Bulletin of Pure and Applied Science Physics, Vol.42D No.1, January-June 2023 P.35-45
Original Research Article

Print version ISSN 0970 6569
Online version ISSN 2320 3218
DOI: 10.48165/bpas.2023.42D.1.3
Available online at www.bpasjournals.com

Study of Optical Properties of PVC/Ag_2O Nano-Composites by Dispersing Spherical Nanofillers into Polymer Matrix under Normal and Heat Treated Conditions

[1]Aman Kumar*, [2]M.K. Bhatt, [3]Md. Shabbir Ahmad, and [2]N.A. Karimi

Author's Affiliations:
[1]Department of Physics, Patna Science College, Patna University, Patna, Bihar 800005, India
[2]Department of Physics, B.N. College, Patna University, Patna, Bihar 800005, India
[3]Hadi Hashmi Senior Secondary School, Gaya, Bihar 823001, India

***Corresponding author:**
Aman Kumar
Department of Physics, Patna Science College, Patna University, Patna, Bihar 800005, India
E-mail: dr.aman03@rediffmail.com

Received on 21.01.2023
Revised on 30.03.2023
Approved on 26.04.2023
Accepted on 03.05.2023
Published on 17.06.2023

ABSTRACT In the present work a novel polymer / metal oxide composites containing Polyvinyl Chloride (PVC) and Ag_2O nanoparticles (NP) were fabricated under room and elevated temperatures. The PVC / Ag_2O NC has been fabricated to enhance the electronic application such as memory devices, sensors, electronic luminescent devices and medical applications. The Ag_2O NP was synthesized by dropwise mixing process having 25 nm in size with spherical surface morphology. The Fourier transform infrared spectroscopy (FTIR) was taken for (1) virgin PVC film (2) PVC / Ag_2O NC and PVC / Ag_2O (heat treated) Composites. The formation of absorbance peaks, their shifting, intensity and maximum absorbance values were considered in all the three C-C, C-Cl and C-H classified stretching modes of vibrations for different composites. It was found in C-C stretch range the virgin PVC back bone chain occurs at 1101 cm^{-1} which shifted to 1076 cm^{-1} for PVC / Ag_2O NC, further shift is evident for PVC / Ag_2O (heat treated) Composites at 1151 cm^{-1}. In addition rocking vibration and wagging of methylene group changes in the same fashion. The change in spectral feature takes places due to filling of Ag_2O NP in PVC matrix, indicates that changes in dipole moments occur as a result of molecular vibrations. It is also observed the absorbance peaks value is high for virgin PVC film for all modes of stretching vibration, which decreases for Ag_2O / PVC (NC) further decrease is evident for Ag_2O / PVC (NC) heat treated composite.

KEYWORDS Polymer nanocomposite; Ag_2O NP; PVC matrix; FTIR; Optical Properties

How to cite this article: Kumar A., Bhatt M.K., Ahmad M.S., and Karimi N.A. (2023). Study of Optical Properties of PVC / Ag_2O Nano-Composites by Dispersing Spherical Nanofillers into Polymer Matrix under Normal and Heat Treated Conditions. *Bulletin of Pure and Applied Sciences- Physics,* 42D (1), 35-45.

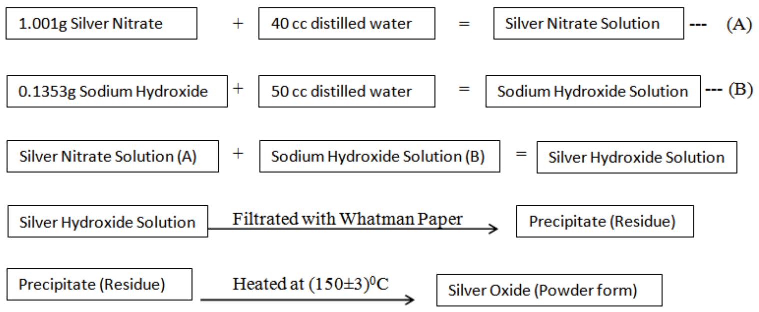
1. INTRODUCTION

A composite in the form of film is a combination of two different materials in different phases in different proportion, where the individual constituents retain their separate identities. It may have two or more than two phases, one phase is called matrix (primary phase) and the other the dispersed phase (reinforced phase).The dispersed phase is embedded in the matrix in a discontinuous form. Polymer composite is a combination of Polymer (matrix) and filler (reinforcement). It has low weight corrosion resistance, high fatigue strength and faster assembly. It is used as a materials in making aircraft, structures, electronic packing to medical equipment and space vehicle [1-2]. Several interaction exits between the monomer and nanoparticle precurs or during the synthesis of polymer nanoparticle (PVC-NP) composite. These interactions include functional group attached on polymer (matrix) chain with polymer-particle surface, positive or negative charges on polymer with polyelectrolyte's, chelation and co-ordination interaction can be employed to immobilize nanoparticle on the surface of polymer particles.

Silver nanoparticle is a material which is used in washing machines, refrigerators, air conditioners, air purifiers, vacuum cleaners due to antibacterial behavior [3-4]. Due to its high electrical conductivity, and unique optical properties, their metal and oxides nanoparticle combine with or reinforce in polymers attracted in very wide applications [5]. It is also well known that Polymer such as Polyvinylchloride has high dielectric material, acts as good host matrices, which encapsulates nanoparticle and metals such as Zinc, Gold, Copper provides capping agent and also chemical stability. The Polymer-Silver nanoparticle composites is very encouraging material in the field such as optical, thermal and electrical etc. [6]. On the other hand Silver nanoparticle proved a considerable agent as antimicrobial properties. In the paper we have fabricated Polymer- nanocomposite systems containing Polyvinyl chloride (PVC) and Silver Oxide (Ag_2O) nanoparticle under different thermal conditions, where the Silver Oxide nanoparticle of size 25 nm having spherical morphology will be filled in PVC matrix. FTIR spectroscopy detects fundamental groups, like Vibrational bands C=C, C-H, C-Cl etc. The FTIR of these bands is fundamental for the investigation of variation of absorbance with energy due to filling of Ag_2O NP into PVC matrices. The FTIR spectrum of virgin PVC film and PVC / Ag_2O composites at room and elevated temperatures will be analyzed at different stretching vibrational modes.

2. EXPERIMENTAL

Schematic view of Synthesis of Silver Oxide Nanoparticles by Sol-Gel Method



Silver nitrate and Sodium hydroxide are used for the preparation of Ag_2O nanoparticles [2-3]. Polyvinyl Chloride in granules form and cyclohexanone as a solvent were used for the synthesis PVC/Ag_2O composites.

We have acquired PVC (polyvinyl chloride) from Reliance Industries Gujarat, India in granule form. We have measured 4 gm PVC by analytical Balance OHAUSE, U.S.A. and 20 cc cyclohexanone (acquired from SDFCL Fine –Chem. Limited, Mumbai) was taken in burette. We put 4 gm PVC into 20 cc cyclohexanone. It was left for 72 hrs. to dissolve completely then it was stirred for 30 minutes. Thus the solution was prepared.

The nanoparticles of Ag_2O (Concentration = 0.00225 gm/cc) as prepared by Sol-Gel method, were spread on the solution of (PVC + cyclohexanone) uniformly. Then it was stirred for 4.30 hrs. and that it was spread on the glass plate floating on mercury for leveling and left for approximately 1 weak for drying in vacuum oven at room temperature. It was then removed from glass plate. Thus the film of PVC doped with nanoparticle was prepared.

Next for the preparation of Ag_2O/PVC nanocomposite at elevated temperature, the Ag_2O NP was spread in PVC cyclohexanone solution and stirred at temperature 50^oC for 4.30 hrs.

3. RESULT AND DISCUSSION

The IR transmittance spectra of virgin PVC film, PVC / Ag_2O composite without heating and PVC/Ag_2O composite with heat treated during the formation of composite are shown in figure 1, figure 2, and figure 3 respectively in the region 500-4500 cm^{-1}. The characteristics of bands are broadly classified in C-Cl stretching region (400-800 cm^{-1}), C-C stretching (900-1500 cm^{-1}) and the third one C-H stretching region falls from 2700 to 3600 cm^{-1}.

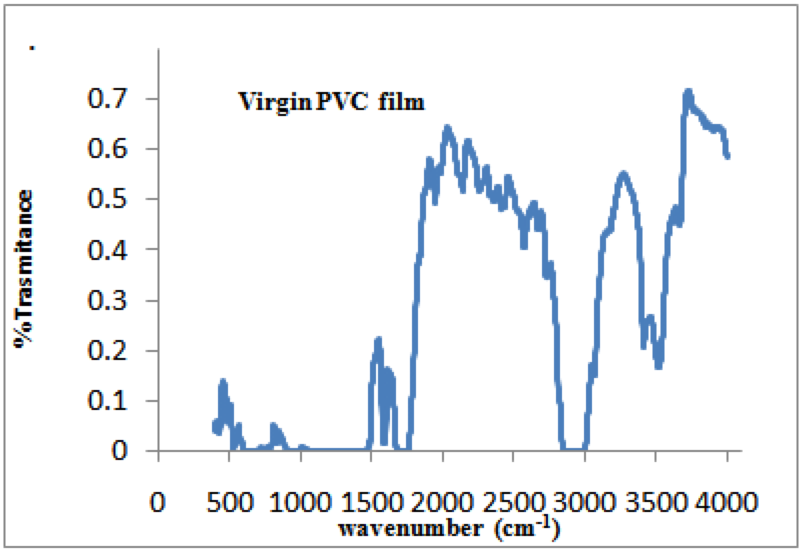


Figure 1: FTIR Spectra of PVC virgin film

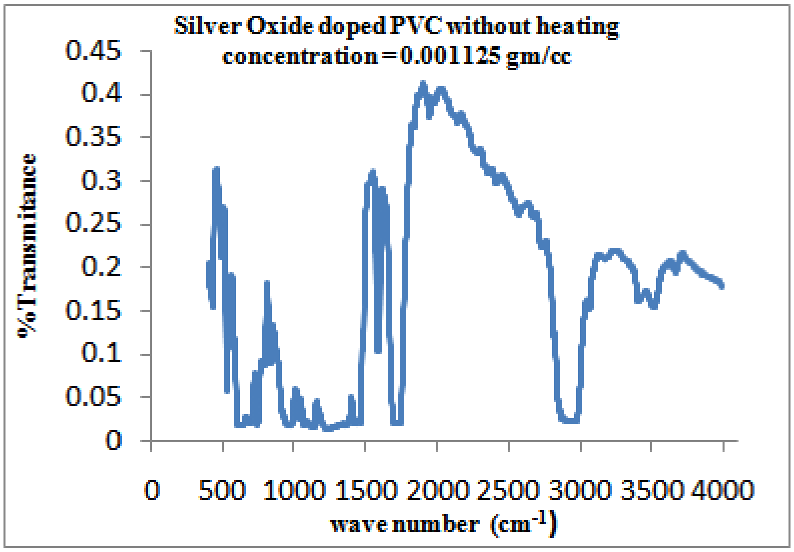


Figure 2: FTIR Spectra of PVC / Ag_2O composite

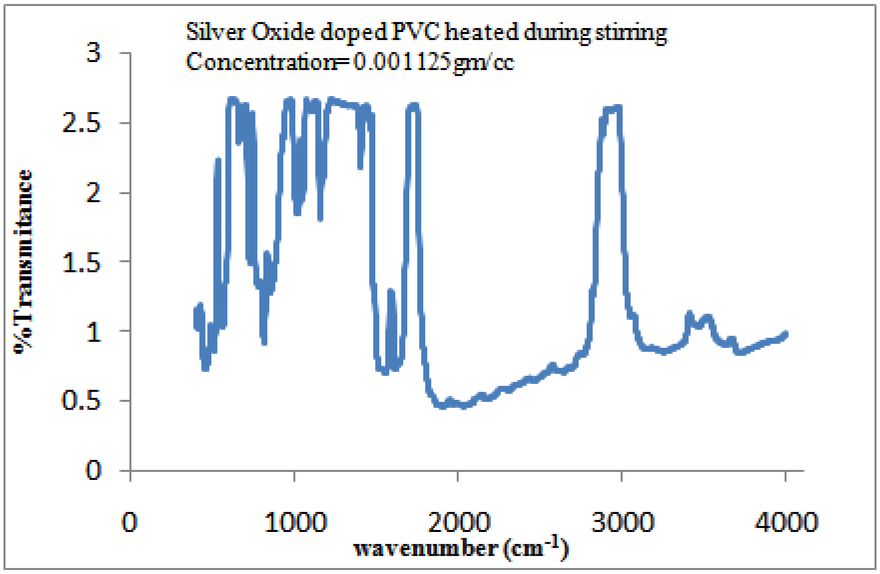


Figure 3: FTIR Spectra of PVC / Ag_2O heat treated composite

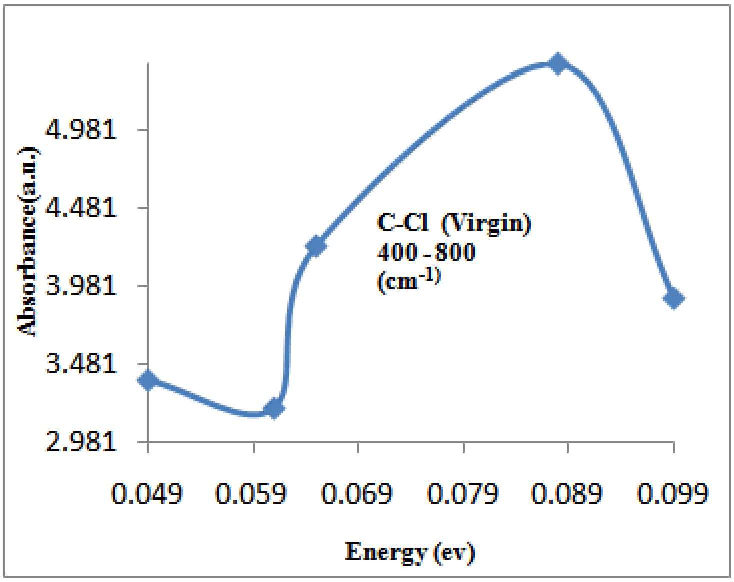


Figure 4a: Variation of absorbance with energy

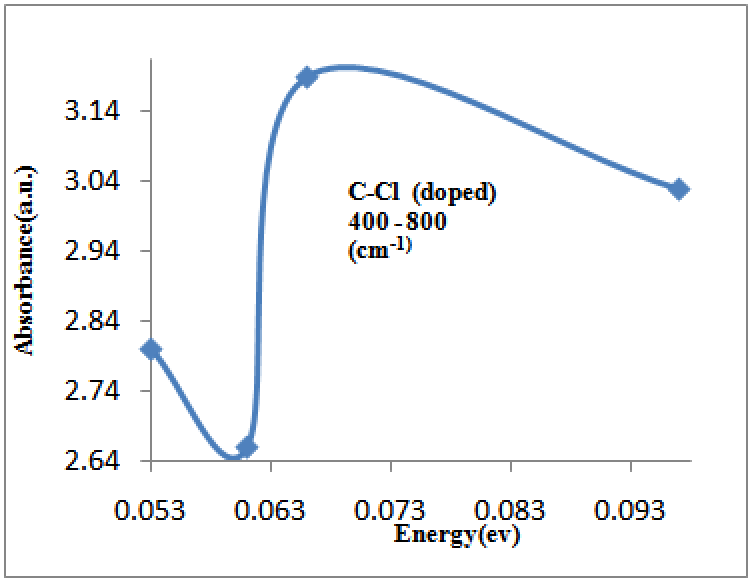


Figure 4b: Variation of absorbance with energy

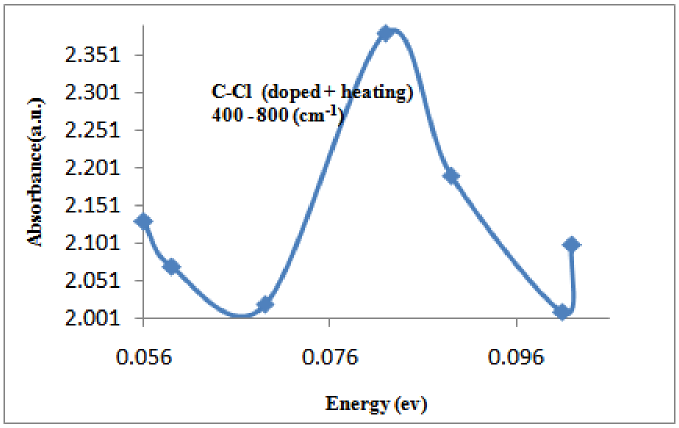


Figure 4c: Variation of absorbance with energy

As evident from Table 1, the FTIR spectrum of virgin PVC film of C-H stretching mode, shows the stretching peaks, occur at 2726, 2846, 3043 and 3049 cm^{-1}. The shifting and formation of new peaks takes place for PVC/Ag_2O and PVC/Ag_2O (heat treated) nanocomposite. In C-C stretch bond, the absorption peaks are evident at 1427 and 1579 cm^{-1}, which indicates the wagging of methyl group for virgin PVC film, where the peak at 1427 cm^{-1} shifted to 1317cm^{-1} for PVC/Ag_2O nanocomposite, which further shifted to 1479 cm^{-1} for PVC/Ag_2O (heat treated) composite. In addition the next peak 1579 cm^{-1} shifts to 1608 cm^{-1} for PVC/Ag_2O (heat treated) composite. In the same C-C stretch bond of virgin PVC, backbone chain occurs at 1101 cm^{-1} which shifted to1076 $cm^{-1}$and 1151$cm^{-1}$for PVC/Ag_2O and PVC/Ag_2O (heat treated) composite respectively. In addition anew absorption peak comes into existence at 1191 $cm^{-1}$for PVC/Ag_2Ocomposite and 1400 cm^{-1} for PVC/Ag_2O (heat treated) composite. The rocking vibration of CH_2 are recorded at 937 and 987 $cm^{-1}$for virgin PVC followed by shifting and formation of new peaks for both Polymer Nano-Composite prepared at room and heat treated temperatures.

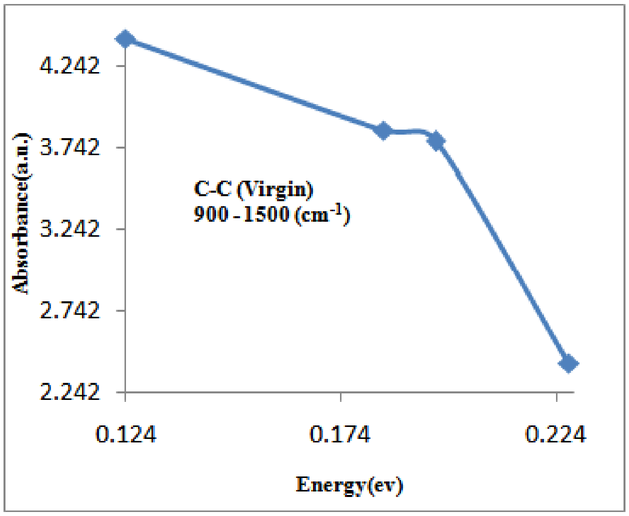


Figure 5a: Variation of absorbance with energy

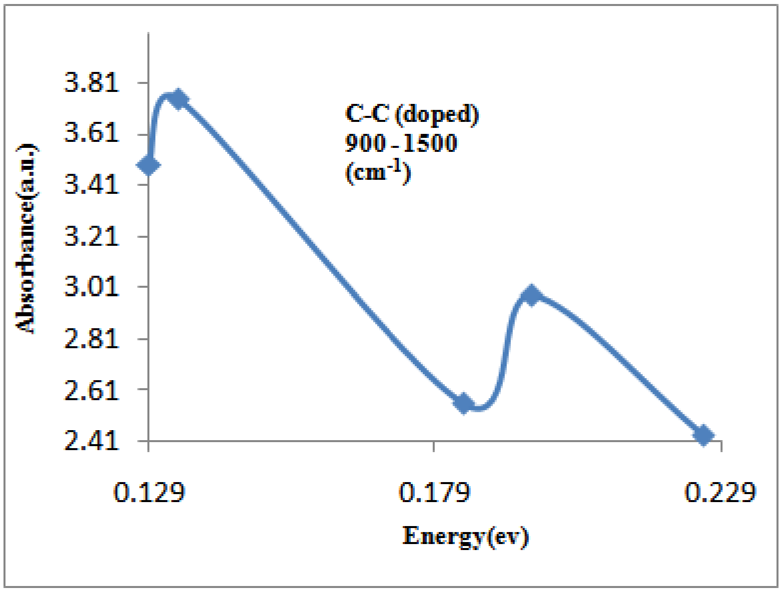


Figure 5b: Variation of absorbance with energy

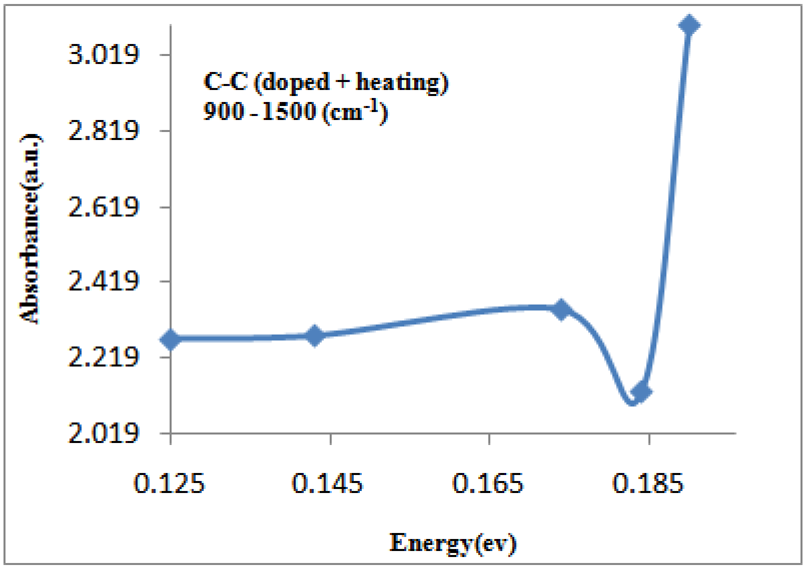


Figure 5c: Variation of absorbance with energy

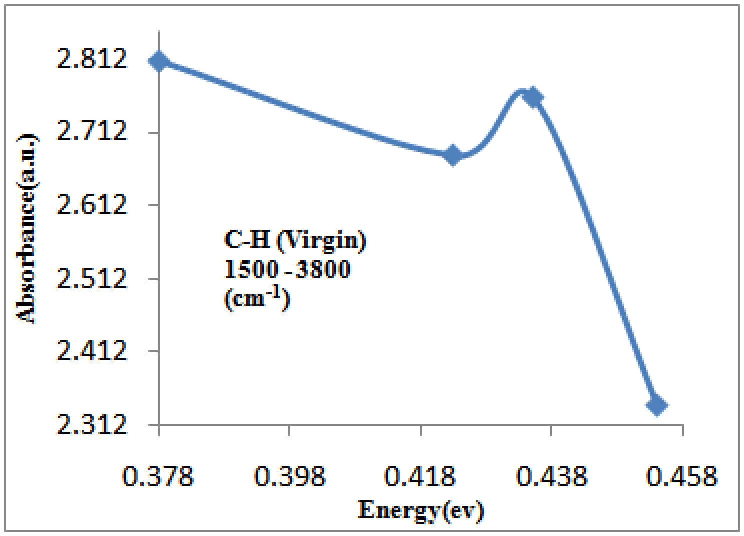


Figure 6a: Variation of absorbance with energy

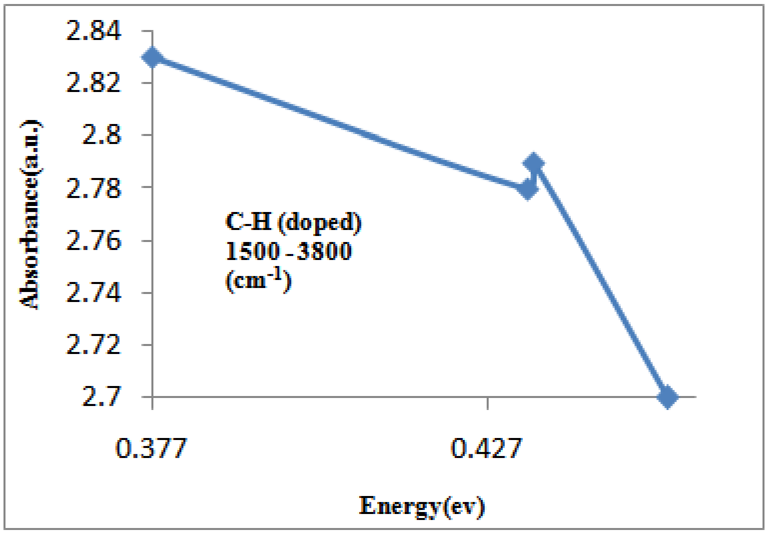


Figure 6b: Variation of absorbance with energy

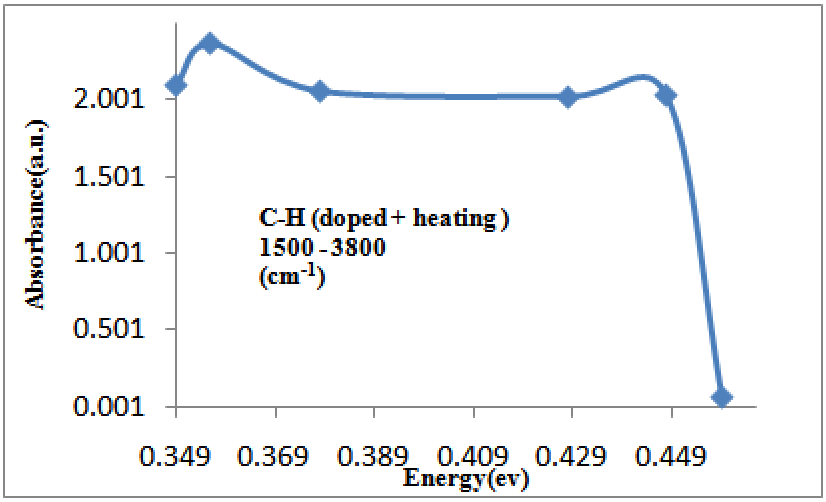


Figure 6c: Variation of absorbance with energy

Table 1: Different FTIR vibrational group of frequencies (wave numbers) associated of Pure PVC, PVC-Ag_2O (room temperature) and PVC-Ag_2O (heating treated) composites.

Mode of vibration	**wave numbers (cm^{-1})**		
(1) C-Cl (400-800 cm^{-1})	PVC Virgin	PVC-Ag_2O (room temp.)	PVC-Ag_2O (heat treated)
	399	……	……
	483	……	……
	……	426	406
	……	437	449
	……	538	503
	593	576	557
	682	601	659
	707	703	723
	800	777	808
(2) C-C (900-1500 cm^{-1}) (Rocking vibration of CH_2)	937	927	1006
	987	941	1027
	……	989	1087
(3) C-C (Back Bone chain) Wagging of methyl group	1101	1076	1151
	……	1191	1400
	1427	1317	1479
	……	1359	1517
	1579	1579	1608
(4) C-H (2700-3400 cm^{-1})	2726	2723	2730
	2846	2865	2867
	……	2927	2867
	3043	3037	3043
	3049	3403	3426
	……	3490	……
	……	3654	3600
	……	……	3695

Table 2: Variation of absorbance with energy (ev) of pure PVC film, PVC/Ag_2O and PVC/Ag_2O (Heat treated) composite.

	Polymer nanocomposite	**Absorbance(a.u.) Peak value**	**Photon Energy(ev)**
C-Cl (400-800 cm^{-1})	Virgin (PVC)	5.4	0.088 ev
	Ag_2O/PVC	3.19	0.066 ev
	Ag_2O/PVC (heat treated)	2.38	0.082 ev
C-C (900-1500 cm^{-1})	Virgin (PVC)	3.75	0.134ev
	Ag_2O/PVC	2.98	0.134 ev
	Ag_2O/PVC (heat treated)	3.35	0.174 ev
C-H (2700-3400cm^{-1})	Virgin (PVC)	2.76	0.435 ev
	Ag_2O/PVC	2.79	0.434ev
	Ag_2O/PVC (heat treated)	2.34	0.356 ev

At lower ranges (400 – 800 cm^{-1}) of frequencies, the C- Cl vibrational absorbance bands are formed at 399, 483, 593, 682, 707 and 800 cm^{-1} for virgin PVC film. The vibrational bond at 399 and 483 (lower than 500 cm^{-1}) are appeared due to impurities present in PVC film. Next a vibrational bond at 538cm^{-1} arises due to filling of Ag_2O NP, where interaction with PVC segment and chain occurred, which shifted to 503 $cm^{-1}$for PVC/Ag_2O (heat treated) composite. The spectrums stated are very comparable to that of earlier report [9, 10].

In addition a new absorption peaks comes into existence at 1191 PVC/Ag_2O Composite, which shifted to a high value 1400 cm^{-1} for PVC/Ag_2O (heat treated) composite. The rocking vibrations of CH_2 are recorded at 937 cm^{-1} and 987 cm^{-1} for virgin PVC followed by shifting and formation of new peaks for both Polymer nano composite. At lower ranges (400-800 cm^{-1}) of C-Cl, vibrational absorbance bonds are formed at 399, 483, 593, 682, 707, and 800 cm^{-1} for virgin PVC film.

The vibrational bond at 399 and 487 (lower that 500 cm^{-1}) are appeared due to impurities present in PVC film. Next a vibrational bond at 538 cm^{-1} arises due to filling of Ag_2O NP, where interaction with PVC segment and chain occurred, which shifted to 503 cm^{-1} for PVC/Ag_2O (heat treated) composite. The spectrums stated are very much comparable to that of earlier report [9, 10].

The change in spectral feature like new absorption peaks and change in intensities and shifting indicates that changes in dipole moment occur as a result of molecular Ag_2O NP and also effect of heating during fabrication of composite [11-12]. The fig (4a), (4b), (4c) and (5a), (5b), (5c) and (6a) (6b) (6c) shows the variation of absorbance with energy (ev) for each stretching modes C-Cl, C-C and C-H stretching mode of vibrations respectively for virgin, doped and doped with heat treated composites. It is observed in table (2) that the absorbance peak show high value for virgin samples for all modes of stretching vibration. It is also evident that the absorption peak decreases accordingly for PVC/Ag_2O and PVC/Ag_2O NP (heat treated) composites.

4. CONCLUSION

A new PVC/Ag_2O and PVC/Ag_2O (heat treated) composite were fabricated, where nanoparticles of Ag_2O having spherical morphology were obtained by Sol- Gel method and drop wise mixing process.

1. The FTIR vibrations shows that for PVC virgin film in C-H stretching mode, the absorption peaks observed at 2726,2846,3043 and 3049cm-Due to filling of such nanoparticles i.e. formation of PVC/Ag_2O PNC, new absorption peaks observed at 2927 and 3654 cm^{-1}, which shifted to 2867 and 3600cm^{-1} respectively for PVC/Ag_2O (heat treated) composites.
2. In the C-C stretch range of virgin PVC backbone chain occurs at 1101 cm^{-1} which shifted to1076 cm^{-1} for PVC/Ag_2O PNC, further shifted to 1151 cm^{-1} for heat treated PVC/Ag_2O PNC. In addition, new peaks are formed at 1191 cm^{-1} for PVC/Ag_2O PNC, which shifted to 1400 cm^{-1} for heat treated sample. In the same C-C stretch band is observed for wagging of methyl group and rocking vibration takes place with a changed value of frequencies.
3. From the variation of absorbance with energy (ev) it is evident that the absorbance peak shows high value for virgin sample which decreases for PVC/Ag_2O composites, and further decrease takes place for PVC/Ag_2O (heat treated) PNC in the C-C stretch range, where as in the other band the decreasing trend is smaller.
4. It is markable observation that higher the photon energy (ev) is required to get the peak absorbance value as we move from C-Cl to C-C and up to C-H mode of vibrations.
5. Considerable variation of absorbance is recorded due to interaction of incident photon energy and polymeric metal oxide nanocomposite in normal and heat treated condition.

Acknowledgements

The authors are grateful to University Grant Commission (U.G.C.) for financial assistance to the Major Research Project No. 34–33/2008 (SR) dt. 29/12/2008, runs under Dr. N. A. Karimi as Principal Investigator. We are also thankful to UGC- DAE Consortium for Scientific Research Indor, for providing FTIR Spectroscopic facilities to characterize the nanocomposite films. We are also very much obliged to the Principal and HOD, Dept of Physics, B. N. College, Patna University Patna for the use of their Nanoscience Laoratory..

REFERENCES

1. A. V. and Balachandar, V., (2018). J. Surface Sci. 34, 121.
2. Kumar, A., Bhatt, M.K., Bhatt, R.J., Karimi, N.A., (2010). Bulletin of Pure and Applied, Science. 29C(2), 101.
3. Kumar, A. and Karimi, N.A., (2015). J. Surface Sci. Technol., 31(3-4), 179.
4. Subban, Rhy.,Arof, A.K., (2004). Eur, Polym. J. 40(8), 1841.
5. Afiq, M., Siddqui, M., et al, (2013). Asian journal of Chemistry 25(6), 3405.
6. Vishnpriya, R., Mulrali, M.K., (.2019) International journal of Basic and Applied research, 9, 418.
7. Tanaka, T., and Imai, T., (2017). 'Advanced Nanodielectrics', (USA, Panstanford) 13.
8. Nesher, G., Marom, G. and Avnir, D., (2008). 'Metal Polymer Composites and Characterization of Polyanilin and other Polymer at Silver Composition .Chemistry and Materials', 20, 4425.
9. Temgire, K., and Joshi, S.S., (2004). 'Optical and structure studies of silver nanoparticles' Radion puppies and chemistry, 5, 1039.
10. Karimi, N.A. et. al. (2006). 'Bulletin of Pure Applied Science', 25-D.
11. Khare, P.K., Panday, R.K. and Jain, P.L., (2000). Bull Matter Sci. 23, 4.
12. Shrivastav, S., Haridas, M. and Basu, Ju., (2018). Bull Mater. Sci., 31,213.