Ageing Behaviour of Epdm/Pvc Composites

C.P. Mohamed Kutty [1],O.P.Nasiya[1], M.Sunil Kumar[2],Muraleedharan Nair[3], M .Jahfar.[4]

[1]department of chemistry, psmo college, malappuram -676 306(kerala) india
[2] department of chemistry,national institute of technology,calicut(kerala) india
[3] deputy director, cfsc, manjeri, malappuram (kerala) india
[4]department of chemistry, farook college, calicut-673632(kerala) india

ABSTRACT

The effect of thermal and weather ageing on observed properties of the EPDM/PVC composites was compared by measuring changes in modulus,tensile strength ,tear strength and elongation at break.The elongation at break and tensile strenght of all samples decreased due to weathering.The morphology of the samples were studied to compliment the observations.The chemical resistance of the samples were also studied in acid and alkali solutions.It can be seen that the 100/10 sample has got the greatest resistance. The results indicate that incorporation of PVC has improved ageing behaviour significantly.

Key words*:* Polymer composites, effect of filler on ageing resistance

I. INTRODUCTION

Many types of thermoplastic elastomers are used in outdoor applications and a common concern of these materials is the durability of the materials in enduse applications[1]. During long periods of service, most of the polymer products gradually lose their properties due to the macromolecular chain degradation. Normally, polymers in the state of their end-use are not pure materials. In many cases there are added substances which alter the engineering and/or chemical properties of the polymer in a useful way. The polymer also may contain small amounts of monomer, entrapped during the polymerization process. Such additives and impurities may participate in the slow chemical degradation of the polymer and, of course, add to the general physical complexity of the polymer. If the polymer is attacked by the environment,the performance of the material in service will be adversely affected.Degardation of the performance of the polymer may lead to premature failure of the material,resulting in increased downtime for the system, and requiring costly maintenance procedures.The study of dimensional stability and mechanical properties of polymeric materi- rials under different environmental conditions such as humidity changes or changes in temperature, solvent, mechanical load, radiation, deserves much importance. This is because materials with superior ageing resistance can be satisfactory durable.

There exist a number of reports on ageing of polymers[2-6]. Harvey Alter examined [7] literature data for the effect of mineral fillers on the mechanical properties of polyethylene at two temperatures, styrene–butadiene rubber, and natural rubber were examined..

The objective of this study is to compare the weather,thermal and solvent resistance of EPDM/PVC cmposites and to compare the properties to those of the control samples.Also accelerated ageing and resistance to chemicals is also investigated.

II. MATERIAL AND METHODS

Ethylene propylene diene monomer (EPDM) [E/P ratio of 62/32 and a diene content of 3.92 % from Herdilla Unimers, New Mumbai]. Poly vinyl chloride (PVC) [from Sigma Aldrich]. The additives such as sulphur,Dicumyl peroxide , zinc oxide, stearic acid, and mercapto benzothiazyl disulphide (MBTS) used were of commercial grade.

The mixing of EPDM with PVC in different ratios was done on a two roll mixing mill Details of formulations are given in Table 1.The samples were compression moulded .

The samples for Field Emission Scanning Electron Microscopy (FESEM) were prepared by cryogenically fracturing them in liquid nitrogen.They were sputter coated with gold and morphology examination were performed on a scanning electron microscope (JEOL-JS IN-T330-A-SEM; ISS Group, Whittington, Manchester,U.K).

Accelerated ageing of the compression moulded specimens was carried out in an air-circulated ageing oven at 100^{o}C for three days. The ageing characteristics of the samples were studied by measuring the changes in different mechanical properties . The samples were exposed to natural weathering (all environmental effects such as rain, sunlight, wind etc) for a period of 4 months from August 2011 to November 2011.. Samples were collected to study of the effect of weathering. Scanning electron microscopy (SEM) on the surface of specimens before and after the exposure were carried out to study effect of natural weathering on structure and morphology.

The mechanical properties were also investigated. The samples were immersed in organic solvents like toluene, carbon tetra chloride and diesel for 24 hours, dried in an air oven for 24 hours and the mechanical properties determined.

The behavior against weathering conditions was studied by the swelling behavior in different solvents and chemical resistance behavior against acids and bases. Known weight (W_1)of the initial samples were immersed in 100 ml of different solvents and 10 %sodium chloride solution at room temperature for 7 days. The samples were filtered and the excess solvent was removed with the help of filter paper, patted dry with a lint free cloth and then final weight (W_f) was noted. The percent swelling was calculated from the increase in initial weight in the following manner.

$$\text{Percent swelling } (P_s) = \left[\frac{W_f - W_i}{W_i} \right] \text{ x } 100$$

For the chemical resistance test, the dried specimens were immersed in 100 ml of 1 N NaOH and 1N HCl for different intervals of time (22-144 hours).After this, the samples were filtered out, dried and weighed. The percent chemical resistance (P_{cr}) was calculated in terms of weight loss in the following manner:

$$\text{Percent chemical resistance } (P_{cr}) = \left[\frac{Wi - W_{aci}}{W_i} \right] \text{ x } 100$$

III. RESULTS AND DISCUSSION

Effect of thermal ageing on mechanical properties

Fig. 1 shows the tensile strenght of peroxide cured pure EPDM before and after thermal ageing at 100^{0}C for 3days .Fig. 2 shows the variation in tensile strenght of 100/2.5 EPDM/PVC after thermal aging for the same period.It can be seen that PVC loaded sample has more aging resistance than pure EPDM.

Effect of solvent swelling on mechanical properties

The retention of mechanical properties of the EPDM/PVC composites after immersing the samples in different solvents like aromatic,halogenated hydrocarbon and mixture of aliphatic hydrocarbons for 24 hours are given in the table 2.Among these solvents,the composite exhibits maximum aging resistance in Kerosene .

Swelling coefficient values

Swelling coefficient values of the 100/5 EPDM/PVC composite calculated in different solvents are given in table 3.

Effect of natural weathering on the mechanical properties

The effect of natural exposure of pure EPDM and 100/2.5 EPDM/PVC composite on tensile strenght are given in fig.3.The modulus of the tested samples has changed to a very small extent during the exposure period.The elongation of the composites decreased drastically in all the samples.Also tensile strenght of the composite samples decreased to some extent.

Effect of natural weathering on Morphology

Scanning Electron Micrograph is a reliable tool to monitor the surface changes during degradation of polymers. The presence of highly eroded surface with small cavities in the samples, indicates the higher degradation after 4 months exposure to natural weathering**.** From the SEM pictures in fig. 4, it is clear that the100/7.5 EPDM/PVC and 100/10 EPDM/PVC composites have undergone less degradation than pure EPDM.

Chemical resistance

The percentage chemical resistance (P_{cr}) of EPDM/PVC composites in water, saline water, IN HCl and IN NaOH after 30 days of exposure are given in table 4 and 5.The results indicate that the composite has high resistance toewards water and saline water.Also,the resistance increases with incorporation of PVC due to the chemical resistance of PVC.

IV. CONCLUSION

The effecet of thermal and weather ageing on observed properties of the EPDM/PVC composites was compared by measuring changes in modulus,tensile strenght and elongation at break. The morphology of the samples were studied to compliment the observations.The chemical resistance of the samples were also studied in acid ,alkali ,water and saline water solutions.The results indicate that incorporation of PVC into EPDM matrix can improve aging behaviour significantly.

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Table 1 Formulation of Mixes (phr)

Ingredient	Vulcanizing system	
	Sulphur	DCP
EPDM	100	100
PVC(varying amount)	(0,2.5,5,7.5,10)	(0,2.5,5,7.5,10)
Zinc oxide	4	--
Stearic acid	2	--
MBTS	1.5	--
Sulphur(varying amount)	(2,3)	--
Dicumyl peroxide	--	4

Table 2: Percentage retention of mechanical properties of 100/5 EPDM/PVC composite after immersion in solvents for 24 hours

Solvent	Tensile strenght	Young's modulus
Toluene	84	58
Carbon tetra chloride	78	68
Kerosen**e**	55	72

Table 3: Swelling coefficient values of sulphur cured 100/5 EPDM/PVC composite

Solvents	Swelling coefficient
Benzene	1.87
Carbon tetra chloride	2.9999
Diesel	0.0036

Table.4: Percentage chemical resistance of100/5 EPDM/PVC in water

Solvent	Pcr
Saline water	0.013
Water	0.017

Table 5: The percentage chemical resistance of EPDM/PVC composites in IN HCl and IN NaOH

Sample	P_{cr} in (HCl)	P_{cr} in (NaOH)
100/0 EPDM/PVC	0.761	1.393
100/2.5 EPDM/PVC	0.5884	1.617
100/5 EPDM/PVC	0.3180	1.6894
100/7.5 EPDM/PVC	0.3913	1.300
100/10 EPDM/PVC	0.2541	1.276

Caption to Figures:

Figure 1 Tensile strenght of peroxide cured pure EPDM before and after thermal ageing; 1. unaged and 2. Aged

Figure 2 Tensile strenght of peroxide cured PVC loaded EPDM before and after thermal ageing;1.unaged and 2. Aged.

Figure 3 Tensile strenght of sulphur cured EPDM/PVC composite before and after natural weathering;1.unaged pure EPDM , 2. aged EPDM, 3.unaged 100/2.5 EPDM/PVC and 4.aged 100/2.5 EPDM/PVC composites.

Figure 4 SEM pictures of EPDM/PVC before and after natural weathering for four months :

(a) 100/0 EPDM/PVC before ageing
(b) 100/0 EPDM/PVC after ageing
(c) 100/2.5 EPDM/PVC before ageing
(d) 100/2.5 EPDM/PVC after ageing
(e) 100/5 EPDM/PVC before ageing
(f) 100/5 EPDM/PVC after ageing
(g) 100/7.5 EPDM/PVC before ageing
(h) 100/7.5 EPDM/PVC after ageing
(i) 100/10 EPDM/PVC before ageing
(j) 100/10 EPDM/PVC after ageing

Figure 1 Tensile strenght of peroxide cured pure EPDM before and after thermal ageing; 1. unaged and 2. Aged

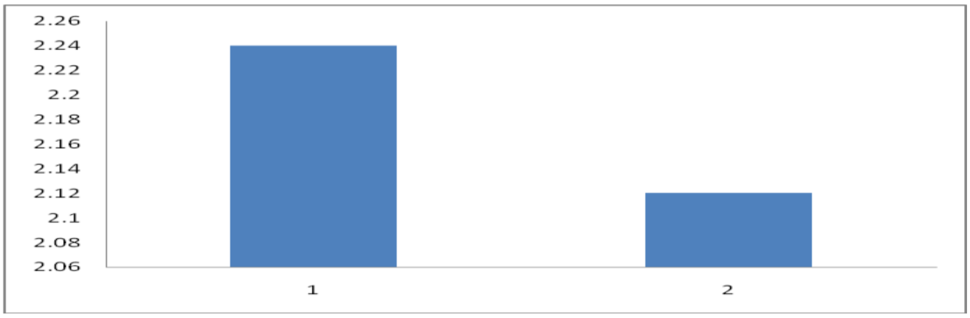


Figure 2 Tensile strenght of peroxide cured PVC loaded EPDM before and after thermal ageing;1.unaged and 2. Aged.

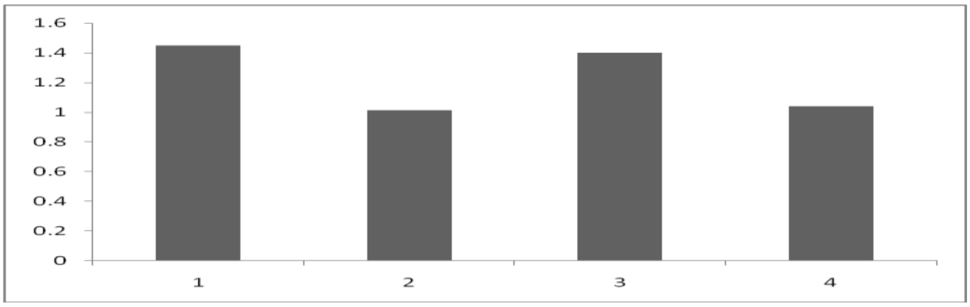
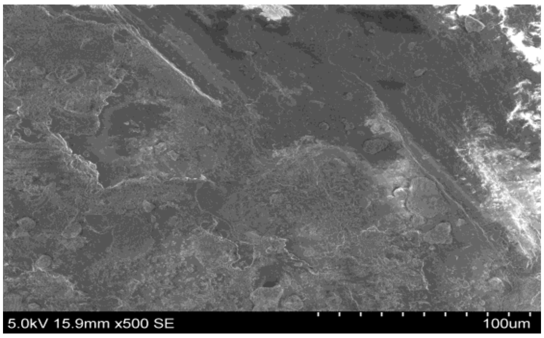
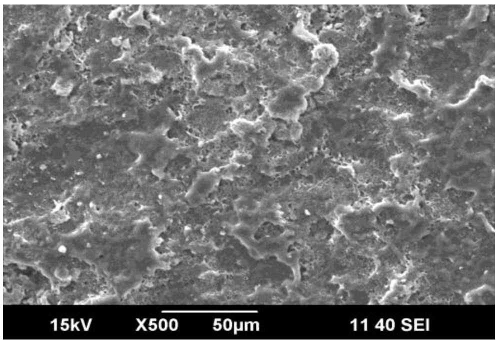


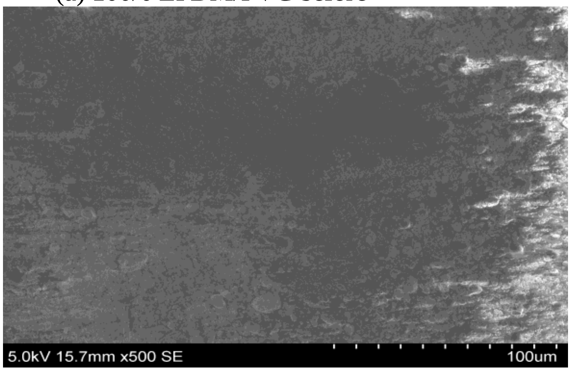
Figure 3 Tensile strenght of sulphur cured EPDM/PVC composite before and after natural weathering;1.unaged pure EPDM , 2. aged EPDM, 3.unaged 100/2.5 EPDM/PVC and 4.aged 100/2.5 EPDM/PVC composites.



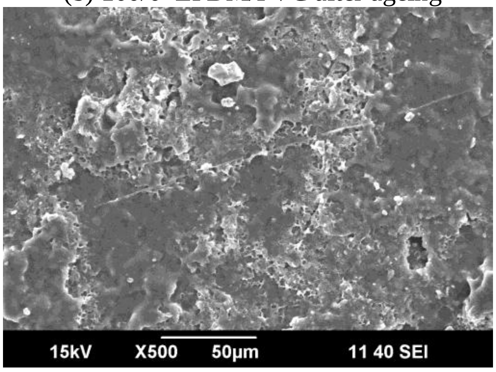
(a) 100/0 EPDM/PVC before



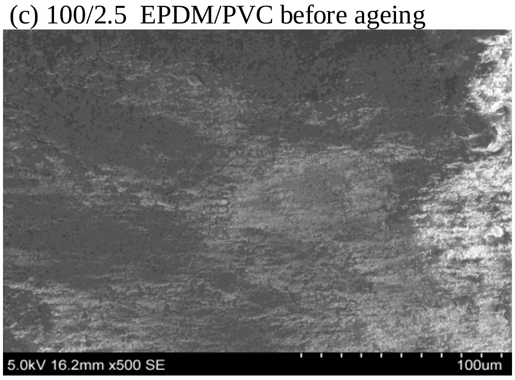
(b) 100/0 EPDM/PVC after ageing



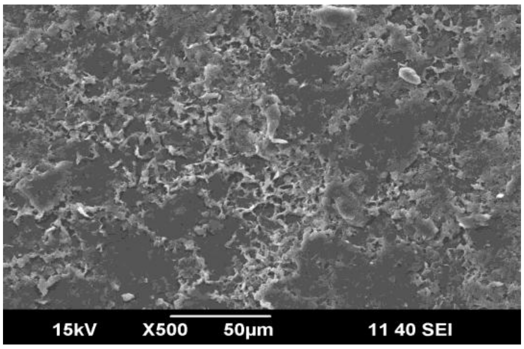
(c) 100/2.5 EPDM/PVC before ageing



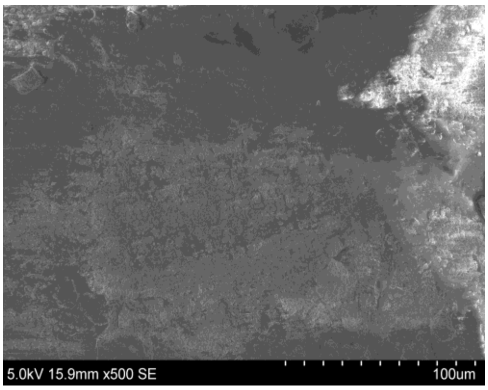
(d) 100/2.5 EPDM/PVC after ageing



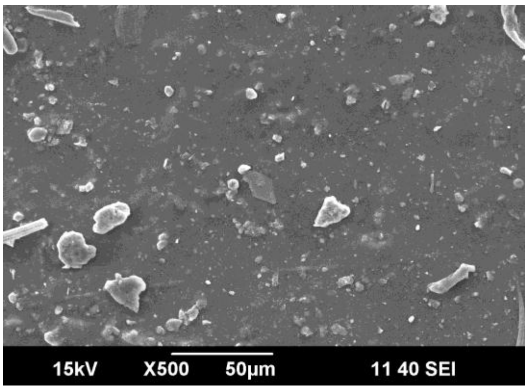
(e) 100/5 EPDM/PVC before ageing



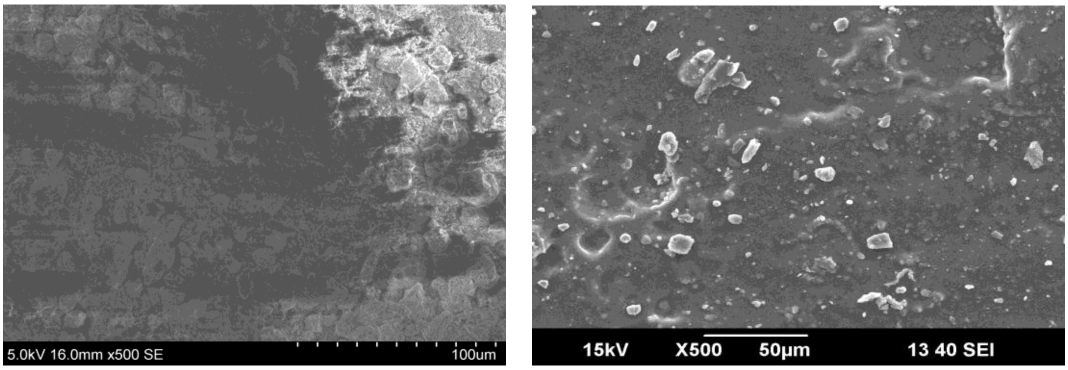
(f) 100/5 EPDM/PVC after ageing



(g) 100/7.5 EPDM/PVC before ageing



(h) 100/7.5 EPDM/PVC after ageing



(i) 100/10 EPDM/PVC before ageing (j) 100/10 EPDM/PVC after ageing

Figure 4 SEM pictures of EPDM/PVC before and after natural weathering for four months: