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Thermal and Structural Investigations of Polyvinyl Alcohol/Polyamide Blend

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Abstract: The present investigation is about the synthesis and structural characterization of polyvinyl alcohol (PVA/ Polyamide (PA) blend. PVA and PA were mixed in proportion*i.e.*80:20, and the final sample in the form of films of ~ 40 μm were peeled out from the dried dip-coated glass slide.Prepared films were characterized using thermo-gravimetric analysis (TGA), Fourier Transform Infrared (FTIR) and UV-visible spectroscopies. TGA thermograph indicated the decrease of weight loss rate of PVA/PA blend in comparison to untreated PVA. Formation of new bands were observed in the FTIR spectrum of PVA, which confirms presence of guest polymer in the prepared blend. UV-visible analysis indicated the change in optical band gap with incorporation of PA in PVA/PA blend.

Keywords: Polyvinyl alcohol; Polyamide; Thermo-gravimetric analysis; Fourier Transform Infrared spectroscopy; UV-visible spectroscopy; Structural behavior

1. Introduction

Polymer is a macromolecule which is commercially very important. At present one can't think about life without polymers as all substances, which we are using in our daily life are somewhere made up of polymer [1-3]. So, interest is developed in scientific community from last few decades to synthesize new polymers or to tailor the characteristics of existing ones [4-8]. As one polymer can't have all the required characteristics, so blending of polymers of different types can be an effective technique todevelop a new material with required properties [9-11].

Polyvinyl alcohol (PVA) is a water soluble, oil resistant, has incredible emulsifying and cement properties, nontoxic, flexible and importantly it is a biodegradable polymer. Due to its

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non-toxicity and biocompatibility, it has many medical applications, such as in eye-drops, contact lenses, cartilage replacement and other orthopedic applications but due to its hydrophilic nature it has limited strength, therefore it cannot withstand high temperature applications [12-15]. On the other hand, polyamide (PA) is used in cloth and automobile industries, utensils and sports goods due to their high durability, high temperature resistance, toughness and strong resistance to abrasion, but at the same time high moisture absorption with dimensional instability and non-biodegradability are its major drawbacks [16-18].

In the present work, an attempt has been made to incorporate the benefits and eradicate the disadvantages of both above mentioned polymers by developing a PVA/PA blend and to characterize its thermal and structural behavior.

2. Experimental details:

PVA in the form of powder and PA resin in the form of bright yellow solid crystal and N-Methyl-2-pyrrolidone (NMP) with 99.9% purity were purchased from Central Drug House (CDH) Pvt. Ltd., India. PVC/PA blend was prepared by mixing 80:20 weight percentages of PVA and PA respectively, in NMP using magnetic stirring for 8 hrs. Glass slides were dipped in the prepared solutions and dried in the oven at 60 ^{0}C overnight. Finally, films (~ 40 μm) of prepared polymeric blendwith different compositions werepeeled off from the dried slides.TGAwascarried out from room temperature to 600 ^{0}C using Mettler Toledo,TGA/SDTA 851. FTIR spectra were recorded in transmittance mode using Shimadzu FTIR-8400S in the range 400-4000 cm^{-1}. Absorption spectra in ultra-violet and visible range were obtained from Shimadzu UV-2600.

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3. Results and discussion:

3.1 TGA analysis

Thermal behavior of PVA, PA and their blend (with 80:20 ratio) is presented in the form of TGA thermographs in Fig.1. The recorded thermographs show structural degradation and weight lossin all studied sampleswith temperature. PVA's complete 100 % weight loss was revealed at 520 ^{0}C.It is further observed from Fig. 1 that the rate of weight loss was more in PVA as compared to other samples, indicating its biodegradable nature [19].However, PA had taken more time and higher temperature to lose its identity due to its strong intra-molecular bonding strength. Its complete degradation was not observed even at higher investigated temperature range, as its weight loss was saturatedto 33.7% after 475 ^{0}C. The prepared PVA/PA blend exhibits the properties of both polymers. Thus, the obtained blend wasshowing better strength than untreated PVA. Therefore, the obtained blend can be very beneficial for applications where PVA with better mechanical strength is required without compromising its bio-degradable character.

3.2 FTIR analysis

Fourier transform infrared spectra of untreated polyvinyl alcohol and polyamide are shown in Fig. 2. In FTIR spectrum of untreated PVA, absorption bands at 850 and 1451 cm^{-1}were assigned tostretching and bending mode ofCH_2bonds, respectively.Absorption bands of (C-O)-C-OH and CO groups were visible at 1095 and 1143 cm^{-1}, respectively. Deformation modesof (CH)-CH_2groupswere observed at 1510cm$^{-1,}$ CH stretching vibrations were revealed around 2930 cm^{-1}, and broad absorption band between 3100-2600 cm^{-1}was indicating the presence of OH groups [20].In Fig. 1 characteristics absorption bands of polyamide are shown with red color. Symmetric and asymmetric stretching vibrations of C-O-C bonds were seen at 1060 and 1245 cm^{-1}, respectively.Aromatic stretching of CH bonds was assigned to the absorption band at 3080 cm^{-1}, C=O bonds of amide groups at 1654 cm^{-1}, stretching

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vibrations of N-H at 3300 cm^{-1}, bending mode of NH_2at1558 cm^{-1}, CH_3C-H stretching vibrations were observed at 2853 and 2950 cm^{-1} [20].

In Fig.2, Fourier transform infrared spectra of PVA/PA blend is presented. Noticeable changes in the FTIR spectrum of PVA were observed whenPA was incorporated in the blend. After theincorporation of 20% PA by weight in the PVA/PA blend, characteristics bands such as at 1558, 1654, 2853 $cm^{-1}$of PA were clearly visible in the FTIR spectra, consequently, it is expected that the resultant blend may have better strength and durability than untreated PVA. Intensity of prominent bands of PVAsuch as at 850, 1095, 1043, 2940 and the absorption between 3100and 3600 cm^{-1}wassustained, which revealed the retainability of original structure of PVA and consequently it's biodegradability, in the prepared polymeric blend.

3.1 UV-visible analysis

UV-visible absorption spectra of PVA, PA and PVA/PA (80:20) blend are shown in Fig.3. It is observed that the absorption edges of untreated PVA and PA were found at 245 and 340 nm, respectively, which were attributed to their respective optical band gaps. Further it is noticeable from the same figure that the absorption behavior of the prepared PVA/PA blend with composition80:20 was lying between PVA and PA, indicating the decrease of band gap of PVA after the incorporation of PA.

Conclusions

On the basis of the above-mentioned results and discussion it can be concluded that the prepared PVA/PA polymeric blend is exhibiting the behavior of both host and guest polymers so possibly it may have better strength, withstand high temperature applications and more durable, without much compromising its biodegradability.

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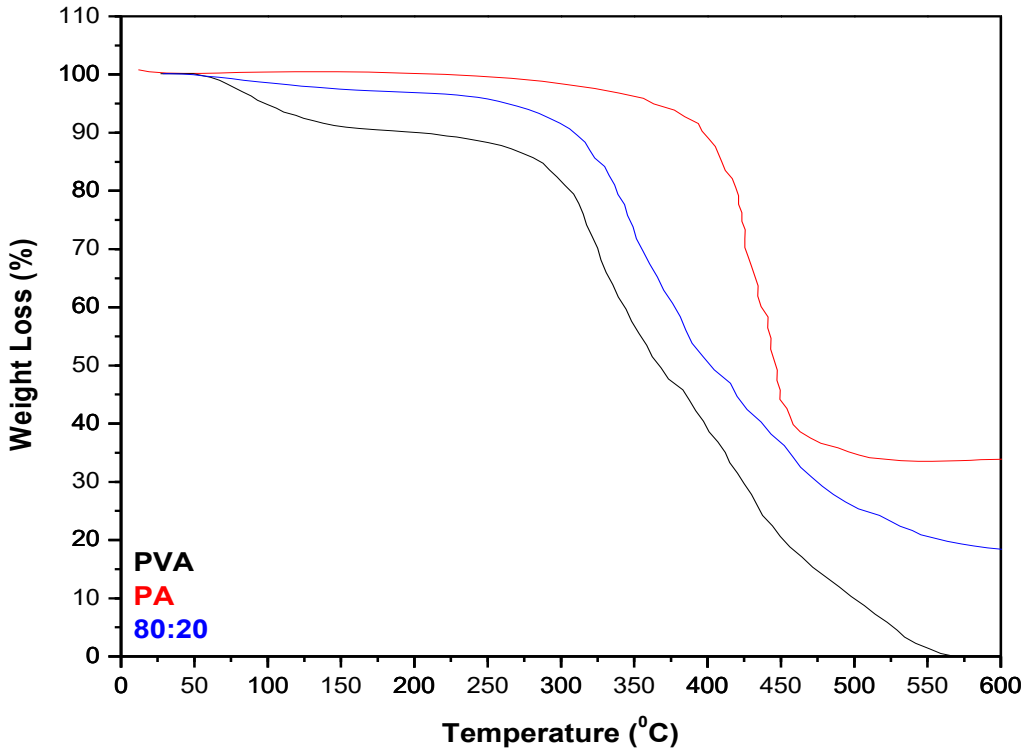

Fig. 1 Thermogravimetric thermographs of polyvinyl alcohol, polyamide and polyvinyl alcohol/polyamide blend.

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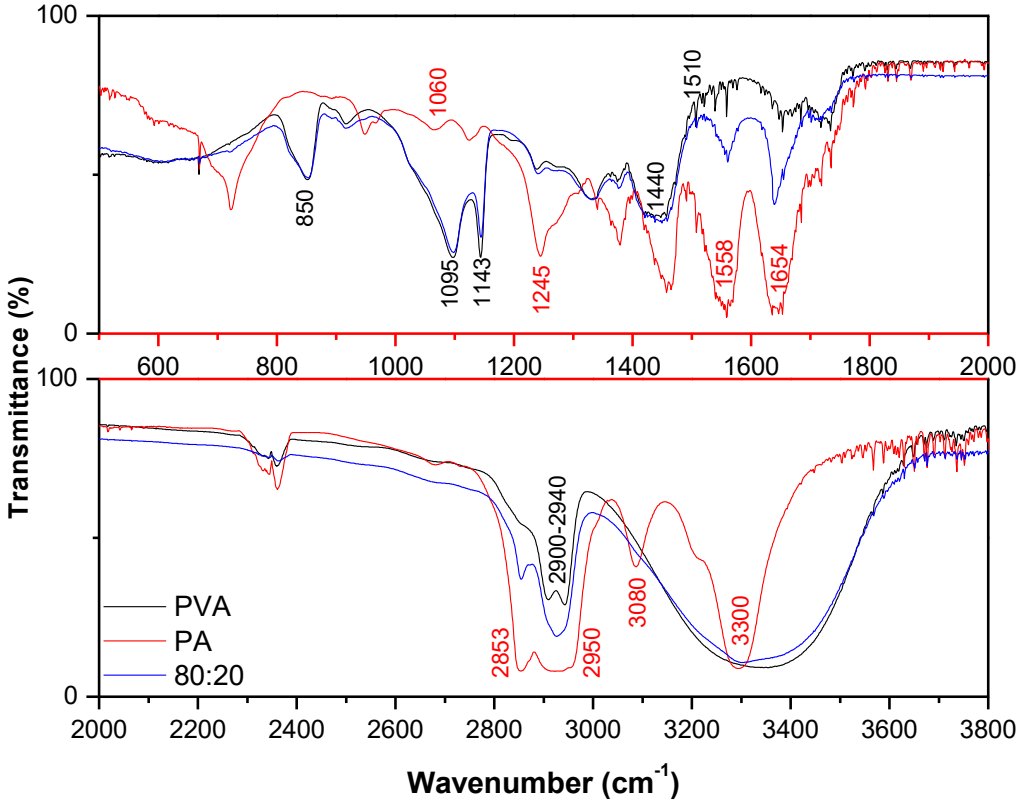

Fig. 2 Fourier transform infrared spectra of PVA, PA and PVA/PA blend.

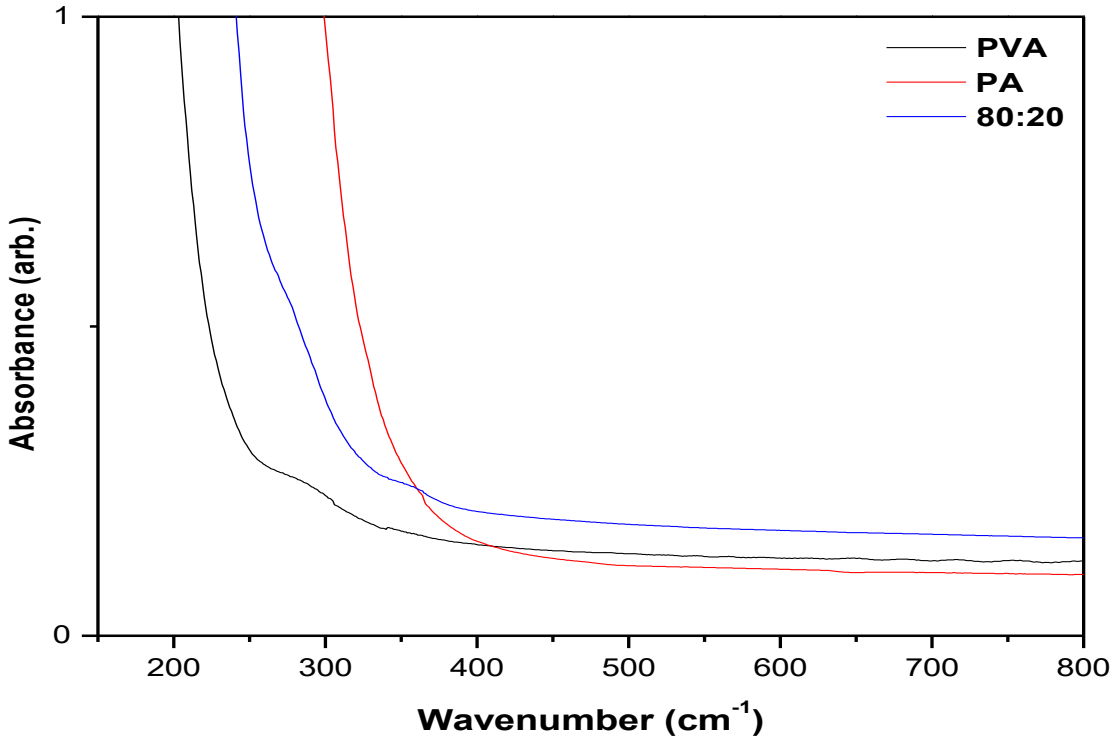

Fig. 3 UV-visible absorption spectra of PVA, PA and PVA/PA blend.