Ebonite Linings Based on Natural and Synthetic Rubber

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Abstract

The corrosion of metals is of great economic importance. Estimates show that the quarter of the iron and the steel produced is destroyed in this way. Rubber lining has been used for severe corrosion protection because NR and certain synthetic rubbers have a basic resistance to the very corrosive chemicals particularly acids.

The present work includes producing ebonite from both natural and synthetic rubbers ; therefore, the following materials were chosen to produce ebonite rubber:

a) Natural rubber (NR).
b) Styrene butadiene rubber (SBR).
c) Nitrile rubber (NBR).
d) Neoprene rubber (CR) [WRT].

The best ebonite vulcanizates are obtained in the presence of 30 Pphr sulfur, and carbon black as reinforcing filler. The relation between the types of rubbers used alone or as blends was investigated and optimum formulations have been achieved.

Blending of NR with SBR, NBR, and WRT enhances the mechanical properties. For the blend of NBR and SBR, the mechanical properties are enhanced with increasing the proportion of SBR in the blend. Blends of WRT with NR, SBR, and NBR enhance the mechanical properties of WRT compounds.

The effect of chemical resistance on rubbers and blends were also studied.

Introduction

The interest in the resistance of elastomers to acids lies in the volume changes that occur with time and temperature, the change in physical properties as the rubber absorbs acids acquire low temperature flexibility(1).

It is very important that polymeric materials should not interact with medium during service. Evidently, this can be achieved by using strong polar polymers in non-polar media, or non-polar polymers in polar media(2).

An important characteristic of polymers (plastic or rubber) is their stability to attack by various aggressive media, such as mineral acids(3).

The solubility parameter concept provides a useful approach to decide on the compatibility of elastomer with liquids. However, this is by no means the whole history because chemical changes, chemical reactions, and hydrogen bonding in the elastomer or liquid can override the simple solubility parameter value. In general the rate of attack of polymer molecule by a corrosion depends on the rate of diffusion of the attacking molecule, and the temperature(4). Polymers are more readily attacked by corrosives at the temperatures above the glass transition temperature (Tg) and when stiffening groups are not present in the polymer molecule, crystalline polymers has more resistance to liquids than amorphousnness(5). Selecting materials to contain corrosive products in industrial operations is a substantial engineering problem, particularly where the materials must withstand attack from a combination of environmental influences. Such a combination might include, for instance, the presence of harshly acidic chemicals, acid condensate, high temperature, and a flow of abrasive particles. In such an environment, few materials have the combination of resistance properties to hold up successfully(6). Among the materials that are considered in severe service environments are stainless steel, and carbon steel lined with a variety of systems: organic resins such as epoxies, polyesters, and vinyl esters; sheet and liquid-applied elastomers; and inorganic materials such as alkali silicate cementitious monolithic and glass block(7). When lined carbon steel is used, the choice of the lining system depends upon a careful study of the process and environmental influences together with an evaluation of the resistance properties of candidate materials. One material that deserves attention in this selection process is sheet-applied elastomers or linings(8).

The corrosion of metal is of great economic importance. Estimates show that a quarter of all the iron and steel produced is destroyed in this way. The prevention of corrosion damage is therefore an economic necessity. It is believed that the existing installations of the chemical industry, in which a great variety of corrosion problems is encountered, would decline in value at a rate of about 1.5% a year if nothing were done to prevent corrosion(9). It follows that no industry in which corrosion problems are encountered can afford to ignore the exceptional economic advantages which result from the protection of plant and equipment through the use of rubber linings.

Because they have good resistance to corrosion, rubber linings are being used in conjunction with the conventional plant and pipeline materials to form combinations which are inexpensive, easy to handle, and have unsurpassed service properties, and which are therefore particularly suitable for chemical process plant[10]. Rubber has been the classical lining material for many decades and it still accounts for the bulk of the consumption of organic lining materials. It follows that no industry in which corrosion problems are encountered can afford to ignore the exceptional economic advanatages which result from the protection of plant and equipment through the use of rubber linings(11).

In this paper, the rubbers used consist of Natural rubber (NR), Styrene butadiene rubber (SBR), Nitrile rubber (NBR), and Chloroprene rubber (WRT). The hardening agent used consist of sulfur. The relation between the types of rubbers used either alone or as blends was studied, and the resistance of phosphoric acid and potassium hydroxide solution were measured.

Experimental

Materials

The polymers used as matrix in this study are NR (SMR 20), SBR 15002, NBR (KOS YN KNB 35L), and Chloroprene rubber-non sulfur modified (WRT). The high abrasion-low structure (HAF-LS-N326) was used as filler. Phosphoric acid (50 and 70 % concentration), and potassium hydroxide (5 and 70 % concentration) are used.

Sample Preparation

For rubber compounding, the recipes were prepared on a two-roll mill: rolls dimensions are: outside diameter 150 mm, working distance 300 mm, speed of the slow roll 24 rpm and gear ratio 1.4. Curing was carried out at a temperature of 160 C°, curing time was 45 minutes for rubber compounds. Compounds recipes are summarized in table 1.

The hardness of vulcanizates was measured using a Shore D durometer according to ASTM D-2240; tensile properties were determined by a tensile tester (Tensometer). Compression set was measured according to ISO 1653 at ambient temperature.

Preparation of Vulcanized Rubber Specimens for Acid Resistance

Standard rubber specimens of rectangular dimensions 25 by 50 by 2.0± 0.1 mm were cut from the acetone-extracted dried rubber sheet.

Two samples of each vulcanized were immersed in 10 ml of liquid at fixed temperature for 96 hours, measurements were made at room temperature and at 70 C°.

After the immersion test has proceeded for the required length of time, the tested specimens were removed. For a sample that was immersed at an elevated temperature, the test specimens were cooled to room temperature by transferring them to a cool clean portion of the test liquid for 30 minutes. The cooled test specimens were dipped quickly into acetone, bolt light with fitter paper free of lint and foreign materials, and placed immediately in a tarred stoppered weighting bottles.

The mass after test was then determined. After weighting, the test specimens were again immersed in the test liquid to collect data on the progressive change, which occur with increasing time of immersion.

Any change in weight was calculated as percentage change of the original specimen weight.

Results and Discussion

Effect of Base Rubbers on Properties of Ebonite

Table (2) shows that mechanical properties for formula based on SBR alone or NBR alone is higher than those based on NR alone and WRT alone or based on blends of SBR and NR formula or blends of SBR with NBR, WRT as well as blends of NBR with WRT.

Synthetic rubbers with butadiene as one of their constituents reacts with sulfur to saturation from $(C_4H_8S)_n$, instead of 32 wt% with NR which corresponds to 37 wt% combined sulfur ,i.e., to a vulcanization coefficient 59.5 sulfur. In practice, sulfur rates both higher and lower than those calculated above are employed to produce specific strength.

Nitrile rubbers are compounded in much the same way as cured natural rubber or SBR. The results in table (2) show that in reinforced NBR vulcanizates, the tear strength is higher than for NR compounds, the fall off with higher rates of deformation and at higher temperatures is less than that for NR (see compounds 3and 10).

Blends of NBR with SBR results in improved tensile strength, and tear strength when the content of SBR was increased (see compound 8).

Blends of SBR and NBR with neoprene give rise to high tensile strength, tear strength, hardness, and low elongation as the content of SBR and NBR were increased (see compounds 9 and 10).

Chemical Resistance to Phosphoric Acid

It is very important that polymeric materials should not interact with the medium during service. Evidently this can be achieved by using strongly polar polymers in non-polar media, or non-polar polymers in polar media.

An important characteristic of polymers (plastic or rubber), is their stability to attack by various aggressive media, such as mineral acids, this is of great practical imoortance[5].

Lining by four types of rubbers and their blends show good resistance to acid, caustic potassium, at temperature up to 70 C°, they are exceptionally resistance to diffusion. The minimum thickness of the lining is usually 3mm for hard rubbers. We have made more concentration on testing resistance for phosphoric acid and potassium hydroxide. Which were carried out in two ways:

a) for 96 hrs at 70 C°
b) for 96 hrs at room temperature

The first route is followed for concentrated 50% and 70% from phosphoric acid,
and the second rout is considered on using:

i) 5% KOH

ii) 70% KOH

Table 3 indicates the resistance of the main lining materials to phosphoric acid and states the temperature to which these data apply.

As can be seen the resistance of vulcanizates to chemicals, is good and products have found particular applications where there is contact with acids such as phosphoric acid.

The table 3 which gives the weight increase or decrease of different vulcaniztes percentages show in change in weight for vulcanizates dipped in concentrated phosphoric acid at 70 C° for 96 hours does not change over 4.9%. This value corresponds to excellent chemical resistance(12).

Since maximum chemical resistance for specially rubber is allowed to 10% change in weight according to their resistance to phosphoric acid, the tested rubber materials can be arranged in the following order.

WRT>WRT/SBR>WRT/NBR>WRT/NR>SBR>SBR/NBR>
SBR/NR>NBR>NBR/NR>NR

As can be calculated from numerating data in table 3. WRT, WRT/SBR, WRT/NBR, and WRT/NR blends have the strongest resistance to phosphoric acid. NR and NBR/NR blend has conditionally resistant. SBR, NBR, SBR/NBR, and SBR/NR blends have resistance to phosphoric acid which is in between the two types.

Polychloroprene rubber contains halogen, which has a strong negative inductive effect. It makes the double bonds remain inactive, that is why neoprene is more resistant to O_2, O_3 and resists oxidizing power of phosphoric acid more than diene rubbers.

Chemical Resistance to Potassium Hydroxide

Samples from NR, SBR, NBR, WRT, NR/WRT, NR/SBR, NR/NBR, SBR/NBR, SBR/WRT, and NBR/WRT were subjected to 5% and 70% potassium hydroxide for 96 hours at 70 C° and room temperature. Results are given in table 3.

A well-known fact is that carbon bonds with O_2, S, N_2 are readily cleaved by acids, basis and other corrosive materials compared with carbon-carbon bonds, since most of these corrosive materials are ionic and / or highly polar in nature(7). Since rubber chains are mostly built up from homochain carbon skeleton, it is easy to identify their stability against normal common chemicals.

According to chemical resistance obtained in the presence of different rubbers and blends, the chemical resistance order can be written as follows:-

WRT>WRT/SBR>WRT/NBR>WRT/NR>SBR>SBR/NBR>

SBR/NR>NBR>NBR/NR>NR

Conclusions

1. Compounds based on SBR alone give rise to higher tensile strength, and tear strength than those based on NR, NBR, and WRT alone or based on blends of NR/SBR, NR/NBR, NR/WRT, SBR/NBR, SBR/WRT, and NBR/WRT.
2. Blending SBR with NR, NBR, and WRT gives rise to higher tensile strength and tear strength as the content of SBR is increased. Ebonite based on nitrile rubber gives rise to higher hardness than those based on SBR,NR or WRT.
3. Ebonite based on neoprene shows lower mechanical properties than NR, SBR, NBR, and NBR. Blending of WRT with NR, SBR, and NBR gives rise to higher mechanical properties as the contents of NR, SBR, and NBR are increased.
4. WRT, WRT/SBR, WRT/NBR, and WRT/NR blends have the strongest resistance to phosphoric acid. NR and NBR/NR blend has conditionally resistant. SBR, NBR, SBR/NBR, and SBR/NR blends have resistance to phosphoric acid and potassium hydroxide which is in between the two types.

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Table(1)Recipes of Rubber Compounds

Compounds	1	2	3	4	5	6	7	8	9	10
NR	100				50	50	50	-	-	-
SBR		100			50	-	-	50	50	-
NBR			100		-	50	-	50	-	50
WRT				100	-	-	50	-	50	50
Zinc oxide	4	4	4	4	4	4	4	4	4	4
Stearic acid	2	2	2	2	2	2	2	2	2	2
Sulfur	30	30	30	30	30	30	30	30	30	30
DPG[a]	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
MBTS[b]	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	1
6PPD[c]	1	1	1	1	1	1	1	1	1	1
Aromatic oil	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
HAFN326	60	60	60	60	60	60	60	60	60	60

a DPG is diphenyl guanidine
b 2.2-dibenzothiazyle disulphide
c N-(1,3- dimethylbutyl)-N-phenyl-p-phenylenediamine

Table (2)Effect of Base Rubbers on Mechanical Properties of Ebonite

Compounds	1	2	3	4	5	6	7	8	9	10
Hardness Shore D	81	83	85	54	82	83	67	84	68	70
Elongation %	6	-	1	40	3	4	23	1	5	6
Tensile strength, Mpa	28.462	32.303	30.955	14.703	30.382	29.7008	21.582	31.654	23.503	22.82
100% modulus, Mpa	-	-	-	-	-	-	-	-	-	-
Tear strength, Mpa	7.321	8.563	7.526	2.172	7.942	7.423	4.746	8.044	5.41	4.172
Compression set%	0.353	0.334	0.213	.1.027	0.343	0.283	0.690	0.275	0.680	0.62

Table (3)Chemical Resistance of Vulcanizates Based on Natural and Synthetic Rubbers

Chemicals	Concentration %	Temperature C°	NR	SBR	NBR	WRT	NR/SBR	NR/NBR	NR/WRT	SBR/NBR	SBR/WRT	NBR/ WRT
Phosphoric acid	50	RT	O	+	+	E	+	O	E	+	E	E
		70	-	+	+	E	+	O	E	+	E	E
	70	RT	-	+	+	E	+	-	E	+	E	E
		70	-	+	+	E	O	-	+	+	E	E
	5	RT	+	+	+	E	+	+	E	+	E	E
Potassium oxide		70	+	+	+	E	+	+	E	+	E	E
	70	RT	+	+	+	E	+	+	E	+	E	E
		70	+	+	+	E	+	+	E	+	E	E

E excellent resistant
+ resistant
o conditionally resistant
- not resistant

تبطينات الابونايت المعتمد على استخدام المطاط الطبيعي والمطاط الصناعي

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الخلاصة

إن لتآكل المعادن أهميه اقتصادية كبيرة . إذ تشير التقديرات إلى إن ربع الحديد والفولاذ المنتج يتعرض للدمار بالتآكل . ولهذا استخدمت بطانات المطاط لتوفير الحماية ضد التآكل الشديد . حيث يمتاز المطاط الطبيعي (NR) وبعض أنواع المطاط الصناعي بمقاومة جيدة للمواد الكيمائية المسببة للتآكل وخاصة الحوامض .

تتضمن هذه الدراسة إنتاج مطاط الابونايت من المطاط الطبيعي والصناعي ، وقد تم اختيار المواد الاتية لأنتاج مطاط الابونايت :

أ . المطاط الطبيعي (NR)

ب . مطاط ستيارين بيوتادبين (SBR)

ج . مطاط النترايل (NBR)

د . مطاط النيوبرين (CR) [WRT]

إن افضل المفلكنات الابونايت يتم الحصول عليها بوجود 30 Pphr من الكبريت واسود الكاربون كمالئ .وقد تم دراسة العلاقة بين نوع المطاط المستخدم لوحدة أو بشكل مزائج وتم الوصول إلى الصيغ المثلى لذلك . وجد إن مزج NR مع SBR، NBR و WRT يؤدي إلى تحسين الخواص الميكانيكية ، أما مزائج NBR و SBR فيتم تحسين خواصها الميكانيكية بزيادة نسبة SBR في الخلطة كما إن مزج WRT مع NR ، SBR ، NBR يحسن الخواص الميكانيكية لخلطات WRT .

فضلا" عن ذلك تضمنت الدراسة تأثير المقاومة الكيميائية على المطاط والمزائج