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Optical and thermal properties of Parkia powder and its blend with Poly(vinyl pyrrolidone)

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Thermal properties of weight loss and melting temperatures for samples of Parkia Powder (PP) and its blend with Poly(vinyl pyrrolidone) (PVP) at 50 weight percentage have been studied using TGA and DSC. The samples are characterized by using FTIR over the range of 4000-500 wave numbers (cm^{-1}). The optical absorption for these samples is also studied using UV-vis Spectrometer over the range of 200-750 nm. The absorption edge of PP is 229 nm and that of PVP is 257 nm, but for their blend absorption edge shifted to 338 nm.

Keywords : Weight loss, melting temperature, optical absorption, Optical band gap, FTIR.

Introduction : Polymers are the materials of great interest in these days because of their extensive applications in the current technology and easy fabrication of thick and thin sample etc. One of the most valuable properties of polymers is their capacity to inhibit electrical conductivity as insulator, but now they are attracting considerable attention as conducting polymer. The technique of blending of polymers has become the centre of attraction because one can design the material of required properties. As there are significant technological applications of these synthetic polymers, it is important to explore the dynamics of these polymers in various environments. Poly (vinyl) pyrrolidone (PVP) is known to have a growing pharmaceutical importance and possesses good electrical properties [1 - 4] which are greatly modified by impregnating it with suitable blending with other polymers. PVP is a biopolymer with molecular formula $(\text{C}_6\text{H}_9\text{NO})_n$. It is white to light yellow,

hygroscopic, amorphous powder [5, 6]. PVP is a potential material having a good charge storage capacity and dopand-dependent electrical and optical properties. Chemically PVP has been found to be inert, non-toxic and interestingly, it displays a strong tendency for complex formation with a wide variety of smaller molecules [7 - 9]. Parkia powder (PP) is from pods of the tree belongs to the family of Leguminosae. Hence the PVP and its addition with parkia powder on physicochemical properties such as thermal stability and parameters of thermal decomposition and optical properties of composites have been studied in the present work.

Materials and Methods : The polymer substance of Poly (vinyl) pyrrolidone (PVP) is obtained from S.d. Fine Chem Ltd, Mumbai, India and the Parkia powder (PP) is obtained from the pods of tree species belongs to the subfamily Mimosoideae and family Leguminosae [10, 11].

The blends of PVP are obtained with parkia powder (PP) in the ratio of 50:50 weight percent. The samples are characterized by using FTIR over the range of 4000 - 500 wavenumbers (cm^{-1}). The thermal properties of PP and PP with PVP are analyzed by using DSC and TGA (Model : Perkin Elmer 7 series). Initially, weight of the sample was 3 mg which was scanned in temperature range of 0-600 °C for TGA at heating rate of 20 °C/min under nitrogen purge and DSC was scanned in the temperature range of 0 - 300 °C at heating rate of 15 °C/min. Further, the optical absorption studies are carried out using UV-visible spectrophotometer (PC2000 ISA) over the range of 200 - 750 nm.

Results and Discussion :

FTIR Spectra: The spectra of FTIR are obtained from the perkin-Elmer FTIR 1650 spectrometer at room temperature using KBr disc method for

characterizing the polymer. The sample was scanned over the range of 4000 - 400 cm^{-1} wavenumbers. The FTIR spectra for optical absorbance in PP and its blend with PVP are given in (Figure 1) and (Figure 2) respectively. The FTIR spectra for pure PP clearly indicates that the absorbance peak correspond to the characteristic chemical bonds present in PP. In Figure (1), the absorbance peak occurs at wavenumber 3395.47 cm^{-1} corresponds to C-H stretch for aromatics, 1650 cm^{-1} N-H bending for amines, 1760 cm^{-1} C=O carboxylic acids, 2926.01 cm^{-1} corresponds to C-H stretch for alkenes. In case for the blending of PP with PVP at 50 weight percent the spectra is given in (Figure 2), and is observed the peaks around the same bands of PP except slight shift in the absorbance peaks with in around 5 - 20 bands. This indicates that the presence of same functional groups and the blends have less absorbance than that of PP.

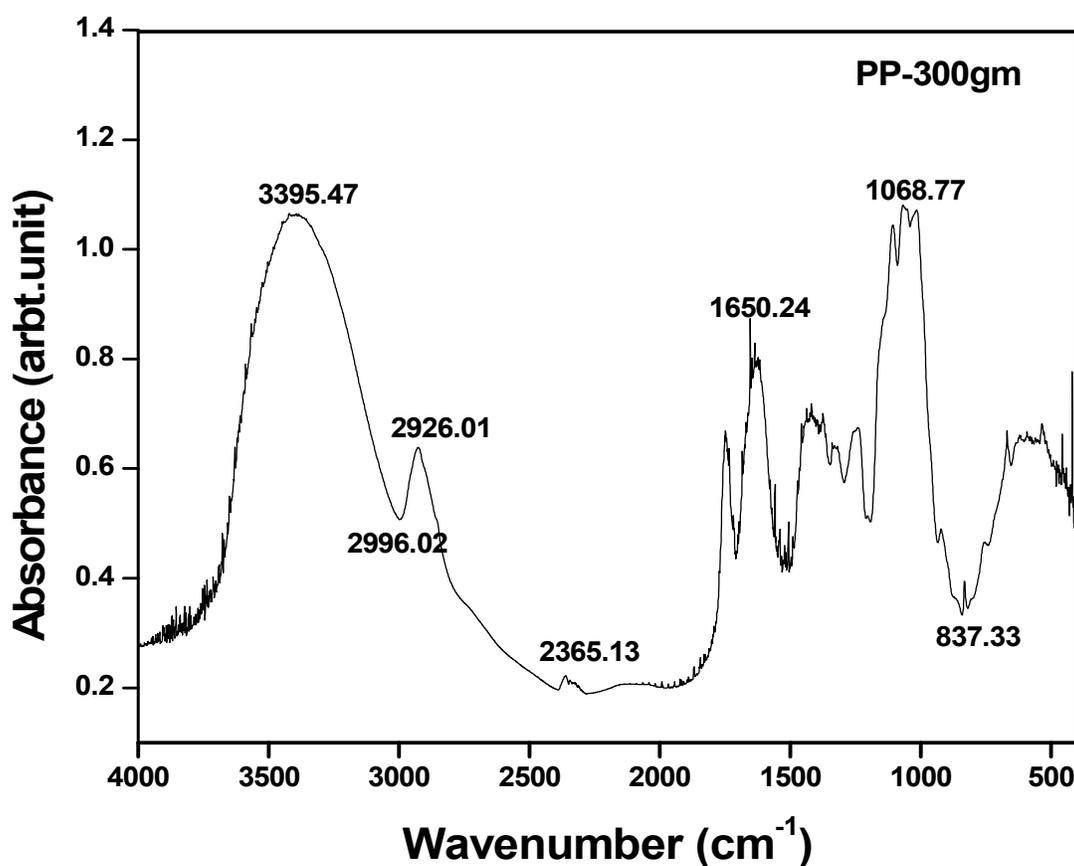


Figure (1) : FTIR Spectra of Pure Parkia Powder.

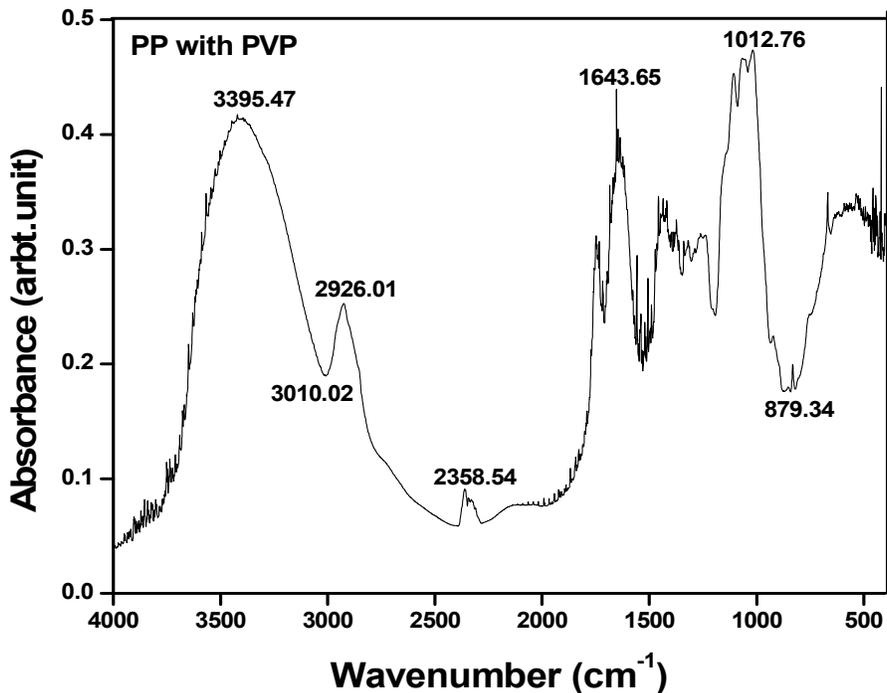


Figure (2) : FTIR Spectra of Polymer Blend of PP with PVP at 50 wt. % each.

UV-Vis Absorbance Spectra : The spectra of optical absorption for PVP and its composite with PP at 50 weight percentage each were studied over the range 200-750 nm using UV-vis spectrometer (PC2000 ISA) [12]. The optical absorption for PVP and its blend with PP are given in (Figure 3). It is observed that the optical absorption edge occurs at 257 nm for the PVP, at

229 nm for the PP and at 338 nm for their blends. It is clearly observed that in case of the blend of PP with PVP the absorption edge was appeared in the higher absorption edge compare to their individual samples. In case of PP with PVP the absorption peak was occurred at 425 nm. This indicates that addition of PVP makes PP transparent in that particular range.

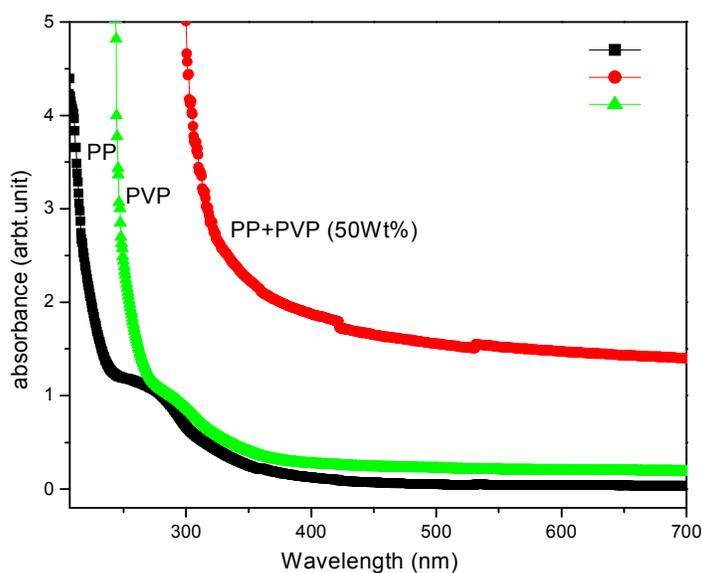


Figure (3) : Optical Absorbance Spectra of Polymer PVP and its Blend with PP.

Optical band gap energy : The optical absorption spectrum of PP and its blend with PVP was recorded in the wavelength region from 200-750 nm and are given in Figure (3). The dependence of optical absorption coefficient with the photon energy helps to study the band structure and the type of transition of electrons. For the direct band gap material, the sample under study has an absorption coefficient (α) obeys the subsequent relation for high photon energies ($h\nu$) according to Tauc's expression.

$$\alpha = \frac{A(h\nu - E_g)^{1/2}}{h\nu} \quad (1)$$

Where E_g is the optical band gap of the bulk material and A is the constant. The variation of $(\alpha h\nu)^2$ versus $h\nu$ is plotted and is given (Figure 4). The optical band gap E_g has obtained by extrapolation of the linear part.

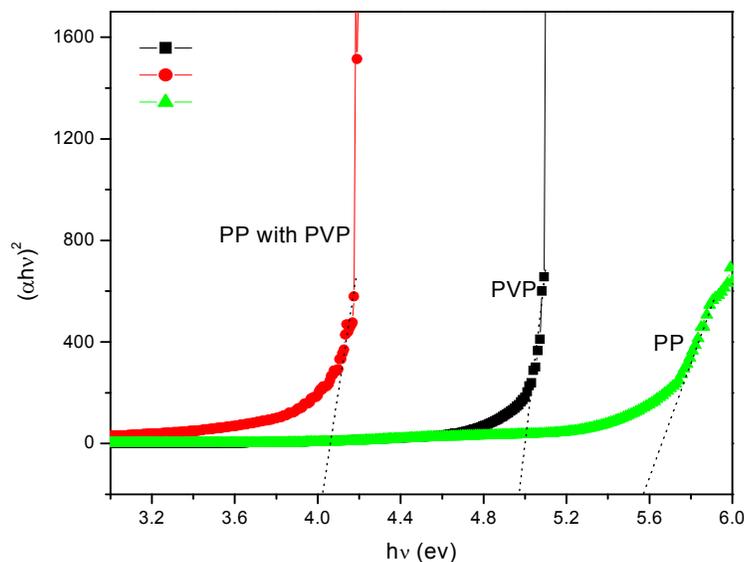


Figure (4) : Optical Absorbance Spectra of PVP Polymer and its Blend with PP.

The values of optical band gap energy of the PVP polymer, PP and their blend is given in Table 1.

Table (1) : Optical Band gap Energy of Polymers and their Blend at 50 wt.%

Sl.No.	Sample	Band gap energy in [eV]
1.	Parkia Powder (PP)	5.59
2.	Polyvinyl pyrrolidone (PVP)	4.99
3.	PP with PVP	4.03

Differential Scanning Calorimeter (DSC) : Thermal analysis gives the information about the stability and structural changes on heating of the sample. The DSC is unique technique for learning

about exothermic and endothermic process due to rearrangement of polymer chain of heating, evaluation of phase transformations such as glass transition, melting, solidification etc. The thermograms of DSC for PP and for the blend of PP with PVP have given in (Figure5) and (Figure 6) respectively. The endothermic dips were observed for both PP and its blend with PVP at ~ 72.09 °C, have corresponds to removal of water from the samples and the other one dip at ~ 91 °C for both the samples may be due to melting of polymer chain. In case of PP at ~ 250 °C may be due to phase change in this sample [13]. The endothermic dip for PP shows the transition from 0.04 to 0.01 mW/mg. In case of the blend of PP with 50 wt. % of PVP having a broad endothermic dip shows the transition from 0.61 to 0.12 mW/mg. The results indicate that the addition of PVP causes the phase change in the sample of PP.

The degree of crystallinity would be calculated using the following relation [14].

$$X_c = \frac{\Delta H_m}{\Delta H_m^0} \times 100 \quad (2)$$

where X_c is the degree of crystallinity, ΔH_m is the specific enthalpy of melting and ΔH_m^0 is the specific enthalpy of melting for 100 % crystalline.

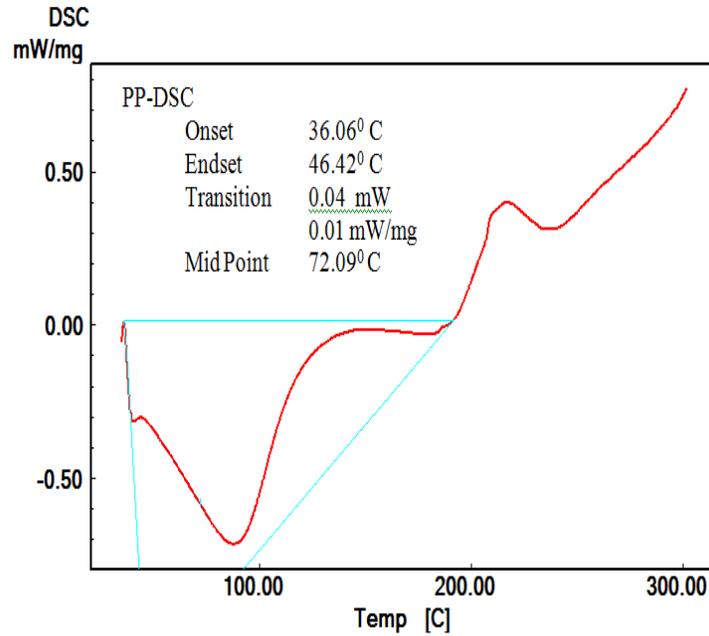


Figure (5) : The thermogram of DSC for Parkia Powder (PP).

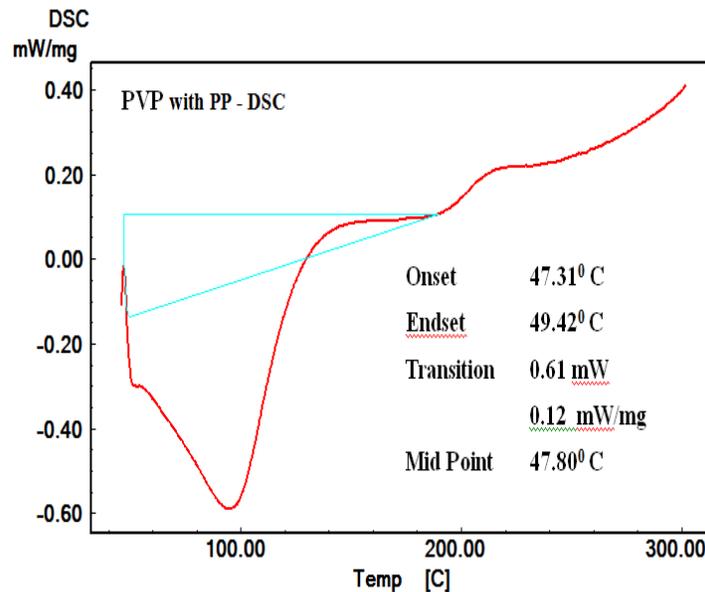


Figure (6) : The DSC thermogram of Parkia powder with Poly(vinyl pyrrolidone) at 50 wt. % each.

Thermal Gravimetric Analysis (TGA) : The thermal properties of PP and the blend of PP with PVP were analyzed by using TGA (Model :

Perkin –Elmer 7 series) to study the weight loss and thermal stability. Initially, weight of the sample was 3 mg which was scanned in

temperature range of 0 - 600 °C at heating rate of 20 °C/min under nitrogen purge. A Thermo gravimetric analysis technique permit continues weighing for samples of PP and its blend with PVP as function of temperature are given in Figure (7) and Figure (8) respectively. From Figure (7), it is observed that there is light weight loss in the range of 100 °C to 190 °C this may be due to some loss of water through evaporation of

physically strong H₂O bonding and impurities present. The decomposition PP started at about 220.37 °C and weight loss -78.708 % (-2.669 mg) at mid point temperature 236.00 °C. In case of the blend of PP with PVP shown in (Figure 8) the weight loss started at about 196.14 °C and weight loss is -42.280 % (-1.706 mg) at mid point temperature 235.96 °C and around 405 – 450 °C the weight loss may be due to its decomposition.

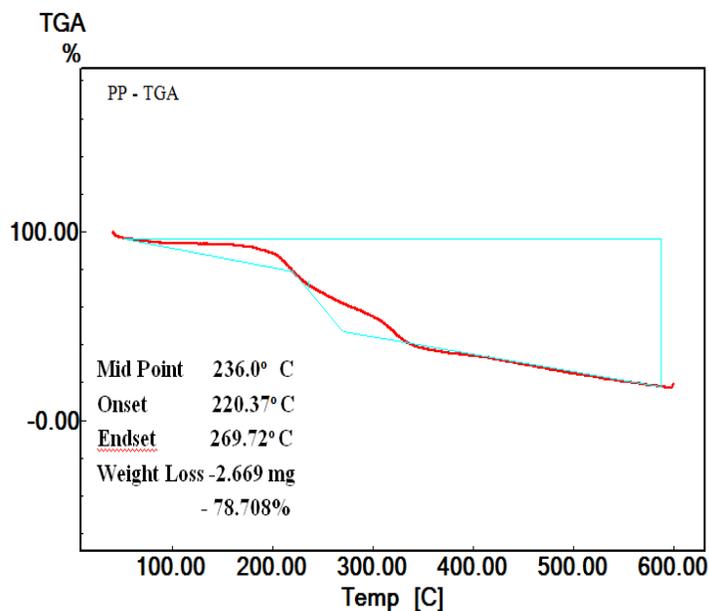


Figure (7) : The plot of TGA thermogram for the sample of PP.

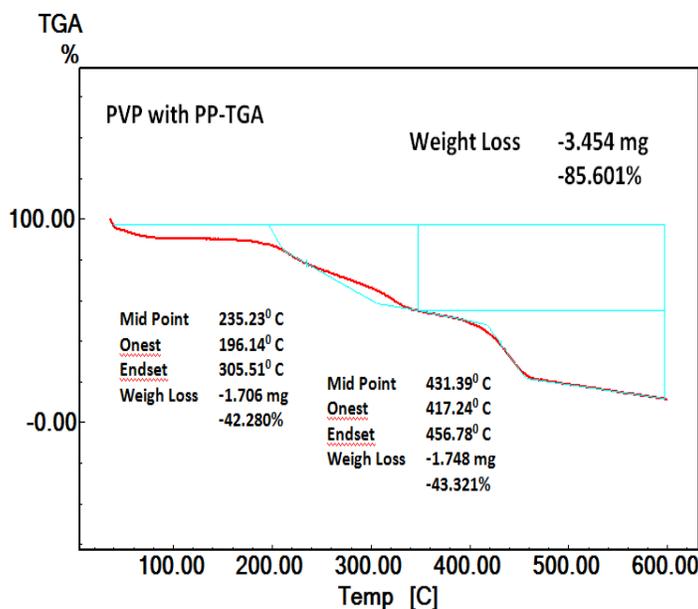


Figure (8) : The plot of TGA thermogram for the blend of PP with PVP at 50 wt. % each.

Conclusions : The FTIR spectra for PP clearly indicates that the absorbance peak correspond to the characteristic chemical bonds present in PP. This indicates that the presence of same functional groups and the blends have more absorbance than that of PP. In UV-vis optical absorption it is clearly observed that in case of the blend of PP with PVP the absorption edge was appeared in the higher wave length compare to their individual samples. The optical band gap E_g has obtained for both PP and its blend. The thermal properties are also studied by DSC and TGA for melting temperature and for weight loss.

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