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# Gamma and electron beam irradiation effects on SiR-EPDM blends

*R. Deepalaxmi*[*], *V. Rajini*

*SSN College of Engineering, Chennai, Tamilnadu, India*

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ABSTRACT

Ethylene Propylene Diene Monomer (EPDM) is widely used as Cable Insulation Material (CIM) due to its good mechanical strength. Silicone Rubber (SiR) is used in high temperature environments due to its good di-electric properties/hydrophobicity. The blending of SiR-EPDM may result in the improvement in their specific properties. The SiR-EPDM blend of equal composition (50:50) was prepared. When such blends are used as Cable Insulation Materials (CIM), they should perform their safety functions throughout their installed life in Nuclear Power Plants (NPP). The CIM will be exposed to Gamma irradiation at the installed locations. The short time accelerated testing was carried out, in order to forecast long-term performance of CIM. Electron beam irradiation is widely used in cable manufacturing industries to improve the performance of the polymeric materials. In the current study, on the purpose to investigate the effect of gamma/electron beam irradiation on the 50–50 composition of SiR-EPDM blend, blend was exposed to 25 Mrad dose of gamma/electron beam irradiation. The electrical and mechanical parameters like Volume Resistivity (VRY), Surface Resistivity (SRY), Tensile Strength (TS), Elongation at Break (EB), Hardness (H) of the virgin, gamma/electron beam irradiated blends were determined as per ASTM/IEC standards. The nature of degradation was investigated using Fourier Transform Infrared Spectroscopy (FTIR). To determine the elemental composition of the materials at the surface, Energy Dispersive X-ray Analysis (EDAX) has been done. Scanning Electron Microscopy (SEM) analysis has been done to study the morphological changes. The occurrence of cross-linking is found to be the mechanism for ageing in gamma/electron beam irradiated SiR-EPDM blends.



* *Corresponding author*. Tel.: +91 9884542232.
E-mail addresses: deepalaxmivaithi@gmail.com, deepalaxmir@ssn.edu.in (R. Deepalaxmi), rajiniv@ssn.edu.in (V. Rajini).
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## 1. Introduction

Ethylene Propylene Diene Monomer (EPDM) has a stable and saturated polymer backbone structure. Due to this, EPDM is found to have an excellent resistance to heat, oxidation, ozone and weather ageing. Silicone Rubber (SiR) is widely used for outdoor high voltage application. It has excellent dielectric properties coupled with high temperature stability. EPDM when added to SiR imparts good mechanical strength and outstanding resistance to attack by oxygen, ozone and weather (Brown, 1994). Hence, the base polymer materials chosen were SiR and EPDM. Blending of these two polymers (SiR-EPDM) is an effective way to develop new material with improved characteristics. The newly formed blend may have good di-electric characteristics, thermal stability, improved mechanical strength and resistance towards polluted environment. Compounded alloys can have excellent electrical and mechanical properties due to the presence of EPDM and may be hydrophobic because of silicone content (Ehsani et al., 2004; Kole & Tripathy, 1994; Raja Prabu, Usa, Udhayakumar, Abdullah Khan, & Abdul Majeed, 2007). The SiR-EPDM blend of 50:50 composition was prepared.

Electron beam (EB) radiation processing is widely used in wire and cable industries. EB processing offers some distinct advantages such as very fast processing, clean, precise control and no permanent radioactivity as the machine can be switched off. The high penetrating power of the electron beam allows the efficient curing/cross-linking of thick polymeric articles. The EB radiation process is practically free of waste products and hence there is no serious environmental hazard. Many researchers have investigated the effects of electron beam irradiation on electro-mechanical properties of various blends of the commonly used polymers (Bhat, 2005, Bhowmick & Vijayabaskar, 2005). But, the effect of electron beam irradiation on the SiR-EPDM blends was never reported.

Also many researchers have investigated the performance of gamma irradiated LDPE/EVA blend and Polyethylene (Banford & Fourace, 1999; Chung Lee, Kim, Ryu, & Lim, 2006; Du & Gao, 2009; Rajini & Udayakumar, 2006, 2009). Also the effect of gamma irradiation on ethylene-octene polymers (Chipara, Grecu, Chipara, Ponta, & Reyes Romero, 1999) and the radiation induced degradation of NBR-EPDM rubbers (Roberto, Erin, Esther Martinez-Pardo, & Luna Zaragoza, 1999) have been reported. Most of the above researchers have taken dielectric strength and dielectric constant as the parameters for investigation. The effect of gamma irradiation on SiR-EPDM blend has never been reported.

So the SiR-EPDM blend was exposed to 25 Mrad dose of gamma and electron beam irradiation. The electrical properties like volume resistivity (VRY), surface resistivity (SRY) and mechanical properties like tensile strength (TS), elongation at break (EB) and hardness (H) of the virgin, gamma and electron beam irradiated blends were measured as per ASTM/IEC standards. The comparison of electro-mechanical properties of the blends with their base polymers was discussed in detail (Deepalaxmi, Balaji, & Rajini, 2013; Deepalaxmi & Rajini, May 2014; Deepalaxmi & Rajini, July 2014). Since the objective of the present investigation is to identify the radiation induced changes in electro-mechanical parameter, the commonly used parameters like dielectric constant and dielectric strength are not considered.

The gamma/electron beam irradiation can cause macroscopic changes in the electrical/mechanical properties of this newly formed SiR-EPDM blend. The changes in electrical/mechanical properties may be due to some alterations in the chemical structure of SiR-EPDM blends. The nature of alteration may vary with respect to the irradiation dose. Hence it is essential to investigate the effect of gamma/electron beam irradiation upon the electro-mechanical properties of the SiR-EPDM blends. The functional groups responsible for the above changes may be investigated through one of the physico-chemical investigation techniques like FTIR. The morphological changes of the virgin, gamma/electron beam irradiated samples of SiR-EPDM blends have been analyzed through the Scanning Electron Microscopy (SEM) analysis. To identify the elemental composition of the materials at the surface of virgin, gamma/electron beam irradiated samples of SiR-EPDM, Energy Dispersive X-ray Analysis (EDAX) analysis has been done.

## 2. Experimental

### 2.1. Materials

Commercially available SiR, EPDM were used for this research. SiR, EPDM and other additives were supplied by M/S Joy Rubbers, India.

### 2.2. Sample preparation

The SiR-EPDM blend was prepared using two roll mixing mill (Shoail make). The detailed sample preparation procedure was explained in (Deepalaxmi et al., 2013).

### 2.3. Irradiation

#### 2.3.1. Gamma irradiation

The Gamma irradiation of SiR-EPDM blend was carried out using $^{60}$CO Gamma chamber facility available at Radiological Safety Division, *Indira Gandhi Centre for Atomic Research* (IGCAR), Kalpakkam, Tamilnadu, India. The Gamma chamber has an irradiation volume of one litre with a dose rate of 3 KGy/hr. The applied dose was 25 Mrad.

#### 2.3.2. Electron beam irradiation

The electron beam irradiation was carried out in air using an electron accelerator with a beam energy of 1.5 MeV (M/S Siechem Industries). The blend was exposed to 25 Mrad dose of electron beam radiation.

Three samples were exposed to the same dose and investigations were carried out. All the results presented in this paper, are the average of the three investigations made at the same conditions.

## 3. Characterization

The virgin, gamma and electron beam irradiated samples of SiR-EPDM blend have been characterized for their electrical and mechanical properties as per ASTM/IEC standards.