

Physico-Mechanical Properties and Oil Swelling Characteristics of Acrylonitrile Butadiene Rubber and Ethylene-Methyl Acrylate Copolymer Blends

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Abstract – Physico mechanical properties and oil swelling properties of Acrylonitrile Butadiene Rubber (NBR) and Ethylene-Methyl Acrylate copolymer (EMA), having varying extents of EMA from 0 to 100% have been investigated at three distinct temperatures (100, 120, and 140°C). FTIR spectroscopy study reveals the physical interaction between NBR and EMA. The impact of blends proportion on physico-mechanical properties have been explored. The physico-mechanical properties such as Tensile strength, modulus increases with increasing EMA concentration in blend. However elongation at break decreases steadily with increasing EMA concentration. Oil swell characteristics of the blend reveals that the NBR phase has more controls the swelling behavior.

Key Words: Physico-mechanical properties, tensile strength, oil swelling, blend composition.

1. INTRODUCTION

Polymer blends are materials of surprising repercussions both in present day and also as among the researchers on account of its colossal excitement for making new materials with a lone blend of properties not found in particular polymer constituent that as too without restoring to the repetitive methods for incorporating new polymers by normal course. Accordingly it's gotten imperative to redesign the planning conditions for the blends to accomplish a definite course of action of end use properties. In spite of the fact that only if there ought to be an event of polymer blends, the stream direct ends up being more unusual and it's very influenced by additional elements basically like the miscibility between the blend constituent, the collaboration at the interface, the morphology of the blend, interfacial bond, and interfacial thickness

An enormous amounts of research articles have been published in the past relatively few decades on the miscibility of polymer blends and a few patents has been filled. The miscibility has been credited to either express correspondence or substance reaction between the blend constituents causing a development in thickness of the blend over the speculative thickness procured from the additivity rule. In most of the cases, this has been reflected in the rheological sign of the blends demonstrating higher mollify

consistency when appeared differently in relation to that procured by the log-additivity rule. The complex rheological lead of the polymer blends have been investigated by a couple of scientists

The mechanical properties, for instance, versatility, static modulus and impact nature of the blends show a positive deviation from that of log additivity rule. The warm adequacy investigations of the blends reveal the synergistic mix and improve warm relentlessness. The blends in like manner show in light of co-crosslinking by using an ordinary easing master, for instance, dicumyl peroxide.

In any case, the rheological properties of such blends are phenomenal, yet they are definitely not hard to evaluate and by and large simple to unravel as they continue about as a single stage melt. Utracki and Kamal have had the alternative to sort the polymer blends into three get-togethers, to be explicit; (a) strongly diverged blends ; having higher assessment of test consistency than that theoretically predicated by using log additivity rule b) unfavorably veered off blends; a lower assessment of thickness than the one foreseen by the additivity rule c) positive-negative wandered blends; which show both positive and negative deviation from the speculative one depending upon the creation falls under this class.

Thereafter, Utracki totally related the rheological properties of these blends in with their thermodynamic lead and structure. He suggested that; (a) the positive deviation is a brand name feature of a homogeneous polymer blend due to unequivocal polymer-polymer associations, (b) the negative deviation and the positive-negative deviation may be connected with the heterogeneous thought of the polymer blends.

A hetero-stage polymer blend may show positive deviation if the interface collaborations are a result of compatibilization, shear joining, or fragmented express associations. Right when the relationship between the stages is hardly anything, the consistency of the blend will show a negative deviation and average weight contrast. This miscibility has been allotted as a result of the invention reaction between the blend constituents during open taking care of inciting a join copolymer.

Blends of EMA and PDMS have been broadly used in packaging organizations because of straightforwardness in processability, incredible optical and physicommechanical and optical properties and basic availability. Lee et al. have investigated the miscibility of EMA/LEMA blends. The in situ compatibilization of PS and PE blends has been represented by Song and Baker.²³ The effect of PP on the rheological direct of PS and SEBS blends have been represented by Raha et al.

A few investigators have analyzed the miscibility of different polymer mixes. Polyethylene acrylic destructive (PEA) is remarkable for its use in standard removal covering, coextrusion covering, and ejection overlay. The benefits of PEA, for instance, splendid connection to various substrates, for instance, aluminum foils, paper, films, etc., have gotten broad thought with respect to utilize it close by various polymers which requires the recently referenced properties for express applications. PEA/EMA blends have various present day utilizes by virtue of their extraordinary mechanical quality, processability and impact quality.

A careful report revealed the nonappearance of information related to the appraisal of mechanical properties of NBR/EMA blends. The current investigation assessment zeroed in on the physic-mechanical properties and oil swelling characteristics of NBR/EMA blends as a component of fluctuating proportions of EMA.

2. EXPERIMENTAL

2.1 Materials

M/s Lanxess Deutschland GmbH supplied Acrylonitrile Butadiene Rubber (Perbunan 3445F), with the following properties: Acrylo nitrile content 33%, specific gravity 0.97, Mooney Viscosity 45, ML (1+4) 100°C is used in the blend preparation. Poly (Ethylene – co-Methyl Acrylate) copolymer (Optema TC 120) having the methyl acrylate content 21%, melting point 81°C, MFI 6 g/min and density of 0.94 g/cm³ was obtained from M/s Exxon Chemical Corporation, Belgium.

2.2 Preparation of the blend

The blends of NBR and EMA having unmistakable blend extents were set up in a Brabender Plasticorder (model PLE-330) at a temperature of 120 °C at a rotor speed of 60 rpm for 5 min. EMA was incorporated first, mollified for 1 min, by then NBR was incorporated and melt mixed for additional 4 min. In all the cases the supreme mixing time was kept up at 5 min.

The blend was then taken out from the plasticorder and sheeted out on a two-roll mill research focus production line (150 x300 mm) rapidly at room tem perature. The blends have been allotted as Ex (x= 0, 30... 100) where x exhibits the weight level of EMA in the blend, for example, E30 shows 30% EMA and 70% NBR.

3. CHARACTERISATION OF BLENDS

3.1 FTIR spectroscopy

The FTIR spectra of blends and their unblemished polymers were recorded in a Fourier transform infrared (FTIR) spectrophotometer of Perkin Elmer made in ATR mode in the area from 4000 to 400 cm⁻¹ and 32 sweeps were taken with a phantom goal of 4 cm⁻¹ and normal of three outputs for each example was taken for the estimation.

3.2 Mechanical Properties

The dumb-bell shaped samples of the mixes utilized for testing were pass on cut from the pressure shaped sheet and the testing was completed after 24 h of development at room temperature. As indicated by ASTM D418-98A, rigidity, % of extensions and modulus were performed utilizing an all inclusive testing machine of Hounsfield make H10KS at a strain pace of 500 mm/min at room temperature (25± 5 °C). Shore a hardness of the mixes were additionally estimated by ASTM D2240 by utilizing Durometer type A (Shore Instrument& Manufacturing INC-Newyork, USA).

3.3 Oil Swelling Studies

Oil swelling or resistance of the blends for different such as ASTM oil #1, ASTM oil #2, and ASTM oil #3 were carried out at room temperature 25 °C and 50 °C. Circular test specimens of 10mm (approx.) diameter were punched out from moulded sheets. Subsequently, these specimens were weighed accurately by using an electronic balance before immersing them into oils. The specimens were weighed at regular time intervals after wiping out the solvents sticking to the surface with a soft tissue paper until reaching the equilibrium weight. % of swelling calculated by using the following equation (gravimetric method):

$$\% \text{ of Swell} = \frac{W_1}{W_0} \times 100 \text{ ----- (2)}$$

Where,

W₁- Weight of swollen sample

W₀- Weight of un-swollen sample

4. RESULT AND DISCUSSION

4.1 FTIR spectroscopy

FTIR spectra of the neat NBR and EMA are shown in Fig 1, the assignments of various peaks are shown in Table 1. The assigned frequency bands are in good agreement with the literature data. The olefinic C–H stretching frequency is shown just above 3000 cm⁻¹, the CH₂ bending vibration is shown at 1436 cm⁻¹, the C–O–C stretching of ester vibration at 1274 cm⁻¹, strong absorption peaks around 2,935 and 2,859 cm⁻¹ are associated with the C–H stretching vibration. The peak around 1462 cm⁻¹ is assigned as to -CH₂ rocking vibration and the peak at 1376 cm⁻¹ is due to the -CH₃ symmetric vibration. The vibration of CN is shown at 2237 cm⁻¹ which is due to NBR and the C–H out-of-plane bending frequency is shown at 968 cm⁻¹. The presence of C=C at 1600

cm^{-1} corresponds to butadiene structure of NBR. The absorption of carbonyl at 1724 cm^{-1} and 1726 cm^{-1} indicate the presence of ester group of EMA.

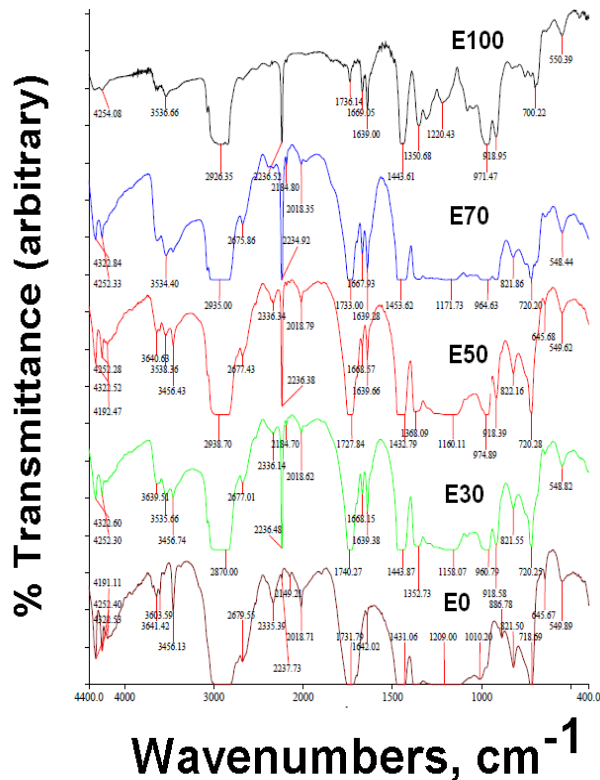


Figure 1 FTIR spectra of NBR/EMA blends

4.2 Mechanical properties;

The stress strain behavior of NBR/EMA blends at different blend compositions are shown in Fig. 2. The NBR and it blends with EMA containing higher amount of NBR show typical behavior of elastomers, while the EMA behaves similar to that of thermoplastic elastomers.

Blending of NBR and EMA changes the stress-strain pattern considerably. The E50 blend shows intermediate behavior. It is observed that with increase in EMA content in the blend, the stress increases and strain decreases as expected. The variation of tensile strength and elongation at break for different blend compositions calculated using mixing rule is depicted in Fig. 2. It is observed that with increase in the EMA contents, tensile strength of the blend increases, and interestingly there is a sharp increase in tensile strength is observed when the EMA content exceeds 50 wt.%. This may be associated with the interaction between EMA and NBR.

The blend having 70 wt. % of NBR has lower tensile strength due to lower modulus of amorphous NBR and because of non interaction between the blend constituents the blend exhibit (70:30 NBR: EMA) lower tensile strength than calculated as per additive rule.

The negative deviation observed in the curve is due to the poor interfacial interaction between NBR and EMA in the blend, which causes poor stress-transfer between the matrix and the dispersed phase. The elongation at break increases gradually with increase in NBR proportion in the blend, EMA changes turns from dispersed phase into the continuous matrix phase is expected to bear all the loads of the blend system.

Figure 2 also shows the variation of Young's modulus as a function of blend ratio. Young's modulus a value obeys the same trend as observed in case of stress at break and beyond 50 wt% of EMA it increases sharply. Therefore, it can be inferred that EMA rich blends exhibit good mechanical properties.

On the other hand, the hardness of the blends shows an increase with increasing EMA content in the blend. The changes E50, E60 and E70 blends show very high hardness values. It's due to rubber phases are discontinuous phase and continuous phases is plastic (EMA).

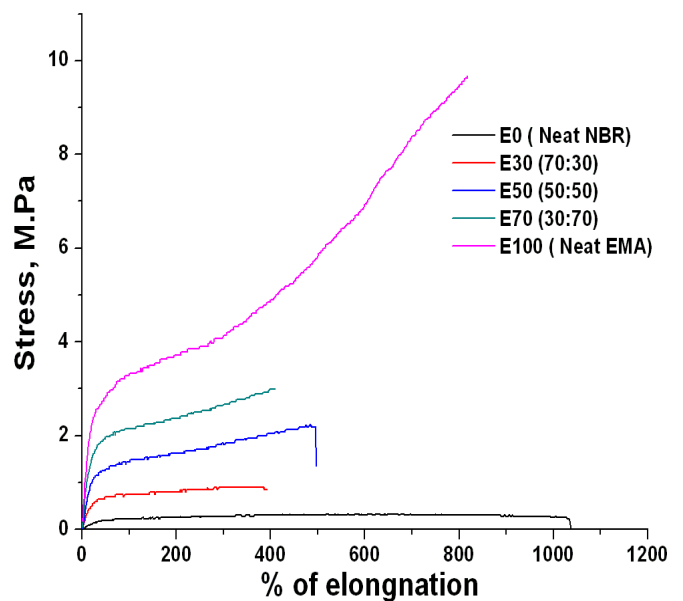


Figure. 2 The stress strain behavior of NBR/EMA blends at different blend compositions

4.3 Oil Swelling Studies

Figure 3 shows % of swell in ASTM oils (ASTM Oil #1, ASTM Oil #2, ASTM Oil #3) of the blend as well as for pristine polymer in three at room temperature (25 ± 5) and $50 \text{ }^\circ\text{C}$ as shown in Table 1. At the point when the fondness among solvent and polymer is enormous, solvation with surface macromolecules will occur and solvents will pervade into within the macromolecules because of temperature. The dissolvable parts that enter can likewise cause the solvation of the polymer chains. It reveals that the NBR is more controls the oil swelling than EMA because NBR is more polar in nature than EMA.

Sample Code	ASTM Oil #1	ASTM Oil #2	ASTM Oil #3
at room temperature			
E0	0	0.57803	1.17647
E30	1.8018	0.85837	13.63636
E50	4.08163	7.48299	16.98113
E70	3.7594	9.15493	22.46377
E100	5.22388	5.17241	19.42857

Sample Code	ASTM Oil #1	ASTM Oil #2	ASTM Oil #3
at 50° C temperature			
E0	0	0.54945	1.65289
E30	1.73913	3.8961	14.47368
E50	3.7037	7.46269	19.35484
E70	4.51613	8.51064	24.05063
E100	2.7027	6.49351	23.17881

Table 1. Oil resistance of the blends at room temperature and at 50° C

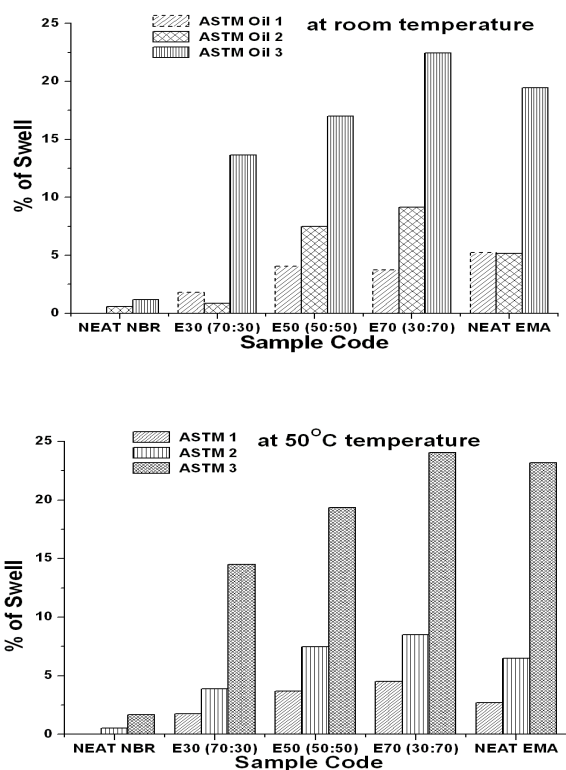


Figure 3. Oil resistance of the blends and its pristine polymers at room temperature and 50° C

5. CONCLUSIONS

The following conclusions have been drawn from the present investigation:

- 1) FTIR spectroscopy reveals the physical interaction between the blend constituents.
- 2) Mechanical properties such as Tensile strength, modulus, Hardness increases with increasing EMA concentration in blend. However an elongation at break is decreases steadily with increasing EMA concentration.
- 3) The melt viscosity decreases for all the blends and pure components concurring with the shear thinning effect of the materials.
- 4) Oil swell characteristics of the blend reveals that the NBR phase has more controls the swelling behavior.

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