to C-Cl. This manifests itself in:

1. A higher versatility in vulcanization, i.e.:

Greater choice in creatives.

Generally faster cure.

Generally shorter scorch time.

Lower curative level needs.

2. A higher tendancy for covulcanization with highly unsaturated rubbers.

In any particular application these differences will determine the preference for one halobutyl or the other, taking also into account the slightly higher polymer cost of bromobutyl. Most cure systems used for chlorobutyl vulcanization can be applied to bromobutyl. Usually an adjustment for scorch is required. In addition, due to its higher reactivity and its more versatile chemistry, bromobutyl can be cured with some chemicals which are inactive or less active with chlorobutyl. Table 4.1 summerizes the most common bromobutyl cure systems together with their cure characteristics and application areas. It should be emphasized that, in contrast to highly unsaturated rubber-sulfur cures, bromobutyl cures are generally accelerated by acids and usually result in very stable crosslinks.

Cure systems

Straight sulfur cure: Bromobutyl cure with sulfur as sole curative in the absence of zinc oxide. This cure, which is more academic than practical interest, is retarted by phenolic antioxidents, pointing to a redical reaction mechanism. It also shows how efficiently bromobutyl uses the sulfur atom, which partially explains its enhanced co-vulcanizability with high unsaturation rubbers.

Zinc-free cures: Zinc-free compounds are are required in some special pharmaceutical closures applications. Bromobutyl is capable of vulcanizing without zinc oxide or any other zinc salt. Preferred curatives are diamines such as hexamethylenediamine carbamate.

Peroxide cures: Although butyl polymers undergo molecular weight breakdownunder the influence of peroxides, chlorobutyl and more so bromobutyl, are capable of crosslinking with peroxides; a good combination is dicumylperoxide and a bismaleimide (HVA-2) as coagent. However, further studies have shown that bromobutyl cures with HVA-2 alone without peroxide, giving low compression set and extremely high heat resistance.

Applications

Tireinnerliners: Because of its low permeability to gas and moisture vapor and its ability to adhere to high unsaturation rubber, bromobutyl is generally the preferred choice for 100 % halobutyl innerliner formulations in tubeless tires. Over 80 % of the total bromobutyl production is currently used in tire innerliners. Its use is mainly in truck tires, which require the highest quality because of their severe service conditions, but its use in passengers tires in 100 % halobutyl compositions is also gaining importance and growing rapidly. A high-quality halobutyl innerliner maintains the tire inflation pressure better, with subsequent improvements in rolling resistance, tread abrasion, tire duration and, most importantly safety.

Radial-tire black sidewalls: Critical properties for black sidewalls on redial passenger-car tires are dynamic ozone and flex resistance for the life of the tire. Also retention of the black color and serviceable adhesion to adjoining general purpose rubber components are essential. Common naturam rubber/polybutadiene sidewall compounds depend on antiozonants to obtain the required ozone resistance. These molecules, however, are generally discoloring, staining and toxic. Compounds based on blends of bromobutyl (at approximately 45 parts) with EPDM (approximately 10 parts) and natural rubber do not require the use of these protective agents, and therefore avoid the drawbacks of general-purpose rubber sidewall compounds. Indeed, they are nonstaining and nondiscoloring since the protection is inherent in the polymer system.

Pharmaceutical closures: Butyl and halobutyl rubbers are extensively used in the pharmaceutical closure field because of their inherent properties:

Low permeability, Resistance to heat, UV, and ozone, Chemical/biological inertness, "Pure", nontoxic vulcanization systems. While butyl still requires sulfur for vulcanization, halobutyl can be cured with sulfurless cure systems, resulting in very low extractables. Bromobutyl has advantage of being vulcanizable without zinc, which is useful for some special closure types.

Heat-resistance coveyor belt: Several types of rubber are used for heat-resistant conveyor-belt cover and skim compounds: resin-cured butyl, chlorobutyl, EPDM and SBR. Bromobutyl gives the best compromise between heat-resistance and

adhesion to textile. Moreover, it generally cures faster than the other rubbers.

Other applications: Other applications are possible with bromobutyl, taking advantage of the wide spectrum of properties of this polymer. Examples are:

Chemical resistance tank linings: Curable contact cements to rubber-to-rubber adhesion. Applications such as sheeting, tank-linings, adhesives, where room temperature cures are required.

Bromobutyl vs. Butyl/chlorobutyl rubber

Bromobutyl rubber is a butyl rubber derivative obtained by reacting butyl rubber with bromine. It has increased cure reactivity, higher compatibility with unsaturated polymers and enhanced adhesion compared to butyl rubber. Bromobutyl rubber is a butyl rubber derivative obtained by reacting butyl rubber with the halogen bromine. Many of the properties of halobutyl vulcanizates are virtually identical, regardless of the halogen employed. With bromine, however, the cure sites in the polymer chain are more reactive, resulting in faster cures and better adhesion to unsaturated rubbers.

3. POLYLEFIN ELASTOMERS (POEs)

Polyolefin elastomers (or POEs) are a relatively new class of polymers that emerged with recent advances in metallocene polymerization catalysts. Representing one of the fastest growing synthetic polymers, POE's can be substituted for a number of generic polymers including ethylene propylene rubbers (EPR or EPDM), ethylene vinyl acetate (EVA), styrene-block copolymers (SBCs), and poly vinyl chloride (PVC). POEs are compatible with most olefinic materials, are an excellent impact modifier for plastics, and offer unique performance capabilities for compounded products. In less than a decade, POE's have emerged as a leading material for automotive exterior and interior applications (primarily in thermoplastic olefins [TPOs] via impact modification of polypropylene), wire and cable, extruded and molded goods, film applications, medical goods, adhesives, footwear. Polyolefin elastomers can be divided into two major categories. The first type is a two-phase polymer system consisting of a thermoplastic matrix, such as polypropylene or polyethylene, with a dispersed second phase of an unvulcanized rubber, such as EPDM, natural rubber and SBR. Hercuprene is an example of this type of polyolefin elastomer. The second category is a family of ethylene-octene copolymers. They are produced by DuPont Dow Elastomers via a proprietary polymerization technique and marketed while long chain structure provides ease of processing. Thus it dislinks the performance and processibility. Polyolefin plastomers are versatile polymers that offer excellent adhesion at high and low temperatures, outstanding processability, and superior levels of performance in packaging and other applications. Designed to optimize processing and end-use performance.

under the trade name Engage. These systems can be vulcanized using peroxides, silanes or irradiation to yield improved high temperature properties. Most commercially available POEs are copolymers of either ethylene-butene (EB) or ethylene-octene (EO). Metallocene poly(ethylene)s (mPE-LLD) are linear low-density poly(ethylene)s that result from the polymerization with metallocene catalysts such as Cp2ZrCl2. These catalysts posses only one type of catalytic centre, the polymers are therefore also called single site catalyzed PEs. The polymers have the same composition as regular LLDPEs but different sequence statistics.

$$\sim\sim\sim(CH_2\text{-}CH_2)\text{-}CH\text{-}CH_2\text{---}(CH_2\text{-}CH_2)\sim\sim\sim$$
$$|$$
$$CH_2$$
$$|$$
$$CH_3$$
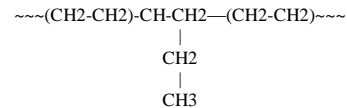
Structure of ethylene –butene elastomer

mPE-LLD with 10-20% 1-octene as comonomer are marketed as polyolefin plastomers (POP), those with ≥24% 1-octene as elastomeric poly(ethylene)s or poly(olefin) elastomers (POE). Today, wide arrays of products are available with properties ranging from amorphous to crystalline, and low to very high molecular weight.

POEs are often chosen over alternatives because they are:

• Suited for thermoplastic or thermoset (peroxide or moisture-cure) applications, either as the main polymer or as a value-enhancing ingredient in compound formulations,

• In pellet-form for use in both batch and continuous compounding operations,

• Providing superior elasticity, toughness and low temperature ductility,

• Polyolefin elastomers offer a unique combination of flexibility and toughness, making them a material of choice for a wide variety of applications.

• Saturated polymers providing excellent thermal stability and UV resistance, and

• Recyclable.

POEs are being adopted in a variety of applications and markets resulting in global demand approaching 200 metric tons since their inception in the early 1990s. This volume should double by the mid-2000s with increasing demand and projected production expansion. The narrow molecular weight of POE provides better rheological behavior, better dispersion and faster mixing, stiffness & toughness

4. BIIR/POE Blend

This development in the area of butyl rubber/POE blend can give the more advantageous characteristics of the presently available butyl compound without compromising the processibility characteristics of parent compound at moderate cost. Thus the modified form of butyl can have a set of more desirable properties and therefore it may be used more advantageously. Here is the example of inner liner application

of BIIR/POE blend: **A**ir inside the tire is 21% Oxygen, O_2. O_2 is the enemy of rubber as it causes degradation and loss in physical properties. **I**t can result in property degradation and a belt-to-belt separation. **U**se of bromobutyl rubber provides the required O_2 barrier properties. **NR** is added to this compound to improve physical properties and adhesion and to lower the overall cost, viscosity , wax content. **Challenges of High Bromobutyl Content:** reduced tensile strength, reduced adhesion to carcass , **d**ifficult processing, **I**ncreased cost. **Benefites of POE in innerliner**: Reduced gas permeability at good physical properties, easy processing & handling. good adhesion properties, **Benefites of POE in innerliner**: Reduced gas permeability at good physical properties. easy processing & handling. good adhesion properties.

5. Experimental work

| Batch	A1	A2	A3
BIIR (gm)	100	100	100
POE (gm)	5	10	15
ZnO (gm)	2	2	2
MBTS (gm)	1	1	1
Sulfur (gm)	2	2	2

Bromobutyl rubber & POE are processed in two roll mill at 85-90^{0}C followed by compression moulding. Hand operated compression molding is used. Molding temperature is 155^{0}C and time required is 5 min. Following batches are prepared to predict the effect of incorporation of POE into BIIR on tensile properties of BIIR. Exxon 2244 and DOW 8999 grades are used for BIIR and POE. MBTS (2,2'-Dithiobisbenzothiazole Disulfide), ZnO (Zinc oxide) and S (sulfur) are used as curing agents.

6. Result and Discussion

POE incorporationupto 10% by weight into BIIR enhance the performance which is equivalent to enhanced performance due to natural rubber. Furthermore it can be examined from the experiment that the processability will also increase without incorporation of oil into BIIR. This facilitates the elimination of plasticizers, generally petroleum oils, which are generally added to have ease of processing and flexibility. Furthermore cost of petroleum oils increases rapidly now-a-days. So the blend can be proved economically beneficial too. However, research is being carried out in the direction of this innovative blend and only further tests and analysis can present actual benefits of the blend.

BATCH	A-1	A-2	A-3
Thickness (cm)	0.224	0.262	0.205
Area (cm^2)	0.134	0.157	0.123
Load peak (N)	4.215	12.216	4.966

Tensile strength (N/cm^2)		31.362	77.711	40.374
modulus	100%	4.550	3.902	4.220
	200%	6.375	5.557	4.573
	300%	8.949	7.911	10.622
Elongation at break		708.814	819.133	672.941
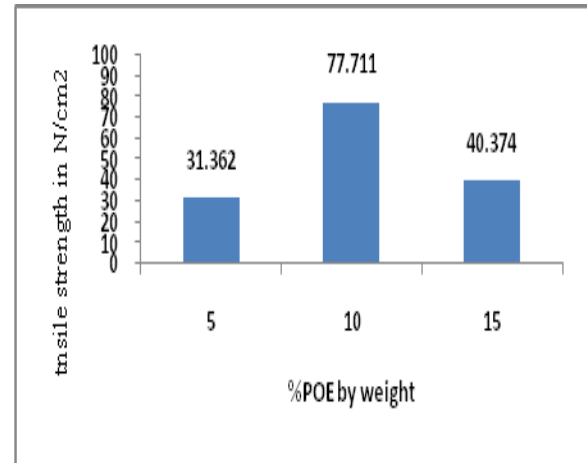
7. Conclusion

The blend of BIIR and POE can be proved excellent polymer material for various industries as it provides both processability and performance. Also it would be cost effective as it replace conventional elastomers and plasticizers as discussed in example of tire innerliner.

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