Inner Tube of AL-Diwanyia Tyre Based on Natural Rubber Blends

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Abstract

Most tubes are made from butyl rubbers, but certain types, such as giant tubes, are based on natural rubber because very high green strength is required when handling the uncured compound. By using blends of natural rubber (NR) and brominated butyl rubber (BIIR), it is possible to maintain high green strength in the uncured compound and improve impermeability and heat resistance of the cured tube.

The best formulations are obtained in the presence of 50 phr of (BIIR) to achieve desired mechanical properties. Improved impermeability was obtained by using 50 and 75 phr of (BIIR) rubber in compounds. Blending of brominated butyl rubber (BIIR) with natural rubber (NR) enhances air retention with acceptable sacrifices in green strength.

When using blends of natural rubber and brominated butyl rubber it is necessary to reduce the sulfur as the brominated butyl rubber (BIIR) content is increased.

Introduction

The use of halogens to modify polymers has fascinated research workers from the earliest days of the rubber industry. The utility of halogenation was first realized when chlorinated natural rubber was developed, followed by the introduction of neoprene by Du Pont[1].

A wide range of polymers, involving either halogenation of the monomer prior to polymerization or of the polymer after polymerization, was developed and introduced to the rubber and plastics industry. Included are fluoroelastomers, chlorinated polyethylene, chlorosulphonated, chlorinated butyl and, more recently, brominated butyl rubber[2].

Despite its early limitations, brominated butyl rubber offered some potential advantages over chlorinated butyl rubber in cure rate and adhesion. Polysar limited concentrated research and development effort towards developing a continuous solution process by which a highly stable and uniform brominated butyl rubber could be manufactured on a large scale. The result was the construction and bringing on stream of the first commercial brominated butyl rubber plant[3].

In this paper we have studied the synthesis giant tubes by using blends of natural rubber (NR) and brominated butyl rubber (BIIR). High green strength in the uncured compound , impermeability and heat resistance of the cured tube were improved by using brominated butyl rubber.

Experimental

Materials

The polymers used as a matrix in this study are NR (SMR 20), and polysar bromobuty X2.The tetramethylthiuram disulfide was used as accelerator and sulfur donor.

Preparation of the Rubber Compounds

Four rubber compounds with different loading amounts of bromobutyl rubber were prepared. For rubber compounding, we used a laboratory mill, rolls dimensions are outside diameter 150mm, working distance 300mm, speed of the slow roll 24 rpm and gear ratio 1.4. Compound recipes are summarized in Table (1). After mixing, the compounds were carefully remilled into flat sheets on a two-roll mill.Rheocurves were recorded by using a Monsanto Rheometer ODR 2000 at 160 °C. The t90 time, which denotes the time for 90% cure.

Permeability was recorded by using Constant Volume Method. The constant volume for the measurement of permeability is covered by ISO 1399. The apparatus consists of a metal cell having two cavities separated by the test piece. The high-pressure cavity is filled with the test gas at the required pressure, which must be measured to an accuracy of 1%. The low-pressure side is connected to a pressure measuring device, usually capillary U tube manometer with an adjustable height reservoir. The test cell must be maintained to within±0.5°C of the required temperature because the permeability of gasses extremely sensitive to temperature.

The test piece is a disk between 50 min and 65 mm diameter and 0.25 mm to 3 mm thick, with a free testing surface of 8 to 16 cm^2. After the cell and test piece were assembled the high pressure side is filled with gas at the test pressure. The increase in pressure on the low pressure side is then measured as a function of time, the manometer being adjusted to ensure that the measurements are taken at constant volume. Steady state conditions are indicated by a linear relationship between pressure changed and time and may take at least an hour to be established.

Shore A hardness was measured at room temperature by using a Zwick duromatic.

Tensile properties were determined by a tensile tester (tensometer 10) according to ASTM D-412 .

Results and Discussion

Cure properties

The levels of the three ingredients (sulfur, zinc oxide, dibenzothiozoledisuphide [MBTS]) used to play a significant role in optimizing heat resistance and set (or growth) of tubes operating at service temperature. Zinc oxide plus minor amounts of accelerator is the proffered curing system. With zinc oxide, the choice of MBTS determines the balance of heat resistance, scorch, and cure times. By adjusting accelerator (MBTS), it possible to keep cure time constant and vary the scorch time to suit given factory process conditions[4]. See Table (2)

Tetramethylthiuram disulfide was used very successfully as the accelerator and sulfur donor to provide good balance of scorch safety and better heat resistance.

When using blends of natural rubber level as the brominated butyl it is necessary to reduce the sulfur level as the brominated content is increased. Because it exhibits reversion and has only fair heat aging behavior[5].

Physical Properties of Inner Tube Compound Containing Bromobutyl Rubber

Bromobutyl rubber can be blended with natural rubber in all proportions to obtain desired compound properties[6]. Physical properties data of inner tube compounds are shown in Table (3). Inspection of the data shows large variations in many of the properties. In particular, tensile strength (18.8-12.0 MPa), elongation at break (510-600%) and tear strength (51-37 KN/m) values vary widely. Tensile strength values are lowest for those compounds having high bromobutyl content; this is associated with the tendency of natural rubber to form crystallites when it is strained. See compounds 3 and 4. However, elongation at break values are highest for those compounds having high contents of bromobutyl, see compounds 3and 4. Tear strength values are highest for those compounds having high content of NR see compounds 1 and 2. Bromobutyl rubber in blends with NR in inner tube compounds shows improvement in the air retention for compounds having high content of bromobutyl.

Impermeability

A fundamental requirement of a tire inner liner is to minimize intra-carcass pressure build up, thus minimizing the danger of belt or ply separations[7].

To minimize intra-carcass pressure, the liner should be compounded to have very low permeability, mainly by the choice of polymer, with black and oil levels in the compound having a lesser effect. For optimum Impermeability, the bromobutyl content should be as high as possible; carbon black level should be high, but at a level that will ensure reasonably low modulus and good flex properties. While oil, which increases permeability, should be kept as low as possible[8]. The effect of brominated butyl content on permeability is shown in Table (3).

Conclusions

Bromobutyl rubber can be used to improve the gas impermeability, energy absorption, resistance to heat, weather, and various chemicals. At the same time, natural rubber provides the properties in a brmobutyl compound mainly, higher green strength and tack; higher tensile properties; higher cured adhesion to NR compounds when using blends of natural rubber and brominated butyl rubber it is necessary to reduce the sulfur as the brominated butyl rubber (BIIR) content is increased.

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Table(1):Recipes of inner tube compounds with various bromobutyl loading

Ingredients	1	2	3	4
	Phr	phr	phr	phr
NR	100	75	50	25
Polysar Bromobutyl X2	-	25	50	75
Zinc oxide	4	4	4	4
Stearic acid	2	2	2	2
Sulfur	-	1.1	0.55	0.55
MBTS	4	4	4	4
TMTD	1.5	0.5	0.2	0.2
Treated whiting	12.5	12.5	12.5	12.5
Paraffinic oil	10	17.5	17.5	17.5
SRF N774	40	60	60	60

Table(2): Inner tube compounds cure properties

Compound	1	2	3	4
TS2[a], min.	6.5	6.3	7.5	7.8
T90[b], min.	4	6	8	8

a Time required for 2% cure .

b Time required for 90% cure.

Table(3):Effect of inner tube compounds with various bromobutl loading on physical properties

Compound	1	2	3	4
Hardness, Shore	53	53	52	49
Elongation, %	510	510	550	600
Tensile strength, Mpa	18.8	15.5	13.4	12.0
300 % modulus, Mpa	1390	1100	890	770
Tear strength (KN/m)	51	40	40	37
Permeability to air ($m^2/s.pa$)	9×10^{-17}	11×10^{-17}	13×10^{-17}	14×10^{-17}

ألأنبوب الداخلي لإطار الديوانية المعتمد على مزائج المطاط الطبيعي

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الخلاصة

يتم تصنيع معظم الأنابيب المطاطية من مطاط البيوتيل، ولكن بعض الأنواع مثل الأنابيب ذي الأحجام الكبيرة تعتمد على المطاط الطبيعي وذلك لان القوة الخضراء العالية (green strength) تكون مطلوبة عند معاملة الخلطة غير المفلكنة. وعند استعمال مزائج من المطاط الطبيعي (NR) والبيوتيل البرومي (BIIR) وجد أنه من الممكن الحصول على القوة الخضراء العالية في الخلطة غير المفلكنة وتحسين عدم النفاذية ومقاومة الحرارة للأنبوب غير المفلكن.ويمكن الحصول على افضل الصيغ بوجود 50 phr من مطاط (BIIR) للحصول على الخواص الميكانيكية المرغوبة. كما تم تحسين عدم النفاذية باستخدام 50 و 75 phr من مطاط البيوتيل البرومي (BIIR) في العجنات. ومن جهة أخرى يؤدي مزج (BIIR) مع المطاط الطبيعي (NR) إلى تحسين الاحتفاظ بالهواء مع تضحيات مقبولة في القوة الخضراء.من الضروري عند استعمال مزائج من المطاط الطبيعي (NR) مع البيوتيل البرومي (BIIR) تخفيض الكبريت كلما ازداد محتوى البيوتيل البرومي (BIIR) .