Epoxyprene - a specialty polymer

EPOXYPRENES are cis 1,4 – polyisoprenes with epoxide groups randomly dispersed along the polymer backbone . Two grades are available commercially from the manufactures Muang Mai Guthrie Public Company Limited of Thailand, *Epoxyprene 25* and *Epoxyprene 50*. indicating 25% and 50% epoxidation.

Epoxidation results in a systematic increase in the polarity and glass transition temperature ; these increase are reflected in the vulcanizate properrties. Property changes with increasing level of epoxidation include :

an increase in damping ;

a reduction in swelling in hydrocarbon oils ;

a decrease in gas permeability ;

an increase in absorption of microwave energy ;

an increase in silica reinforcement ;improved compatibility with polar polymers like polyvinyl chloride ;

reduced rolling resistance and increased wet grip.

The epoxidation process also reduces the level
Of protein inherent of the starting natural rubber.

Strength and fatigue properties of *Epoxyprenes* are still high because being stercoregular polymers.
Epoxyprenes are able to undergo strain crystallization.

The general properties of *Epoxyprenes* are shown in Table 1. *Epoxyprenes* exhibit a unique set of properties and should be considered where there are problems with current polymer usage of new specifications need to be met.

Processing

Generally processing characteristics are similar to those of a natural rubber and standard mix cycles may be employed. However, *Epoxyprenes* do mot need to be
premasticated even though their Mooney viscosities are high, as the breakdown on a mill or in an internal mixer is rapid. The rapid initial breakdown of *Eprxyprene* 25 leads
to easy dispersion of fillers and power savings. The slower subsequent breakdown rate enables mixes to be reworked without substantial changes in viscosity. The breakdown rate of *Epoxyprene* 50 is higher than that of *Epoxyprene* 25.

Table 1 : Typical properties of ***Epoxyprenes***.

Property	Epoxyprene25	Epoxyprene 50
Epoxide level, %	25 ± 2	50 ± 2
Glass transition temp C°	-47	-24
Density,Mg/m^3	0.97	1.02
Solubility parameter,(jm^3)$^{0.5}$	17.4	18.2
Lovibond colour	4.5	3.5
Mooney viscosity	70-90	70-90
ML(1+4),100 C°	80-100	80-100
Protein level,amg/g rubber	0.0008	0.0008
Latex allergen activity, [b] normalized unit	2 - 4	2 - 4

a. Lowry method used to measure protein levels. Protein levels of SMR CV and AMR 10 measured at <0.02 mg/g rubber.

b. RAST method used. Control samples : untreated gloves, 362: raw natural latex,100.

The high adhesion characteristics of ***Epoxyprenes*** can result in their compounds sticking to the rolls of mills under certain processing conditions. Such problems can be overcome by careful control of the mill temperature or by the simple addition of a process aid such as ***Struktol A60.***

Compounding

Epoxyprenes may be vulcanized in the usual manner applicable for unsaturated polymers. However, for best ageing resistance, the use of sulphur is recommended at 1.5 parts phr or lower. Hence, a semi EV or EV systems, sulphur donor or sulphurless formulations are normally used for ***Epoxyprenes***.[1] As with other rubbers, prevulcanization inhibitors can be used to extend processing safety.

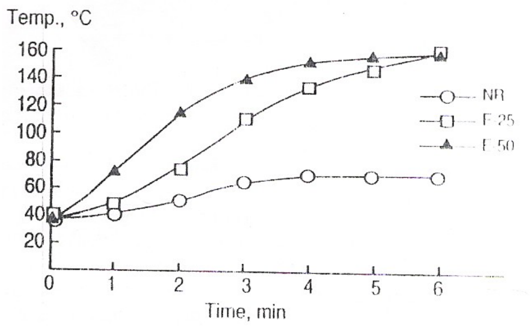
The principles of protection of unsaturated rubbers against oxidative ageing and ozone are applicablu to ***Epoxyprene***. In addition the sulphur acids produced by oxidation of the sulphur crosslinks may open the epoxides resulting in stiffening of vulcanizates. These acids are also produced in other sulphur crosslinked polymers but are not detrimental to properties. The addition of abase to ***Epoxyprene*** formulations neutralizes these sulphur acids and inhibits the stiffening of vulcanizates.

All ***Epoxyprene*** formulations should be compounded with a base, the preferred material being calcium stearate at a loading of 3 to 5 parts phr. This level of base lcads to substantial improvements in ageing resistance.

Table 2 : Physical properties of black and silica ***Epoxyprenes***

Filler (50 Parts phr) Polymer	N330 Black			Silica		
	NR	E-25	E-50	NR	E-25	E-50
Hardness,IRHD	65	69	73	65	67	68
Modulus at 300%,MPa	11.9	12.4	13.5	5.8	12.8	12.6
Tensile strength, MPa	29.5	25.5	24.5	23.5	21.0	27.5
Elongation at break, %	495	435	500	720	405	435
Compression set,25%,24b/70°C°,%	18	17	21	32	18	22
Akron abrasion,mm^3 / 500 rev	21	14	11	63	15	14
Goodrich HBU,°C	7	7	23	47	7	19
Dunlop resilience,% , 23 °C	66	49	31	68	51	38

Figure 1 *: Microwave energy absorption by Epoxyprenes*



Epoxyprenes respond to the addition of fillers in a similar manner to other rubbers with the exception of silicas. Here a high degree of reinforcement is observed in the absence of a coupling agent due to a specific interaction between the rubber and filler. Comparable vulcanizate properties are observed for black and silica filled vulcanizates (Table 2) without the addition of a silica coupling agent.

Epoxyprenes may be compression moulded, extruded and injection moulded employing standard formulations, particularly those associated with natural rubber.

Due to its polar nature, ***Epoxyprenes*** can be heated using microwave energy and have been used as additives to increase the microwave heating rate of non-polar polymers (Figure 1)

Properties/Applications

The properties of ***Epoxyprenes*** and hence, applications. are dominated by its ability to strain crystallize, its glass transition temperature and solubility parameter. Vulcanizates thus exhibit low

Figure 2 : *Air permeability rating at 23 °C*

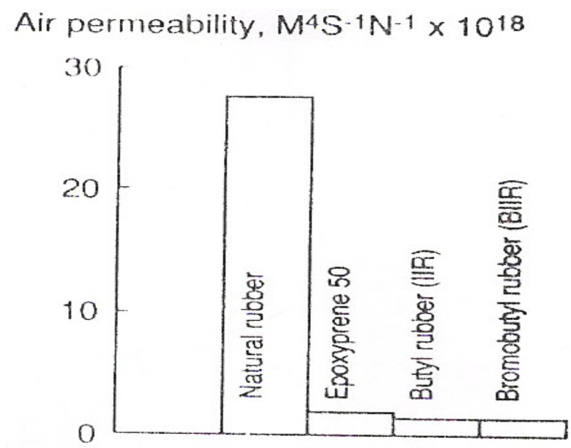
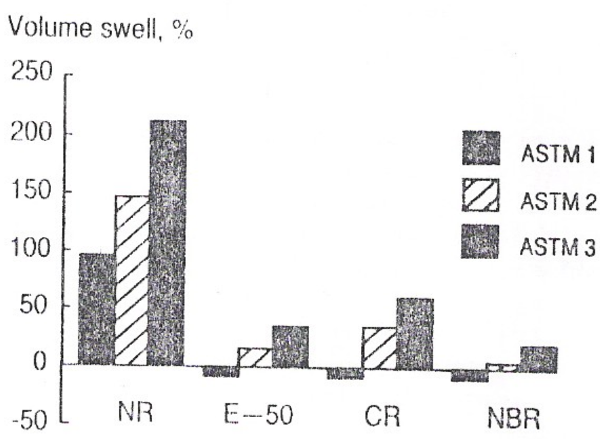
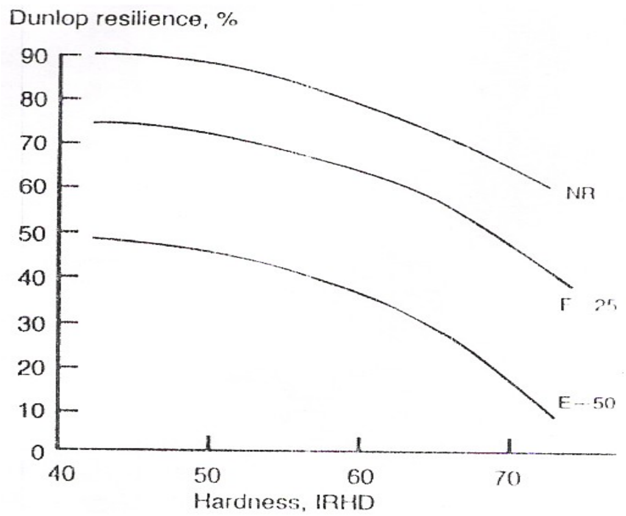


Figure 3 : *Oil resistance of some selected polymers.*



gas permeability (Figure 2) and high oil resistance (Figure3). ***Epoxyprenes*** are beneficial where these properties are required in combination with high tensile, fatigue or tear strengths, particularly when the use of reinforcing fillers is not practical.

Figure 4 ***: Relilience of natural rubber and Epoxyprens.***



Typical properties of black-and silica-filled (no coupling agent) ***Epoxyprene*** vulcanizates are recorded in Table2.

The good Akron abrasion resistance is indicative of the excellent wear resistance of ***Epoxyprene***-covered conveyor belts operating under severe conditions.

The glass transition temperature increases with epoxide content hence damping increases and resilience decreases. Typical resilience/hardness correlations for natural rubber, ***Epoxyprene 25*** and ***Epoxyprene 50*** are shown in Figure 4. Thus ***Epoxyprenes*** are used in antivibration mountings, surrounds for audio speakers, machinery, road vehicles and railway coaches. High damping is also advantageous in shock absorption, eg footwear components such as heel inserts or mid sole components. Acoustic devices such as constrained layer damping components have been constructed to reduce noise emission from vibrating pannels in machinery or automotive vehicles. [2]

A compatible blend with PVC can be used to further increase the damping of ***Epoxyprene 50*** ,with the additional advantage of enhancing ozone resistance.

As the damping is related to the glass transition temperature, the former is temperature dependent. However, a recently developed blend system based on ***Epoxyprene*** exhibits high damping characteristics over a wide temperature range.[3] This system has extensive applications.

Figure 5 :

Wet traction/rolling resistance properties of polymers containing 50 parts phu of filler. The higher the value the better property performance.(a) NR/black.(b) OESBR/black (c) ***Epoxyprene 25*** */ black. (d)* ***Epoxyprene 25****/silica.*

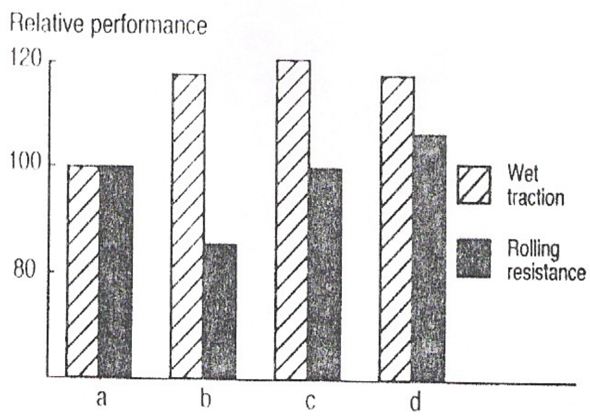
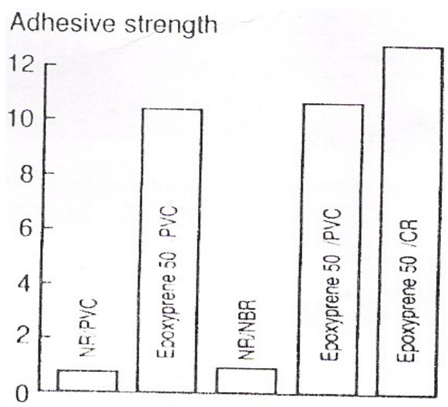


Figure 6 : *Cured adhesion of* ***Epoxyprene***



The high hysteresis of ***Epoxyprenes*** is also translated in high wet friction properties. ***Epoxyprene 25*** is an excellent tyre tread rubber as its hysteresis/temperature profile results in high wet traction and low rolling resistance, properties which are illustrated in Figure 5.

The solubility parameters and ability of ***Epoxyprene*** to exhibit specific interactions with chlorinated polymers, eg polychloroprene and polyvinyl chloride,results in excellent adhesive properties. ***Epoxyprenes*** are employed as primers, tie coats, sealants and bonding agents. The adhesion of

Epoxyprenes to a number of other polymers is shown in Figure 6.

Analysis of ***Epoxyprene*** samples by the Rubber Research Institute of Malaysia[4] showed negligible levels of water solution proteins present in the rubber (Table 1) Clinical test on allergenicity by the University of Finland. where the allergen activity lot all the samples was normalize talking the control (Natural rubber latex) as 100. indicated very lows allergernicity for the two ***Epoxyprene*** sample.

Epoxyprene's unique combination of desnable properties make it the preferred .special purpose polymer for a range of new applications of as an improvement over other polymers to enhance existing products.

References

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There are many potential applications for Epoxyprene,but this paper only presents the basic properties of these polymers and a limited number of applications More detailed information and technical advice and assistance in the use of Epoxyprenes in particular applications can be obtained from:

MUANG MAI GUTHRIE PUBLIC COMPANY LIMITED.