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Compatibility Of Solvent Blended EPDM/CPE Rubber Blends-A Novel Synthesis And Characterization

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The study on the development of compatible polymer blends, specifically Ethylene Propylene Diene Terpolymer (EPDM) and Chlorinated Polyethylene (CPE), is challenging due to their differing polarities. Typically, compatibilizing agents are required to achieve a homogeneous blend between the non-polar EPDM and polar CPE. In this work, we successfully prepared EPDM/CPE blends using a solvent blending method without the need for compatibilizers. The resulting blends exhibited excellent compatibility, as confirmed by Scanning Electron Microscope (SEM) images, highlighting the potential of solvent blending in overcoming polarity differences between polymers.

Keywords: EPDM, CPE, solvent blending, morphology, compatibility.

Introduction

The development of chemically resistant polymers especially with better mechanical and thermal properties has attracted greater attraction from the scientific community due to the increasing potential for technological applications such as roofing and mechanical goods. EPDM, due to its excellent mechanical properties, chemical and thermal resistance suits well for the above applications. But it finds lacking in few other aspects which can be made up by blending with other polymers and reinforcing with fillers. It can also be compounded to meet specific properties to a limit depending first on the EPDM polymers available, the processing and curing method(s) employed.

Janczak et al (1989) have stated that, with the addition of PE or PP to EPDM, its tear strength, hardness and coefficient of kinetic friction increase. Masoud et al (2006) have reported that solvent blending of PP and EPDM in a composition of 50:50 showed two-phase morphology and increase in barrier property. For rocket motor insulation, EPDM a non-polar rubber lacks sufficient bonding with the propellant matrix. Bonding properties are found to improve when EPDM is blended with other polar rubbers like polychloroprene, chlorosulphonated polyethylene (CSE), etc. This type of polar polymer when blended with EPDM rubber enhances the insulator-to-propellant interface bonding.

Still, no work has been reported till date with EPDM blended chlorinated polyethelene using solvent blending. So it's worthwhile to study the effect of chlorinated polyethelene on EPDM/chlorinated polyethelene blends. In this present work chlorinated polyethelene is blended with EPDM in various compositions, their functionality and morphology were studied using FT-IR, XRD and SEM.

Experimental

Materials

The EPDM and CPE rubbers used for the study were the product of DOW Chemical Company. The EPDM rubber which is in the form of pellets having ethylene content 70%, diene content 4.9%, Mooney viscosity 70ML (at 125ºC), typical molecular weight 200,000 (GPC Dow test method) and density 0.88g/cc. The cross-linking agent was 98% pure dicumyl peroxide crystals, purchased from Sigma-Aldrich, manufactured by Aldrich, Japan. Analor grade (AR) Toluene with 99.5% purity was obtained from NICE Chemicals, Cochin.

Preparation of novel EPDM/Chlorinated polyethelene blends

Required amount of EPDM rubber and Chlorinated polyethelene rubber were dissolved in toluene and the whole mixture was mechanically stirred for 5 hrs at 60º C and finally cured by adding dicumyl peroxide, before transferring into a glass mold. Thin films of the blends were obtained after the solvent was extracted out. The composition of the mixture is given in Table 1.

Table 1: Compositions of EPDM/Chlorinated polyethelene blends

Sample Code	EPDM	CPE (per hundred parts of EPDM)	Dicumyl peroxide (per hundred parts of EPDM)
E	100	0	2
E 5CPE	100	5	2
E 10CPE	100	10	2
E 15CPE	100	15	2
E 20CPE	100	20	2
E 25CPE	100	25	2

Characterization

IR determinations were performed with a Perkin Elmer Spectrum GX1 FT-IR spectrometer (Monza, Italy) equipped with a Spectra Tech. Total Attenuated Reflectance (ATR) accessory.

Number of scans was 32 at 4 cm^{-1}. Data were processed with the Perkin Elmer software package; a Galactic Grams 32 v5.2 software package was used for the curve fitting procedure.

X-ray diffraction (XRD) was performed and the pattern were collected from the Rigaku Miniflex diffractometer (30 kV, 10 mA) with Ni-filtered Cu Ka radiation (0.1542 nm).

For phase morphology analysis, the samples were cryogenically fractured using liquid nitrogen. SEM photographs of the fractured surfaces were taken after preferential extraction of the minor phase using a Philips 505 microscope (Royal Philips Electronic, Eindhoven, Netherlands).

Results and Discussion

Morphology and Chemical Functionality Studies

The IR spectroscopic analysis was done and the results show the presence of chlorinated polyethelene with EPDM. The FT-IR spectrum of EPDM rubber (Figure 4.1) shows C-H stretching (2925 and 2580 cm^{-1}), C=C stretching (1630 cm^{-1}), CH_2 bending (1460 and 720 cm^{-1}) and CH_3 bending (1375 cm^{-1}). The signal at 910cm^{-1} is also characteristic of the EPDM rubber (=CH-CH_2-). The infra-red spectra of chlorinated polyethelene (CR)-filled EPDM have the signals corresponding to EPDM, as well as those (745, 825, 1376, and 1641 cm^{-1}) characteristic of chlorinated polyethelene (CPE) rubber. This is indicative of the blending of EPDM with chlorinated polyethelene rubber.

The XRD pattern of EPDM/chlorinated polyethelene blends (Figure 4.15 to 4.19) shows an initial decrease and steady increase of crystallinity on addition of chlorinated polyethelene to EPDM matrix. Initially when chlorinated polyethelene was added to EPDM, the 2θ value decreased to 19.29° from 20.76°. This is significant when crystallinity decreases from 71.41 to 71.08%. On further addition of chlorinated polyethelene, the angle steadily increases thereby showing a small increase in crystallinity to 72.70% for EPDM filled with 25 phr of chlorinated polyethelene.

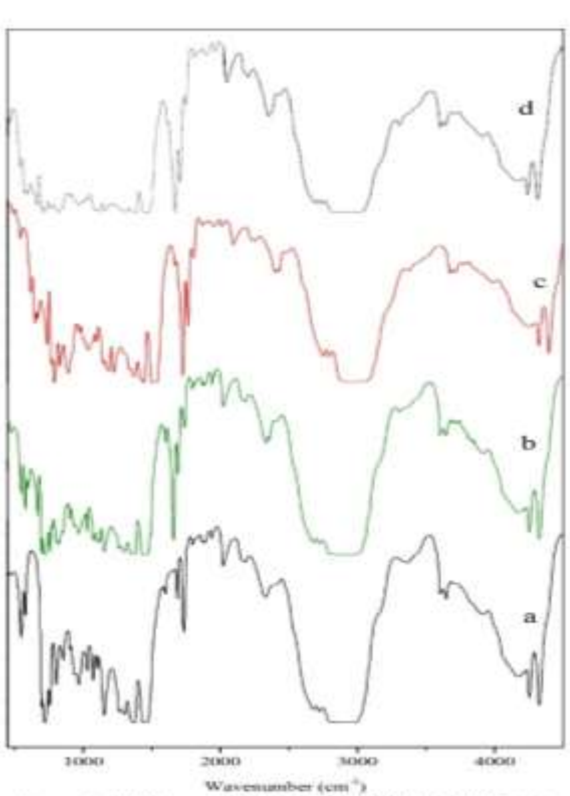

Figure 1: FT-IR spectra of (a) pure EPDM, (b) EPDM/5% CPE (c) EPDM/10% CPE (d) EPDM/20% CPE

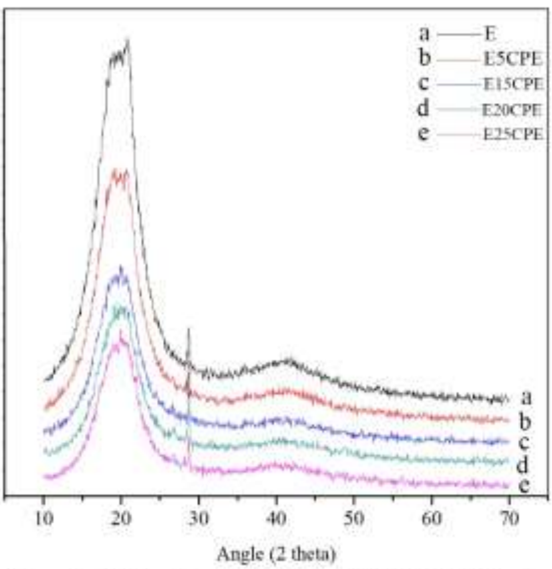

Figure 2: XRD patterns of EPDM and EPDM/CPE blends

Also the crystal index initially decreases on introduction of chlorinated polyethelene into EPDM from 0.5996 to 0.5931 and then on further addition of chlorinated polyethelene it increases to 0.6246 (E 25CPE). This increase may be due to the crystalline nature of chlorinated polyethelene compared to EPDM. Thus addition of chlorinated polyethelene even though initially decreases the crystallinity, it increases later on considerably.

Table 1: Crystallinity of the Blends and Composites

Sample	% Crystallinity	Crystal Index
E	71.41	0.5996
E 5CPE	71.08	0.5931
E 10CPE	71.33	0.5989
E 15CPE	71.45	0.6004
E 20CPE	71.47	0.6009
E 25CPE	72.70	0.6246

The SEM image of EPDM (Figure 3) shows an even layer of rubber. This may be due to the even distribution, perfect morphology and better cross-linking of the EPDM rubber chains by the peroxide cross-linking agent used. The dicumyl peroxide used as curing agent is well suited for curing the EPDM rubber used in this present work. Also the concentration of curing agent is good enough to maintain a perfect even cross-linking within the EPDM rubber matrix.

Chlorinated polyethelene when mixed with EPDM it will form an incompatible blend due to the large difference in polarity. But in solvent blending, mutual interaction of macromolecules within the solution may exert a positive interaction between the two components. In addition, the mechanical stirring and sonication can further effect even distribution of the chlorinated polyethelene within EPDM matrix. Use of a peroxide curing agent could further induce effective crosslinking between the two matrices. The present work is in fact a combination of all the above said efforts to successfully effect a homogenous blending.

There is perfect compatibility between EPDM and chlorinated polyethelene even as high as 20% (Figures 3). There seems to be no agglomeration with 5%, 15%. In the case of 25% chlorinated polyethelene-filled blend, the incompatibility of two blends is obvious and the surface seemed to be corrupted and fractured.

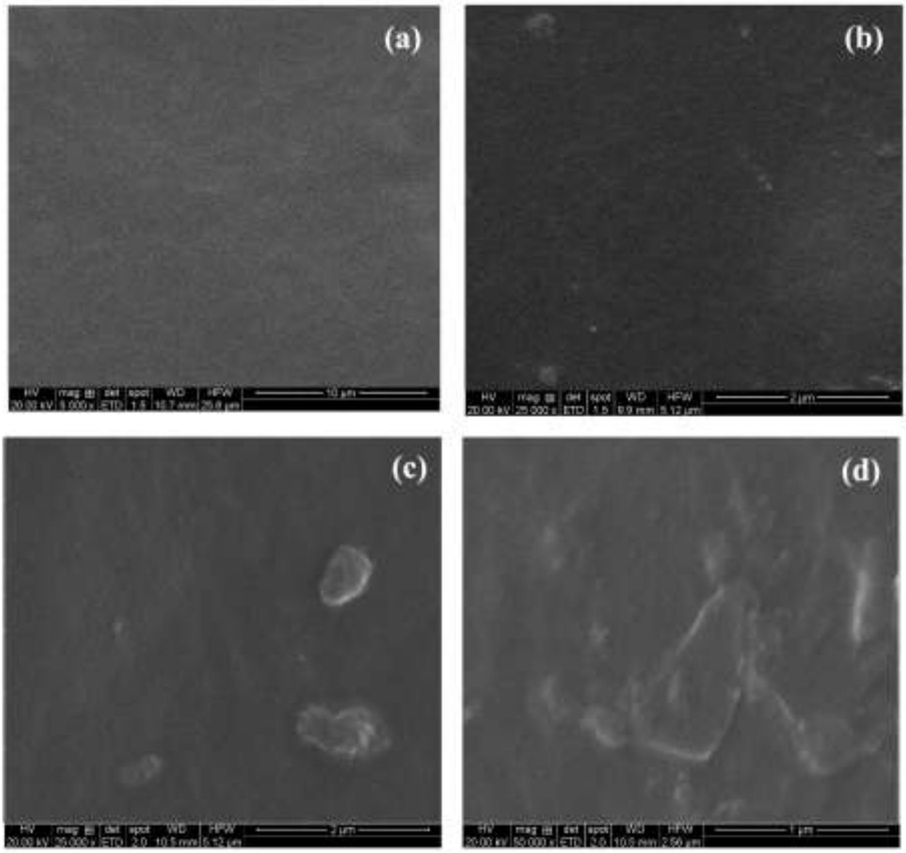

Figure 3: SEM images of (a) pure EPDM (b) EPDM/15% CPE
(c) EPDM/20% CPE and (d) EPDM/25% CPE

Presence of a few insignificant tiny spots for 20% blending indicates the maximum limit of blending. This has been already corroborated for the good mechanical and thermal properties elsewhere.

Conclusion

Non-polar Ethylene Propylene diene terpolymer (EPDM) demands polar inducement in the form of compatibilizing agents for getting a homogeneous blend with chlorinated polyethylene (CPE). The infra-red analysis shows presence of CPE within the EPDN matrix and SEM results confirms a homogeneous mixture. This homogeneous blend can prove useful in many possible application especially in semi-conduction and circuit films considering the presence of polar chlorinated polyethylene.

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