International Journal of Research in Science and Technology http://www.ijrst.com

(IJRST) 2023, Vol. No. 13, Issue No. I, Jan-Mar **e-ISSN: 2249-0604, p-ISSN: 2454-180X**

To Study the Effect of Solvent on AC Conductivity and Dielectric Constant on Blend Formation of Poly (Styrene): Poly (Vinyl Acetate)[1]

H.G. Pande, G. T. Lamdhade

Department of Physics, Vidya Bharati Mahavidyalaya, Camp, C.K. Naidu Road, Amravati, Maharashtra, India

DOI:10.37648/ijrst.v13i01.006

Received: 02 February 2023; Accepted: 17 March 2023; Published: 18 March 2023

ABSTRACT

The main objective of this work is to illustrate miscibility, when formation of poly blends occurred in different solvents. Isothermal evaporation method was used to achieve poly blends of poly styrene and poly vinyl acetate (PS: PVAc).The FTIR spectroscopy results revel that there are miscibility exists. For these blends with different solvents, electrical conductivity and dielectric constant were measured at different temperatures (313K, 323K, 333K and 343K) and at the different frequencies (1 KHz to 10MHz) using 4284 LCR meter. It is found that ac conductivity of polyblends thin film varies with temperature for all values of frequencies and it varies with increase in frequencies at constant temperature. The dielectric constant also varies with the increasing of the temperature of polyblends.

Keywords: *Solvents; Polystyrene (PS); Polyvinyl acetate (PVAc); Miscibility; AC Conductivity; Dielectric Constants.*

INTRODUCTION

Polymers and their blends are significant materials, growing with a lot of potential applications in various areas. In recent era, the scientists have focused toward the synthesis and development of new efficient polyblends materials derived monomer polymers like Poly-vinyl acetate (PVAc), Polystyrene (PS), Polymethyl methacrylate (PMMA) etc. So many methods were developing to synthesis polyblends. One most used method is isothermal evaporation method because its ease and low costing. In this method different solvents were used such as Acetone, Methyl-ethyl ketone (MEK), Tetra hydro furan (THF), Toluene and pure distilled Water etc [1-5] to dissolve polymeric materials to form homogenous solution. During this procedure, several improvements in physical and chemical properties like dielectric properties, mechanical and thermal durability and process ability rather than development of new polymers are also observed.

EXPERIMENTAL

Poly-styrene (PS) and Poly-vinyl acetate (PVAc) were supplied by Sigma –Aldrich, Co., 3050 spruce street, St. Louis. MO 63103 USA 314-771-5765. Methyl-ethyl ketone (MEK), Tetra hydro furan (THF) and Toluene used as organic media, (E-Merck India Ltd., Mumbai) are being used as a solvent for poly-blending process. All chemicals

---

[1] *How to cite the article:* Pande H.G., Lamdhade G.T., To Study the Effect of Solvent on AC Conductivity and Dielectric Constant on Blend Formation of Poly (Styrene): Poly (Vinyl Acetate), IJRST, Jan-Mar 2023, Vol 13, Issue 1, 40-47, DOI: http://doi.org/10.37648/ijrst.v13i01.006

were of analytical grade used. In the present work, thin films were prepared by Isothermal Evaporation Technique (IET) [3, 6].

Preparation of Polyblends

Polystyrene and Poly-vinyl acetate were dissolved in Methyl-ethyl ketone, Tetra hydro furan and Toluene in three different beakers. Stirring was continued for one hour before deposition of film. Total concentration of the polymeric mixture in solvent was kept 5%. So, films of polymer blends were prepared by IET [2-3, 5-6].

Measurements

FTIR measurements were carried out using the single beam FTIR [Agilent Technologies, Singapore]. The FTIR spectra of all samples are in the range of 700-3800 cm^{-1}. The ac frequencies were applied (in the range 1 KHz –10 MHz) across the sample by using the 4284 A precision LCR meter [Agilent Technologies, Singapore].

RESULTS AND DISCUSSION

FTIR Spectroscopic Analysis

Fourier transform infrared (FTIR) spectroscopy is one of the widely used optical methods to study the interaction of electromagnetic radiation in the infrared region with chemical compounds.

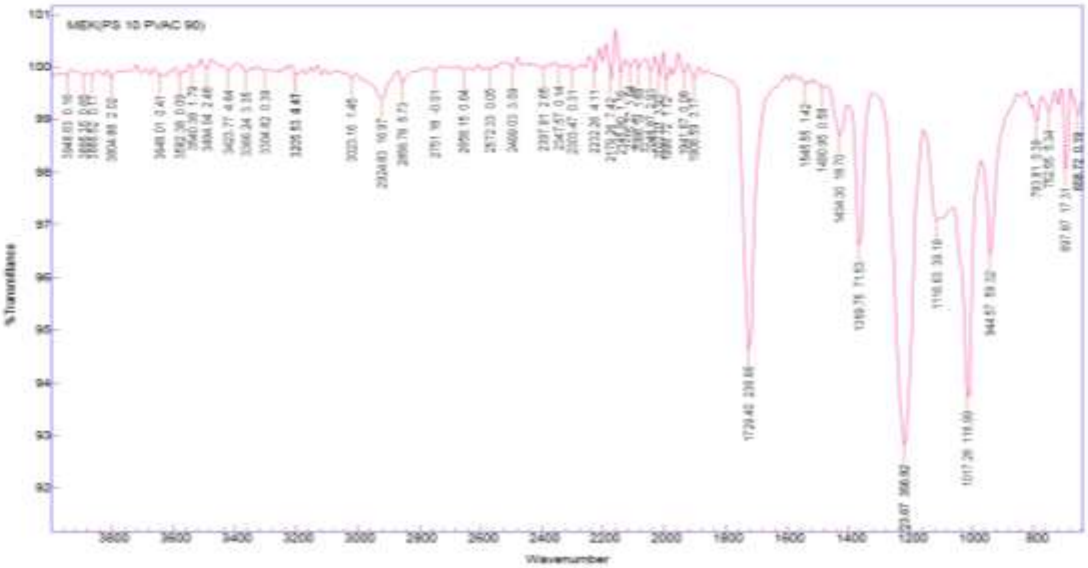


Fig.1 (a): FTIR PS (10) + PVAc (90) (MEK)

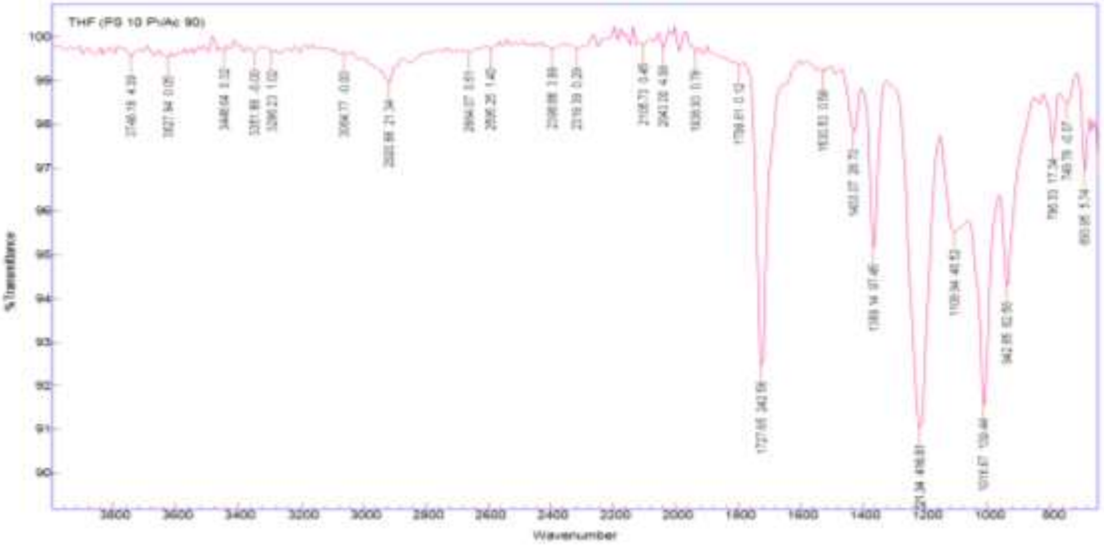


Fig.1 (b): FTIR PS (10) +PVAc (90) (THF)

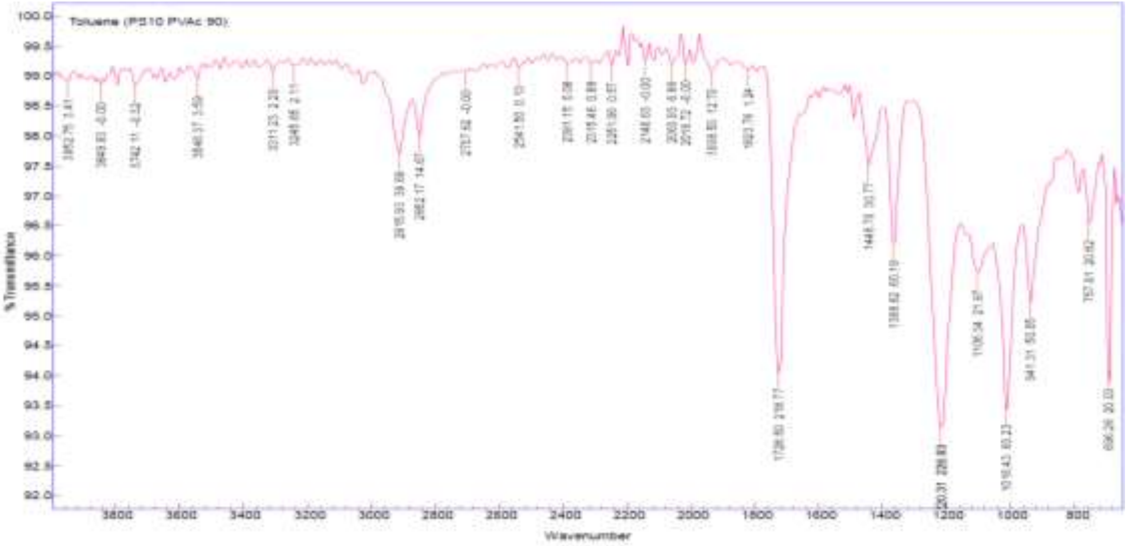


Fig.1 (b): FTIR PS (10) +PVAc (90) (Toluene)

Figure 1(a), (b) and (c) depicts the FTIR spectra of PS: PVAc blend dissolved in MEK, THF and Toluene respectively in the wave number range 700 – 3800 cm^{-1}. From figures it is observed that the vibrational bands at (2924 and 2856), (3064 and 2920) and (2915 and 2852) cm^{-1} are ascribed to O–CH$_3$ (ester group) asymmetric stretching and symmetric stretching vibrations, respectively. The intense band at around (1729.40, 1727.65, 1728.50) cm^{-1} represents the C=O stretching band of an un-conjugated ester. At (1369.75, 1369.14, 1368.92) cm^{-1}, a prominent band is evident, here the CH$_3$ (C=O) group strongly absorbs acetate esters. The strong band at (1223.67, 1221.34, 1220.31) cm^{-1}and the band at (1116.63, 1109.94, 1106.34) cm^{-1}are ascribed to C–O–C symmetric stretching and C–O stretching vibrations, respectively. Also the peak at (944, 942, 941) cm^{-1}is ascribed to CH bending vibrations. This all show the evidences for PVAc [1]. However, each repeat unit in PS contains a pendant benzene ring. Mainly PS characterizing bands are observed. The methylene (CH$_2$) asymmetric stretching bands are observed at 3023.16 cm^{-1}. There is a C=O stretching at 1729.40 cm^{-1}. The out-of-plane C–H bending mode of the aromatic ring is shown at 944.57 cm^{-1}and the ring-bending vibrational band appears at 693 cm^{-1}[7-9].

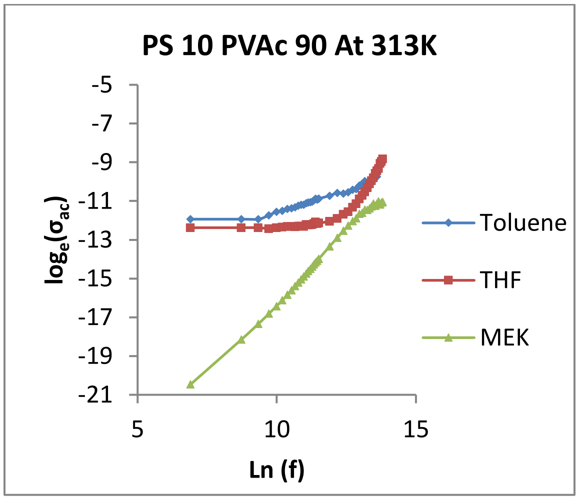
From FTIR spectrum of PS: PVAc polyblends it is also observed that spectrum that C=O stretching at 1727 cm^{-1} and C-C stretching in aromatic ring found at 1433 cm^{-1} and typical C–H bend being usually present as band at 1369 cm^{-1}. Some bands are disappeared in the blends and the intensity of some bands was changed. All results data suggest that homogeneous polymer composites are formed over all the blend compositions.

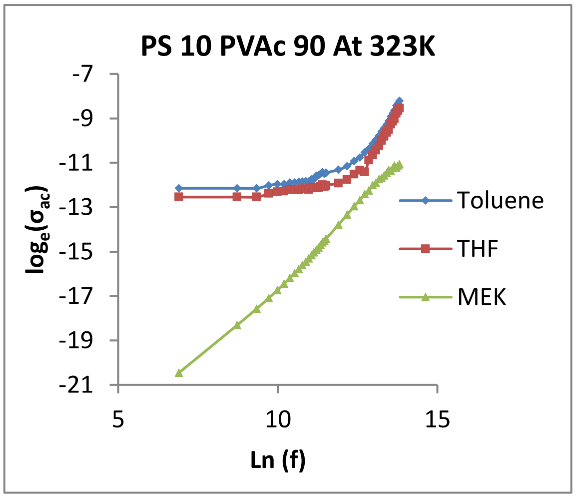
Further the FTIR spectrum recorded on PS: PVAc blend did not indicate the existence of any interaction between the components. There is no change in the position of either peak of aromatic ring of PVAc or the ether lone pair peak of PS, which means that neither ether linkage is interacting nor the aromatic ring is affected by blending these two polymers. Furthermore it is to be pointed here that the Sun's formula seems to be well applicable in describing the miscibility of PS: PVAc blend system [10].

AC Electrical Conductivity and Dielectric Constant Studies

Figure 2 (a) shows the relation between frequency and ac conductivity for (PS: PVAc) blends in MEK, Toluene and THF at constant temperature 313K, 323K, 333K and 343K. Plot shows rise in conductivity with increasing frequencies from 1 KHz to 10 MHz. The rise of conductivity on increasing the frequency and temperature is a common respond for polymeric thin films samples. It is due to the tremendous increase of the mobility of charge carriers in the blend films i.e. at higher frequencies blends of molecules starts vibrating with large amplitude within the polymeric chains hence the effect of increase in conductivity of blends [8,11].

It also shows that conductivity shifted above the frequency axis for blend dissolve in Toluene, THF and MEK solvent respectively. Further table 1 illustrates that Frequency their corresponding ac conductivities values for PS (10): PVAc (90). From table it's clear that PS: PVAc (THF as Solvent) shows maximum ac conductivity among other solvent samples. In observed that in same poly-blend film σ_{ac} increases with frequency which is the common characteristic of disordered materials. Hence an increase in frequency leads to increase in ac conductivity [12]. Furthermore, almost all the prepared PS: PVAc films show similar behaviour up to 10 MHz, which is typical for hopping conduction.





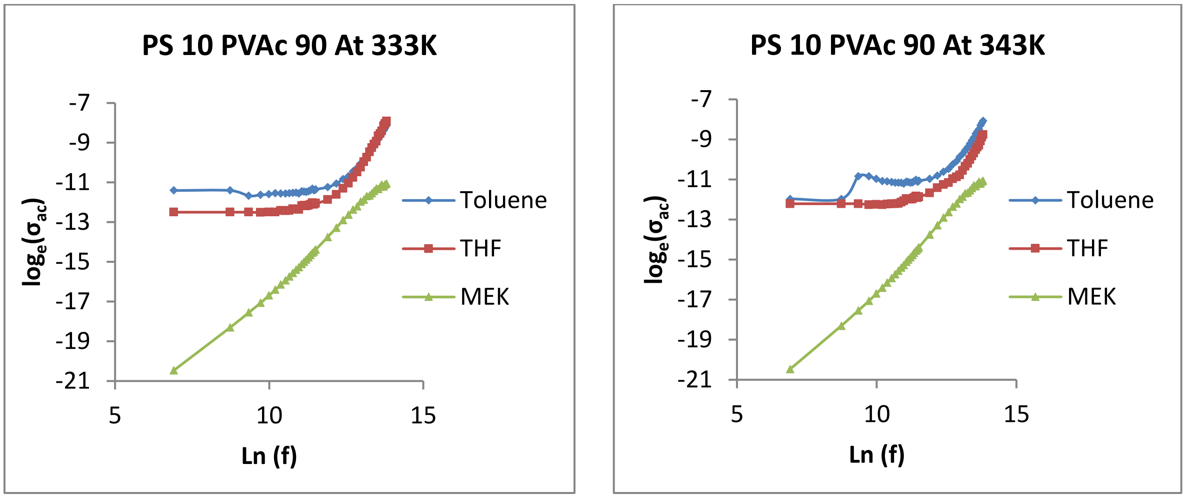


Fig. 2 (a): Variation between frequency and a.c. conductivity for blend in different solvent at constant temperatures.

Table 1: Frequency their corresponding a.c. conductivities values for PS (10): PVAc (90)

Constant Temperature	**Values**	**Solvent**					
		Toluene		**THF**		**MEK**	
313K	Frequency	1kHz	10MHz	1kHz	10MHz	1kHz	10MHz
	A.C. Conductivity ln[S/m]	1.6639	4.8380	1.09	8.88	0.5264	0.1263
323K	Frequency	1kHz	10MHz	1kHz	10MHz	1kHz	10MHz
	A.C. Conductivity ln[S/m]	0.2221	7.6013	1.34	5.91	0.5314	0.1037
333K	Frequency	1kHz	10MHz	1kHz	10MHz	1kHz	10MHz
	A.C. Conductivity ln[S/m]	0.2501	7.9442	1.09	8.88	0.5355	0.1072
343K	Frequency	1kHz	10MHz	1kHz	10MHz	1kHz	10MHz
	A.C. Conductivity ln[S/m]	1.3705	8.5226	1.18	5.50	0.6217	0.1771

Figure 2 (b) shows the relation between frequency and dielectric constant for (PS:PVAc) blends in different solvent i.e. Toluene, THF and MEK at constant temperatures 313K, 323K, 333K and 343K. Plot shows rise in dielectric constant with increasing frequencies from 1 KHz to 15MHz**.** The rise of dielectric constant upon increasing the frequency and temperature is a common respond for all blends samples [11, 13-14]. Table 2 illustrates that Frequency their corresponding dielectric constant values for PS (10): PVAc (90). From table it's observed that PS: PVAc (THF as

Solvent) shows maximum dielectric constant among other solvent samples. For the future research scope THF dissolve polyblends samples will used.

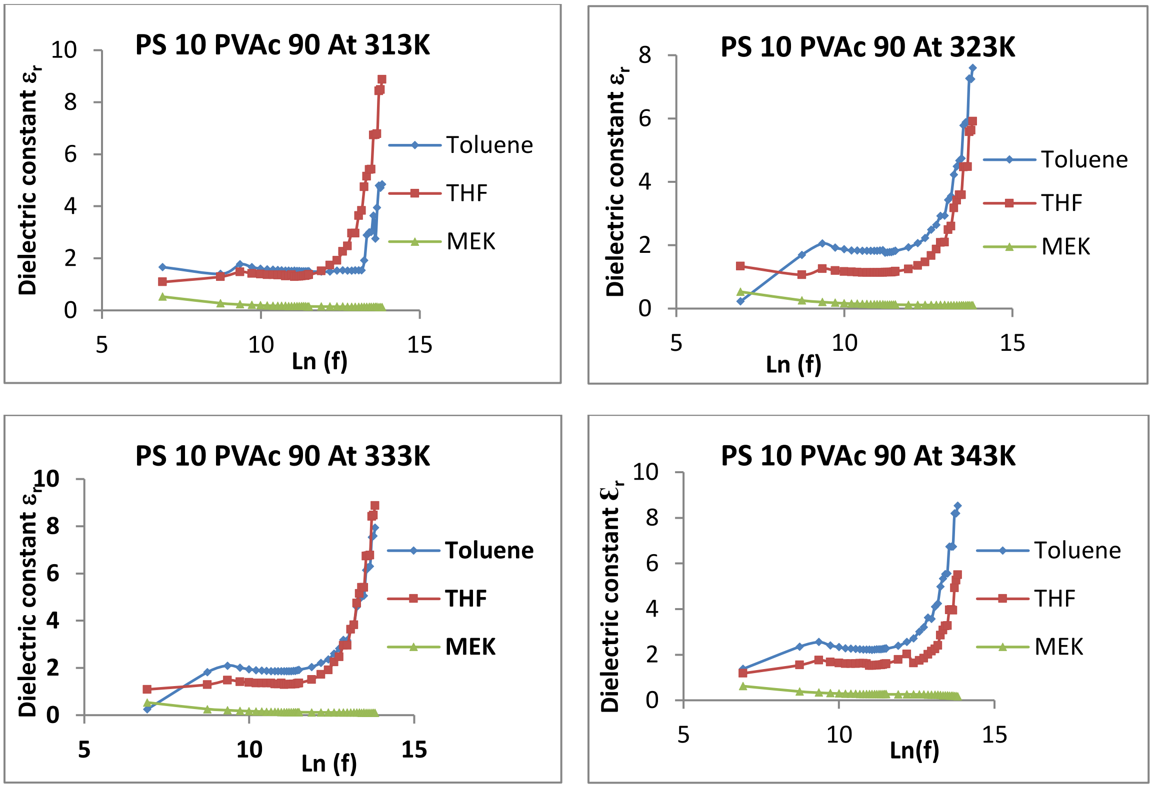


Fig. 2 (b): Variation between frequency and dielectric constant for blends in different solvent at constant temperatures.

Table 2: Frequency their corresponding dielectric constant for PS (10): PVAc (90)

Constant Temperature	**Values**	**Solvent**					
		Toluene		**THF**		**MEK**	
313K	Frequency	1 kHz	10MHz	1 kHz	10MHz	1kHz	10 MHz
	Dielectric Constant	1.6639	4.8380	1.09	8.88	0.5264	0.1263
323K	Frequency	1 kHz	10MHz	1 kHz	10MHz	1kHz	10 MHz
	Dielectric Constant	0.2221	7.6013	1.34	5.91	0.5314	0.1037
333K	Frequency	1 kHz	10MHz	1 kHz	10MHz	1kHz	10 MHz
	Dielectric Constant	0.2501	7.9442	1.09	8.88	0.5355	0.1072
343K	Frequency	1 kHz	10MHz	1 kHz	10MHz	1kHz	10 MHz
	Dielectric Constant	1.3705	8.5226	1.18	5.50	0.6217	0.1771

CONCLUSIONS

FTIR results concludes that miscibility of PS (10): PVAc (90) polymer blends were maximum in Toluene, moderate in THF and minimum in MEK solvents. Hence all samples show the miscibility existence.

The ac electrical conductivity and dielectric constants have been measured for (PS:PVAc) blends in different solvent i.e. MEK, THF and Toluene at constant temperature 313K, 323K, 333K at the different frequencies. It is found that ac conductivity of blends thin film increases with increase in frequencies at constant temperature and also the dielectric constant increases with the increasing frequencies of blends. Further graphs revels that Toluene dissolve blend shows maximum ac conductivity at different constant temperature, THF dissolve blend shows moderate ac conductivity range while MEK dissolve blend shows minimum ac conductivity. Furthermore in case of dielectric constant similar consequence follows all blend samples.

ACKNOWLEDGEMENT

Financial support and characterization facility sanctioned by UGC-DAE Consortium for Scientific Research Indore Centre under Collaborative Research Project (2017-18) for this work is gratefully acknowledged by authors.

Conflict of Interest: None

REFERENCES

1. Cristovan, F. H., Paula, D. F. R., Lemos, S. G., De Oliveira, A. J. A., & Pereira, E. C. (2009). DC conductivity study of polyaniline and poly (acrylonitrile-butadiene-styrene) blends. *Synthetic Metals*, *159*(21), 2188-2190. DOI: https://doi.org/10.1016/j.synthmet.2009.08.042
2. I.S. Elashmawi, N.A. Hakeem, and E.M. Abdelrazek, (Oct 2008), Spectroscopic and thermal studies of PS/PVAc Blends; *Physica B: Condensed Matter* volume 403 issue 19-20, 3547 - 3552, https://doi.org/10.1016/j.physb.2008.05.024
3. H. Rawal and S. Devi, (Dec 1993), Compatibility of Poly(styrene)/Poly(vinyl acetate) Blends; *Polymer Journal*, volume 25 issue 12, 1215 to 1221 https://doi.org/10.1295/polymj.25.1215
4. S.G. Vidhale and N.G. Belsare, (2013), Effect of IR Radiation on the Dielectric Properties of Salicylic Acid Doped Poly- blend Thin Films of PS and PMMA; *International Journal of Scientific & Engineering Research*, Vol.4 [09].
5. P.A.P. Mamza and B.T. Nwufo, (22 Jan 2010), Density and Morphological Properties of Some Reinforced Polymers; *Nigerian Journal of Basic and Applied Sciences* volume 17 issue 2, https://doi.org/10.4314/njbas.v17i2.49888.
6. M. M. Kummali, G. A. Schwartz, Angel Alegría, Richard Arinero, Juan Colmenero, (15 Sep 2011), Compatibility studies of polystyrene and poly(vinyl acetate) blends using electrostatic force microscopy; *Journal of Polymer Science Part B: Polymer Physics* volume 49 issue 18 pages 1332 - 1338, https://doi.org/10.1002/polb.22301.
7. P.P. Raut, G.T. Lamdhade, F. C. Raghuwanshi, T. Shripathi, (2016) *National Conference on Material Science and Renewable Energy Sources (NCMSRES) Proceeding*, 200-202.
8. N. G. Belsare, A.S. Wadatkar, R. V. Joat, T. S. Wasnik, F. C. Raghuwanshi, K. B. Raulkar, and G.T. Lamdhade, (2011), Polyvinyl chloride–polymethyl methacrylate micro-composite polymers: miscibility; *Journal of Electron Devices*, 11, 583-587.
9. V.Rao, P.V Ashokan, M.H Shridhar, (April 2000), Studies of Dielectric Relaxation and A C Conductivity on Cellulose Acetate Hyderogen Phthalate-Poly(Methyl Methacrylate) Blends); *Materials Science and Engineering: A*; volume 281 issue 1-2,pages 213 to 220, https://doi.org/10.1016/s0921-5093(99)00723-6.
10. Mohammad Saleem Khan, Raina Aman Qazi and Mian Said Wahid, (April, 2008), Miscibility studies of PVC/PMMA and PS/PMMA blends by dilute solution viscometry and FTIR; *African Journal of Pure and Applied Chemistry*, Vol. 2 (4), pages 041-045.
11. H. Kaczmarek, (Nov 1995), Photodegradation of polystyrene and poly(vinyl acetate) blends—I. Irradiation of PS/PVAc blends by polychromatic light; *European Polymer Journal* volume 31 issue 11, 1037 - 1042, https://doi.org/10.1016/0014-3057(95)00094-1

12. K. Prabha, H. S. Jayanna, (2015), Study the Frequency Dependence of Dielectric Properties of Gamma Irradiated PVA(1-x)PSx Polymer Blends; *Open Journal of Polymer Chemistry* volume 05 issue 04 , 47 - 54, https://doi.org/10.4236/ojpchem.2015.54006
13. P. Dutta, S. Biswas, M. Ghosh, S. K. De and S. Chatterjee, (Jun 2001) The dc and ac conductivity of polyaniline–polyvinyl alcohol blends; *Synthetic Metals* volume 122 issue 2, 455 - 461, https://doi.org/10.1016/s0379-6779(00)00588-9.
14. I.C. McNeill, (May 1997), Thermal degradation mechanisms of some addition polymers and copolymers; *Journal of Analytical and Applied Pyrolysis*; volume 40-41, 21- 41, https://doi.org/10.1016/s0165-2370(97)00006-5