

An FTIR Study of Characterization of Neat and UV Stabilized Nylon 6,6 Polymer Films

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Abstract

The work is concerned with the characterization of as cast films of neat and UV-stabilized nylon 6,6 by employing FTIR measurements. Band assignment is made for neat and UV-stabilized nylon 6,6 using FTIR spectra confirm their molecular structure. UV-stabilizer added to nylon 6,6 has caused reduction in the absorbance of the vibrational bands and thus stabilizes the behavior of the polymer in the end and uses specially in harsh environment.

Keywords: Nylon 6,6, UV-stabilizer, FTIR spectra.

Introduction

Polymer characterization is an essential step in working with polymers. The main characterization techniques involve the use of Fourier transform infrared and x-ray diffraction methods. As a rule, such efforts are directed toward a specific purpose. The structure and molecular conformation of the macromolecules ultimately determine the mechanical, physical and chemical properties of polymers [1]. Thus precise characterization of molecular order is a primary prerequisite to understand macroscopic properties of polymeric materials [2,3].

Nylon is a generic designation for a family of synthetic polymers known as polyamides (PA), and nylon 6,6 is one of the most important engineering thermoplastics often used in adverse environment.

The nature of the chemical repeat unit (presented in figure 1) pose the polymer in many industrial applications such as nylon fibers for carpeting, clothing, tire cord and solid nylon for bearings and gears due to its good abrasion resistance and self-lubricating properties and nylon ribbons for tying cables due to its good creep modulus [4].

The polymer is synthesized by condensation polymerization of hexamethylenediamine and adipic acid. It is semi-crystalline and the crystals melt at high temperature. In spite of its superior properties, nylon 6,6 is very sensitive to moisture absorption and moisture content must be controlled during melt processing of nylon 6,6 [5].

The aim of the present work is directed in the key points of characterization of polymers employing FTIR technique.

Experimental

Ribbons of nylon 6,6 were obtained from local market. The ribbons were dissolved in a mixture of 1:1 weight ratio of formic acid and phenol at ambient temperature. The mixture was cast into a glass mold and left to dry at ambient temperature. The cast nylon films were peeled from the mold and the FTIR spectra have been recorded in the range 400-4000 cm^{-1} using shimadzu 8400 series at Ibn-Sina chemical industrial center. The standard samples were

made by mixing finely chopped polymer with KBr and compressing the mixture in a pellet-making press. The KBr discs with polymer were placed in the FTIR cell and the spectra were recorded. The FTIR spectrum is a useful tool to identify the chemical nature of the polymer and to determine its composition.

Results and Discussion

FTIR spectroscopy has been applied in the identification of the basic structural units of nylon 6,6 and UV stabilized nylon 6,6. The FTIR spectra of the two types of polymers are presented in figures 2 and 3. Band positions in the spectra are utilized in confirming the molecular structure of the polymer [6,7]. Absorbance was calculated as:

$$\text{Abs} = \log T = \log (I/I_0)$$

where T is the transmittance and I/I_0 is the relative intensities of sample and standard respectively.

The vibrational frequencies of all the fundamental bands along with their relative intensities and probable assignments are given in tables 1 and 2 for both the neat and UV stabilized nylon 6,6.

Comparison of the frequency bands of nylon 6,6 with the reference nylon 6,6 [8] confirm that the cast neat films are those for nylon 6,6 with band shifts not exceeding $\pm 5 \text{ cm}^{-1}$. This is characterized by the major band: the amide bands at 1639 and 1539 cm^{-1} and N-H, CH_2 (a symmetric stretching) and CH_2 (symmetric stretching) at 3306, 2932 and 2862 cm^{-1} respectively. These bands are indicative of their high absorbance (see table 1).

For the UV stabilized cast nylon 6,6 films however, the amide bands have shifted from those of the neat nylon 6,6 sample by about 20 cm^{-1} due to the effect of UV stabilizer. It is also noted from the absorbance results in table 2 that the UV stabilized materials tend to reduce the absorbance of all the bands assigned a consequence that characterization is useful in identifying the chemical nature of the polymer.

Conclusion

The characterization study on neat and UV-stabilized nylon 6,6 has been carried out using important experimental technique. Their molecular structures were confirmed by FTIR spectra from assignment of absorbance bands. Once the molecular structure is understood, it becomes easy for a polymer scientist to relate the polymer structure to its performance properties in end use.

References

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Table (1): Assignment of FTIR spectrum of neat nylon 6,6

Wave number (cm ⁻¹)	Absorbance	Assignment
3410	0.34	N-H stretching I
3306	0.38	N-H stretching II
3082	0.18	C-H stretching (asym)
2932	0.28	CH ₂ stretching (asym)
2862	0.25	CH ₂ stretching (sym)
1639	0.53	Amide I stretching
1539	0.46	Amide II stretching/ CH ₂ (asy)(mdef)
1469	0.31	N-H deformation/ CH ₂ scissoring
1269	0.34	Amide III stretching
1200	0.29	CCH bending (sym)/ CH ₂ twisting
934	0.17	C-C stretching
691	0.20	C-C bending
579	0.18	C-C deformation

Table (2) :Assignment of FTIR spectrum of UV stabilized nylon 6,6

Wave number (cm ⁻¹)	Absorbance	Assignment
3414	0.28	N-H stretching I
3240	0.14	N-H stretching II
2928	0.09	CH ₂ stretching (asym)
2855	0.08	CH ₂ stretching (sym)
1686	0.19	Amide I stretching
1612	0.22	CH ₂ deformation (asym)
1516	0.14	Amide II stretching
1431	0.15	N-H deformation
1304	0.17	CH ₂ wagging
1261	0.19	Amide III stretching
1173	0.16	CH ₂ twisting
1122	0.15	C-C stretching (sym)
1018	0.15	C-C stretching
922	0.05	C-C stretching
667	0.08	C-C bending
575	0.06	C-C deformation

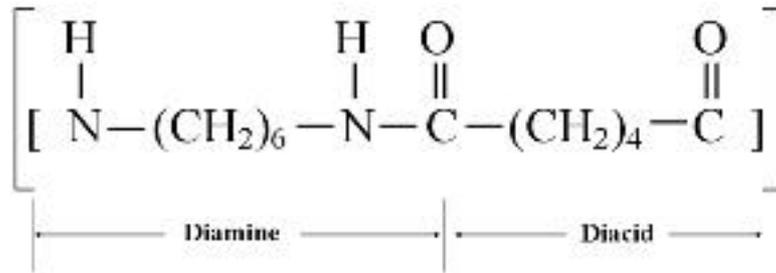


Fig.(1): Chemical structure of nylon 6,6

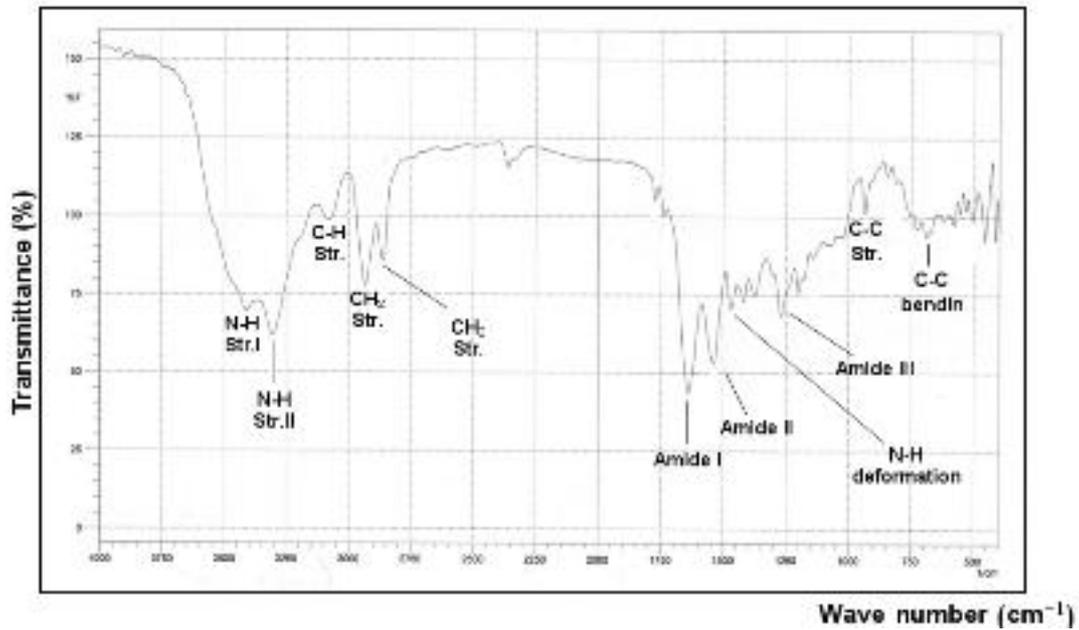


Fig.(2): FTIR spectrum of neat nylon 6,6

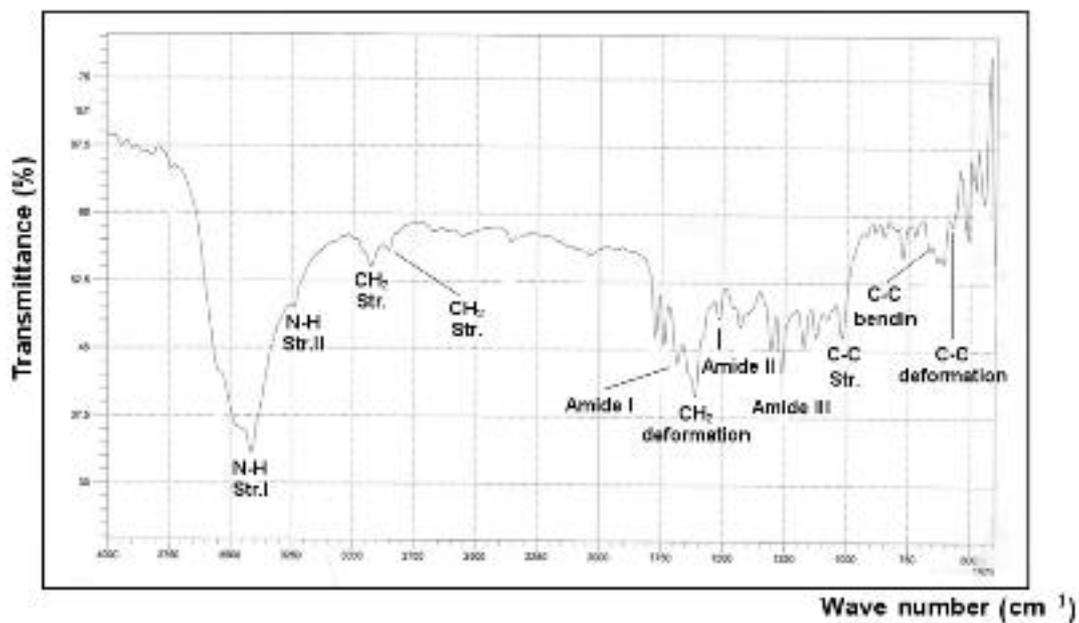


Fig. (3): FTIR spectrum of UV-stabilized nylon 6,6

دراسة FTIR لتشخيص افلام بوليمر نايلون 6,6 النظيفة والمستقرة للاشعة فوق البنفسجية

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الخلاصة

يعني العمل بتشخيص افلام مصبوبة للنايلون 6,6 النظيفة والمستقرة للاشعة فوق البنفسجية باستخدام قياسات تحويل فورير للاشعة تحت الحمراء FTIR. تم عمل تعين الحزم لكلا من النايلون 6,6 النظيف والمستقر للاشعة فوق البنفسجية باستعمل اطياف FTIR التي ثبتت التركيب الجزيئي للبوليمر. تبين ان اضافة المواد المستقرة للاشعة فوق البنفسجية إلى النايلون 6,6 يؤدي إلى نقصان في امتصاصية حزم الاهتزاز وبذلك تؤدي إلى استقرار سلوك البوليمر عند الاستخدام لاسيما في البيئات القاسية.