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Study on the Performance of Ternary Blends at Different Drying Temperature

N. Sunitha
Researcher, Department of Chemistry, Nesamony Memorial Christian College, Marthandam, Tamil Nadu, India
R. S. Jeba Jeevitha
Assistant Professor, Department of Chemistry,
Nesamony Memorial Christian College, Marthandam, Tamil Nadu, India

Abstract:
Million tones of synthetic polymers are produced worldwide every year. Among the polymers produced, some polymers are non biodegradable due to their stability and they do not readily enter in to the degradation cycle. To solve the problem the biodegradation of plastic has been studied extensively for the past three decades. Various biodegradable materials were prepared to overcome this serious problem. These types of polymers were degraded in the soil, activated sludge, or compost after the service life is over. The present work reports synthesis and characterization of ternary blend using polyvinyl alcohol, polyvinylpyrrolidone, polyacrylamide. Thin films of ternary blends were prepared by using solution cast method. Gluteraldehyde was used as cross linking agent. The films were characterized by using FTIR spectroscopy, XRD, TGA/DTG and SEM. The degradation properties have been studied by using soil degradation.

Keywords: *Polyvinyl alcohol, polyvinyl pyrrolidone, polyacrylamide, ternaryblends, gluteraldehyde.*

1. Introduction

The development of polymer based blends/ composites have gained considerable interest to the researchers due to their wide range of application in many field due to their lightweight and water soluble properties [1]. The use of polymers in medical applications covers a broad diversity of fields including implants, prostheses, ophthalmology, dentistry and bone repair. Polymers like polyvinyl alcohol (PVA), polyvinyl pyrrolidone (PVP), and poly acrylamide (PAM) play an important role as a temporary scaffold, a temporary barrier and a drug delivery system. Blending of three or more polymers has become an important technique for preparing materials with tailor-made properties different from those of the constituent polymers [2].Blending of polymers may result in reducing their basic cost, improving their processing and maximizing their important properties [3]. The increase in properties of the blend depends on the degree of compatibility and miscibility of polymers at the molecular level.

PVA is a semi crystalline, water soluble, non toxic, better films, and fiber forming polymer. Due to their bio compatible, excellent chemical resistance, good mechanical properties and biodegradability, these polymers were used in many fields [4, 5]. PVA hydrogels have been used for various biomedical and pharmaceutical applications. Another polymer PVP is also vinyl polymer which has wide applications in biomedical field because of its properties including adhesion, excellent physiological compatibility, low toxicity and reasonable solubility in water and most organic solvents [6].When these two polymers are mixed, the interaction between PVA and PVP are expected to take place through inter molecular hydrogen bonding between the hydroxyl group of PVA and carbonyl group of PVP [7].PAM is an important hydrophilic polymer for preparation of hydrogels. The application of PAM hydrogels in controlled release of agrochemicals and bioactivity have been investigated [8, 9]. The ternary blends prepared using these three polymers (PVA, PVP, PAM) have higher properties and are used in various fields due to their stability and biodegradation character [10].

2. Experimental

2.1. Material

Polyvinyl alcohol (mol. wt13000), polyvinylpyrrolidone (mol.wt.40000), polyacrylamide (mol.wt.5000000) and gluteraldehyde were purchased from high purity laboratory chemicals.

2.1.1. Film Preparation

About 10g of PVA was dissolved in 450ml distilled water at 70°C. The solution was stirred using magnetic stirrer for 1 hour. After complete dissolving 2.5g of PVP and 2.5g of PAM with 200ml of distilled water is added. A whitish homogeneous viscous gel was formed. To this solution add 2 drops of gluteraldehyde as cross linking agent. The whole mixture was stirred for 2 hours. The prepared solution was poured in to a mould and dried at room temperature for one week. The wet film obtained was peeled off from the plates and stored for further analysis. The film obtained is noted as 1PPA.Thesame experiment was conducted by changing the temperature for drying (i.e.) instead of drying at room temperature the film was dried at 70°C for 48 hours. The film obtained was peeled off from the plate and used for further studies. The sample is denoted as 2PPA.

2.2. FTIR Study

FTIR spectroscopy has been widely used by many researchers to study the formation of blends. The FTIR spectra of PVA/ PVP/ PAM ternary blends were recorded using a Schimadzu FTIR- 470 spectrometer by KBr disc technique. The blended samples were recorded in the range of 600 – 4000cm^{-1}.

2.3. XRD Study

The X-ray diffractometre was used to find out the crystallinity of blends prepared. The samples were analysed using KPERT-PRO diffractometre with monochromatized Cu Kα radiation (scan speed of one minute in a 2θ range of 5° - 40° room temperatures).

2.4. SEM Micrograph

Areas ranging from approximately 1cm to 5 microns in width can be imaged in a scanning mode using conventional SEM technique. Electron microscopic micrographs of the blend samples were obtained under high resolution using JOEL JSM6390LV SEM equipped with phoenix energy dispersive system. It was used to investigate the morphology and distribution of polymers.

2.5. TGA/DTG Study

Films were cut in to small pieces and placed in aluminium pans for thermo gravimetric analysis (TGA) on a Perkins Elmer STA 6000 model in Sophisticated Analytical Instrument. The temperature program was a linear ramp of 38° C upto a final temperature of 72° C. A nitrogen pure gas was used during the TGA heating.

2.6. Bio-Degradation Property

The biodegradation property of films was determined by burying the sample in the soil.In the soil landfill microorganisms show significant degree of biodegradation in short incubation times. The degradation of films was evaluated by measuring the weight loss.

3. Results and Discussion

3.1. FTIR Study

FTIR spectra of 1PPA show a broad band at3258 cm^{-1} due to OH groups in the polymer chain. The low intensity of this peak is due to better cross linking of polymer with gluteraldehyde. Two peaks observed at 2918.30 cm^{-1} and 2851 cm^{-1}due to C-H broad alkyl stretching band. The band at 1650 cm^{-1} is due to the flexural stretching of NH amide. The sharp band at 1094cm^{-1} corresponds to C=O stretching of acetyl groups present on the PVA backbone. The band at 1444cm^{-1} and 1293cm^{-1} are ascribed due to the CN group of amide. In 2PPA all the peaks are same like 1PPA but the intensity of the peak are decreased may be due to the blending nature of polymer.

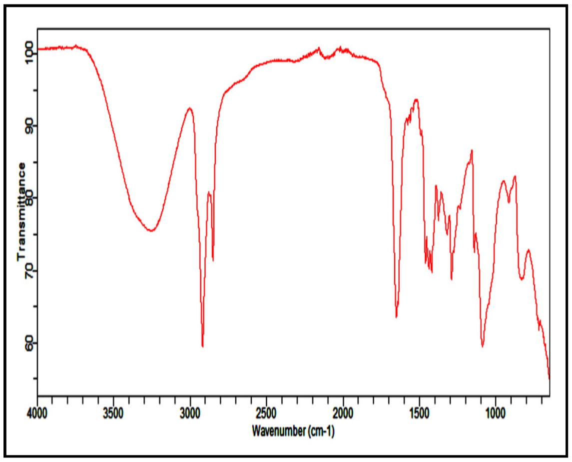

Figure 1: FTIR spectra of 1PPA blend

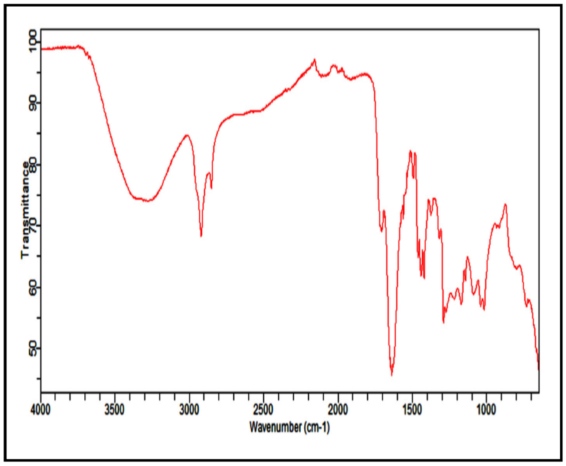

Figure 2: FTIR spectra of 2PPA blend

3.2. XRD Study

The sample 1PPA and 2PPA shows intense peak at 2θ= 20°. At 40° a small broad peaks obtained due to its amorphosity. The decrease in intensity may due to the disturbance in the regular patterns of the atoms. The peaks at 29° and 32° are due to the presence of polyacrylamide.

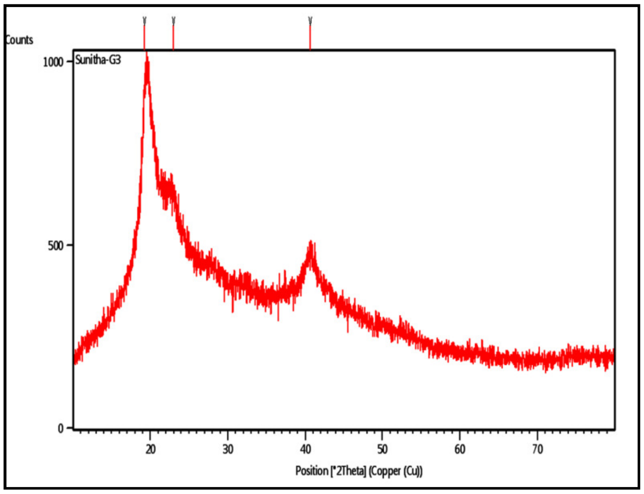

Figure 3: XRD pattern of 1PPA blend

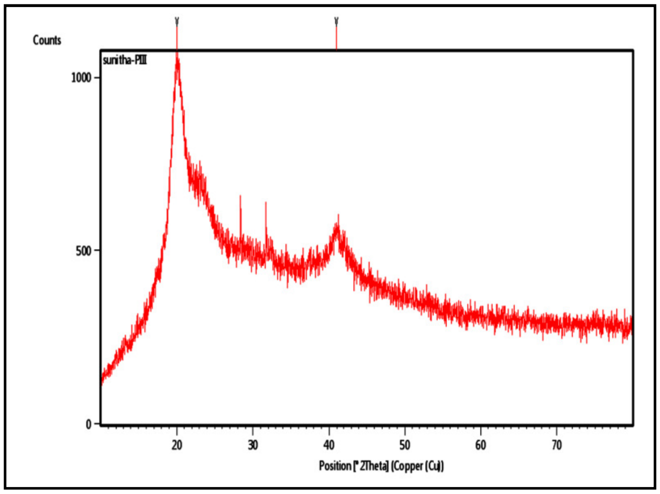

Figure 4: XRD pattern of 2PPA blend

On comparing 1PPA with 2PPA these peaks are diminished due to their blending nature. The XRD spectra of 1PPA show the crystalline index 0.59 and the percentage of crystallinity 71.20%. The crystallinity percentage of 2PPA is 70.08% and the index value is 0.57.

3.3. Scanning Electron Microscopy

Scanning electron microscopy is a well known electron beam technique in which electron scattering is used to image the topography of the sample surface under investigation. The electron beam is rastered across the conducting sample surface with the signal from the emitted secondary electrons displayed via an electron detector.SEM images of 1PPA show a very small agglomeration but in 2PPA due to the changes in drying temperature. There is a clear distribution takes place and shows a neat film.

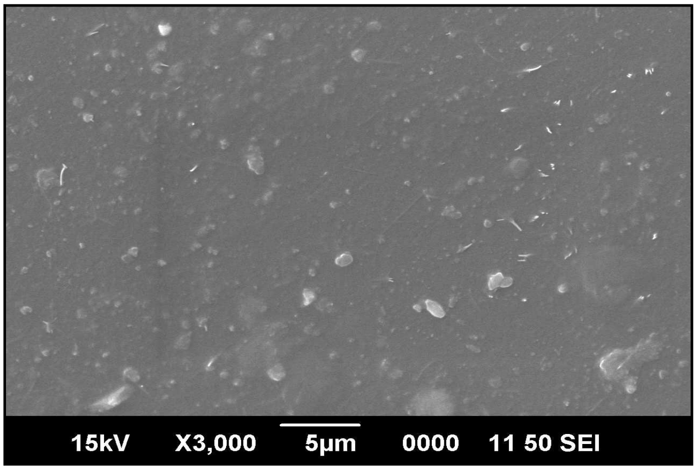

Figure 5: SEM micrograph of 1PPA

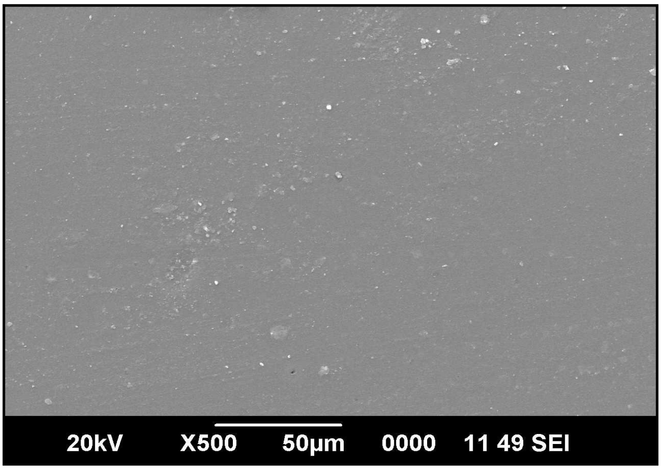

Figure 6: SEM micrograph of 2PPA blend

3.4. TGA/DTG Study

Percentage weight loss at various temperature							**Residue**
Sample code	100° C	200° C	300° C	400° C	500° C	600° C	
1PPA	0.66%	6.97%	14.97%	54.42%	88.26%	89.95%	10.05%
2PPA	2.28%	9.86%	15.45%	50.55%	88.04%	97.21%	2.79%

Table 1: Percentage weight loss of ternary blends

Table 1 shows the percentage weight loss of ternary blends at various temperatures. The initial weight loss about 6.97% is due to the loss of bound water molecules. At 200°–400°C first thermal degradation occurs with a weight loss of 54.42% due to liberation of one ammonia molecule for every two amide groups resulting in the formation of imide. Above 400°–500°C a second thermal degradation takes place due to the thermal degradation of imide and breaking of the polymer backbone. Above 500°C there is no degradation observed. Two sharp endothermic peaks are obtained at 370°C and 450°C due to the formation of new covalent bonds.

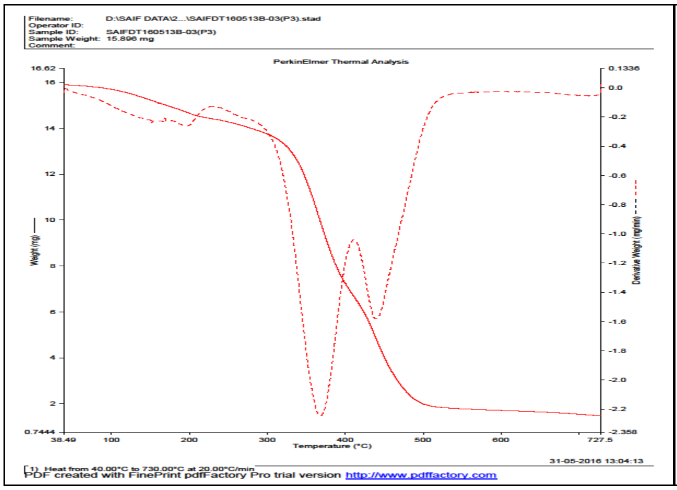

Figure 7: TGA/DTG of 1PPA blends

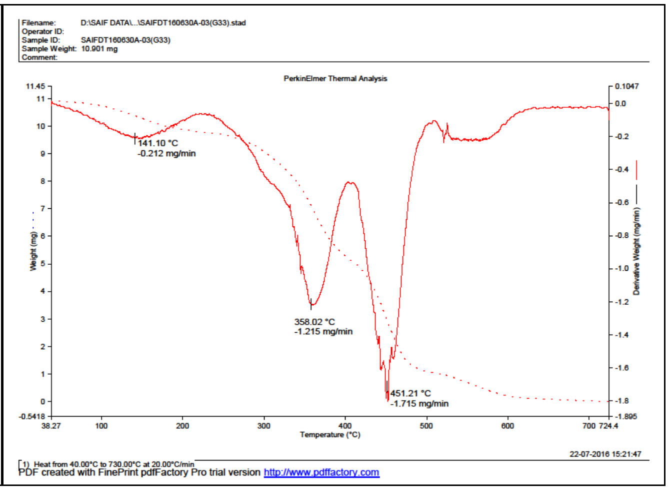

Figure 8: TGA/DTG of 2PPA blends

Similarly for sample 2PPA, the initial weight loss is 9.86% upto 200°C due to the evaporation of water molecules. The first thermal degradation takes place with weight loss about 50.55% at 200°C- 400°C due to the structural decomposition of the blends. Due to the addition of PAM with PVA/PVP blends a second degradation takes place at above 400°C with the weight loss of 88.04%. On comparing the T_{max} value of 1PPA (360°C) and 2PPA (451°C), 2PPA shows high thermal stability than the 1PPA due to the change in drying temperature.

3.5. Soil Degradation

In soil degradation studies the weight loss and percentage degradation of samples 1PPA and 2PPA are shown in table 2. On comparing the percentage degradation of 1PPA with 2PPA the value is high for 2PPA may be due to adhering of soil and debris particle on the film surface. On comparing all the blends the ternary blends (PVA/PVP/PAM) prepared by drying above the room temperature shows higher degradation percentage (89.47%).

Sample code	Initial weight	Final weight	Weight loss	Percentage of degradation (%)
1PPA	80mg	40mg	40mg	50%
2PPA	95mg	10mg	85mg	89.47%

Table 2: Percentage degradation of ternary blends

4. Conclusion

The present work reports synthesis and characterization of ternary blend using PVA, PVP and PAM. The prepared ternary blend has good properties due to the water soluble property and hydrogen bond interaction among PVA, PVP, and PAM. Collecting the above results the FTIR spectra of ternary blends shows some changes in the peak due to blending nature with other polymer. The XRD spectra show the crystalline and amorphous nature of the polymer. The amorphosity increases due to the blending nature. The SEM image shows an equal distribution of particles which increase the properties. From TGA/DTG the thermal stability of 2PPA is high due to the formation of ternary blends. The degradation study shows the percentage degradation of ternary blends. From overall results we can conclude that due to hydrogen bond interaction the ternary blends prepared enhanced the stability and properties of the polymer.

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