

# Mechanical and Thermal Characterization of Ethylene Vinyl Acetate Copolymer/Sodium Silicate Composite Films

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## Abstract

Intercalated composite films of Ethylene Vinyl Acetate (EVA) with sodium silicate (SS) are prepared using solvent casting technique. The films are prepared by varying the vinyl acetate percentage in EVA and suitable quantities of sodium silicate in wt/wt concentration are mixed in EVA solution with high speed stirring for homogenous dispersion. The functional groups present in both EVA and EVA/SS films are confirmed through FTIR spectral analysis. Stress-Strain curves are obtained for both EVA and EVA/SS films in order to determine the improvement in various tensile parameters. An increase in the thermal stability of the developed composite was recorded by thermo gravimetric analysis (TGA). Copyright © VBRI Press.

**Keywords:** EVA, SS, FTIR, TGA, solvent casting technique.

## Introduction

The structural formation and properties of a thin film of inorganic macro molecules are the current interest of research. Polymers can be treated as fascinating molecules in which chain and segmental motions are giving rise to a complexity in properties and behaviour [1]. Polymer thin films play a vital role in the evolution of present modern technology. In recent years, because of its unique chemical, physical and dynamic properties EVA plays an immense role in extensive industrial applications, which makes EVA as a distinguishable copolymer over others [2]. The distribution of VA content with respect to ethylene-vinyl acetate (EVA) mainly depends on constituted applied products which is one of the most important characteristics [3]. Polymer layered silicate composites [4] are the recent raise of emerging composite materials due to their enhanced mechanical [5, 6], improved thermal [7-9] and fire retardant [10, 11] properties. Current work is the preparation and characterisation of EVA composite films with varying the percentage of vinyl acetate and sodium silicate in one attempt by the solvent casting technique.

## Experimental

### Materials

A solid (pellets) form of EVA, VA monomer for synthesis and Chloroform for solvent were procured

from Scientific Chemical Suppliers, Chennai, India. Sodium Silicate was purchased from Sigma Aldrich, USA.

### Preparation of EVA, EVA-SS composite films

Pellets of Ethylene Vinyl Acetate have been soaked in Chloroform solvent for about 8 to 9 hours. The resultant well soaked EVA is then magnetically stirred at the room temperature for about 5 to 6 hours to attain a homogenous solution. By Solvent Casting Technique three variant percent (18%, 58% and 88%) of VA in wt/wt ratio with EVA are prepared as films at the state of room temperature. EVA-SS composite films are prepared by the addition of 1% and 7% of SS in EVA in wt/wt concentration. The composite films are made for all the three variant percent of VA in EVA. Uniform thicknesses are maintained on all the ensuing films of concerning 0.2mm as well are evenly textured. The resultant films further used for characterization studies.

### Characterization

The functional group identification on samples are made with PerkinElmer spectrum two FTIR Spectrometer in absorbance mode instrumentation ranging from 4000 – 450 cm<sup>-1</sup>.

Studies to make out the thermal behaviour of resultant EVA films of different VA content in it carried out using Thermo gravimetric analysis (TGA) with PerkinElmer/Pyris made instrumentation. Testing

were made at the temperature of 20 °C/min, the weight loss of sample is measured under the temperature ranging from 50-800 °C.

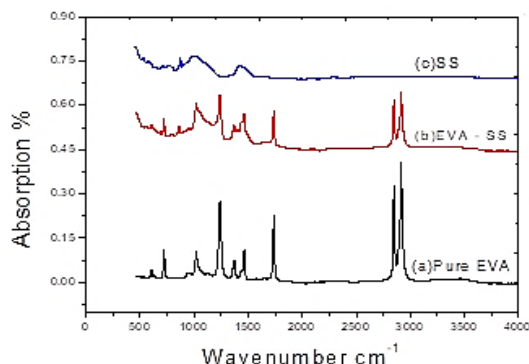
Mechanical properties of EVA films with a specimen of 1cm width and 5cm length were measured by ASTM D-638-00 using an Instran testing machine Model5567.

## Results & discussion

### FTIR spectral analysis

**Fig. 1** shows the FTIR absorption peaks for EVA, SS and EVA-SS composite. The changes in surface layer of polymer are studied in relation to the absorption regions 3100-3600  $\text{cm}^{-1}$  (O - H), 1739  $\text{cm}^{-1}$  (C = O), 1600-1700  $\text{cm}^{-1}$  (C = C), 1372  $\text{cm}^{-1}$  ( $\text{CH}_3$ ) and 1237 $\text{cm}^{-1}$  (C - O) are observed in comparison with the wave number (1464  $\text{cm}^{-1}$ ) corresponds to the deformation bands of  $\text{CH}_2$  group [12]. The peak at 2916  $\text{cm}^{-1}$  corresponds to the anti-symmetric stretching of  $>\text{CH}_2$ . The Si-O-Si linkage at 700-1079  $\text{cm}^{-1}$  in the absorption peak indicates the existence of silicate in EVA-SS composites.

From FTIR spectrum of EVA/SS, it can be observed that the presence of functional groups of both EVA and SS which confirms the incorporation of SS into EVA. In addition, it can also be noticed that the slight shifts in the peak positions of EVA due to the presence of SS.



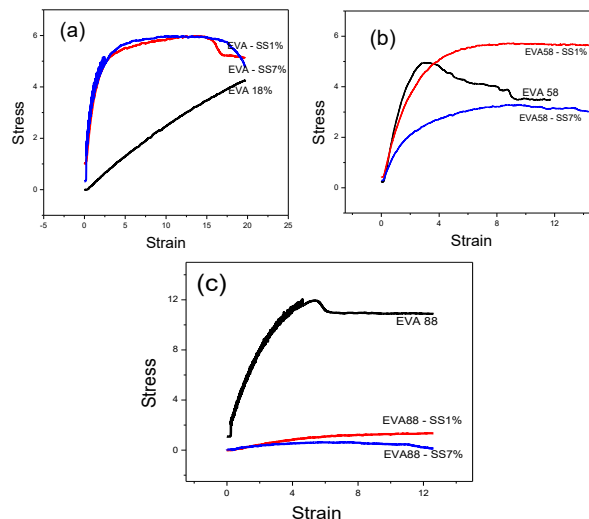
**Fig. 1.** FTIR spectral response of EVA, EVA-SS, SS.

### Mechanical analysis

The mechanical data relating stress and corresponding strain were recorded for films with three varying concentration of VA in EVA, which shows improvement on Tensile strength, breaking stress and toughness by increasing VA in EVA as listed in **Table 1**. The resultant curves correspond to the polymer material with varying percentage of vinyl acetate and of SS with EVA shows the behavior of a typical viscoelastic polymer by exhibiting initial linear rise and proportionality limit over the stress-strain curve [13]. The values of tensile strength, breaking stress and toughness of all the proportions of EVA-SS are listed in **Table 2**. Higher the percentage of SS in EVA with lower percentage of VA shown improved mechanical properties as in **Fig. 2(a), (b), (c)**.

**Table 1.** Mechanical properties of Ethylene Vinyl Acetate with varying VA content.

VA in EVA (%)	Ultimate Tensile strength ( $\text{N/mm}^2$ )	Breaking stress ( $\text{N/mm}^2$ )	Toughness ( $\text{N/mm}^2$ )
18	4.286	4.227	4.431
58	4.957	4.495	4.714
88	11.912	10.982	11.531



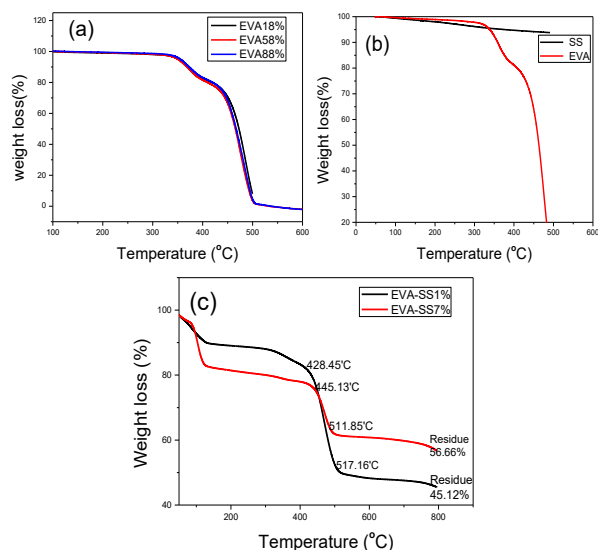
**Fig. 2.** (a) Stress-Strain curve of EVA18-SS1, 7% (b) Stress-Strain curve of EVA58-SS1, 7% (c) Stress-Strain curve of EVA88-SS1, 7%.

**Table 2.** Mechanical properties of EVA-SS composite film.

EVA - SS (in %)	Ultimate Tensile strength ( $\text{N/mm}^2$ )	Breaking stress ( $\text{N/mm}^2$ )	Toughness ( $\text{N/mm}^2$ )
18 - 1	5.955	5.227	5.488
18 - 7	5.894	4.831	5.072
58 - 1	5.713	5.652	5.934
58 - 7	3.283	3.041	3.193
88 - 1	1.349	1.304	1.369
88 - 7	0.552	0.152	0.159

### Thermogravimetric analysis

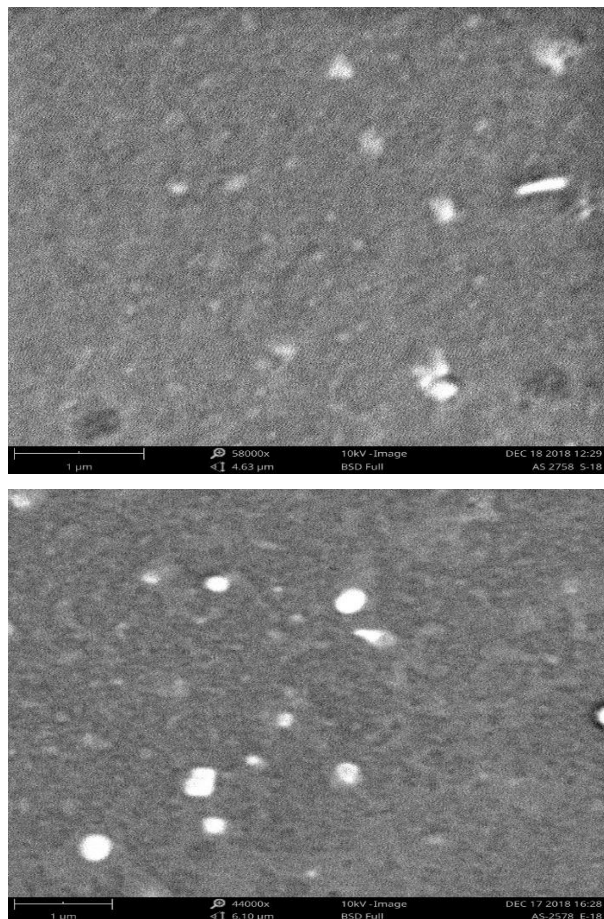
TGA measures the degradation in mass over the sample on heating and of use to know the thermal stability of the samples. TGA provides dependable information on physio-chemical factors, isothermal or non-isothermal heating processes of characterization [14-16]. Two level of oxidative degradation occurs in EVA as shown in **Fig. 3(b)**. The level one degradation correspond to the deacylation of vinyl acetate group with the elimination of acetic acid takes place at the mean of 300 and 380°C. Further the level two degradation of vinyl polyethylene chains formed in level one occurs at the range of temperature in between 380 and 450°C. In the second stage of degradation there will be a rapid weight loss with increase of temperature as in **Fig. 3(a)**. The introduction of sodium silicate(SS) in EVA shifting the first level of degradation temperature from the range of 300°C to beyond 400°C and the second level to beyond 500°C as in **Fig. 3(c)**. Degradation in the range of 100°C shows the loss of water molecules to form a glass seal. Increase in percentage of sodium silicate in EVA composite film increases the degradation temperature to the higher range.



**Fig. 3.** TGA of (a) EVA with 18, 58, 88 percentage of VA (b) EVA, SS (c) Representative EVA-SS 1, 7 percentage.

### Morphology of EVA, EVA-SS

The SEM images with the magnification of about 44K for EVA and of 50K for EVA-SS thin films are shown in above **Fig. 4**. It is observed that the films are smooth and well-defined spherical crystallites with grain size <math>< 1\mu\text{m}</math>.



**Fig. 4.** SEM micro structure of (a) Plain EVA (b) EVA-SS.

### Conclusion

The ethylene vinyl acetate copolymer/sodium silicate composite were prepared using a simple solution casting method. Fourier transform infrared spectral analysis confirms the existence of the functional groups related to EVA, EVA-SS composite films. The mechanical properties Ultimate tensile strength, breaking stress, toughness of the films can be increased by increasing the percentage of VA in EVA and for EVA-SS composite films. The improvement in tensile strength can be achieved by the added percentage of SS, merely with the lower percentage of VA in EVA. The stress-strain relations for EVA-SS composite films with various wt% can be revealed that the dispersion of individual silicate sheet is optimum with incorporation of SS only with the EVA of having lower percentage of VA in it. TGA exhibits higher thermal stability, hence increase in percentage of sodium silicate in EVA composite film increases the degradation temperature to the higher range. Further SEM characterization confirms the variation in particle size in EVA and EVA-SS composite films.

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