Journal of Molecular Structure 1090 (2015) 39–43

Contents lists available at ScienceDirect

Journal of Molecular Structure

journal homepage: www.elsevier.com/locate/molstruc

Optical activity of transparent polymer layers characterized by spectral means

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HIGHLIGHTS

- Rotatory birefringence is estimated from the channeled spectra of HPC solutions.
- Dispersion parameter is evaluated in the visible range.
- Specific rotation of 30% HPC solutions in water, methanol and acetic acid is computed.

ARTICLE INFO

Article history:
Received 1 October 2014
Received in revised form 17 December 2014
Accepted 22 December 2014
Available online 29 December 2014

Keywords:
Specific rotation
Optical rotatory dispersion
Hydroxypropyl cellulose (HPC) solutions

ABSTRACT

The method based on the channeled spectrum, validated for inorganic optical active layers, is used now to determine the optical activity of some transparent polymer solutions in different solvents. The circular birefringence, the dispersion parameter and the specific rotation were estimated in the visible range by using the measurements of wavelengths in the channeled spectra of Hydroxypropyl cellulose in water, methanol and acetic acid. The experiments showed the specific rotation dependence on the polymer concentration and also on the solvent nature.

The decrease of the specific rotation in the visible range with the increase in wavelength was evidenced. The method has some advantages as the rapidity of the experiments and the large spectral range in which it can be applied. One disadvantage is the fact that the channeled spectrum does not allow to establish the rotation sense of the electric field intensity.

Introduction

Depending on their anisotropy degree, the substances can affect the light polarization state in the propagation process. Different effects which are sensitive to the light polarization state are neglected during the ordinary spectroscopy measurements, but they are useful to investigate various phenomena occurring for molecules lacking certain types of molecular symmetry [1].

Chirality or asymmetry of a molecule means that its mirror images cannot be superimposed, characteristic that makes possible a physical separation of such structures. The interaction of chiral compounds with electromagnetic radiation is similar with that of achiral ones in that they will exhibit optical absorption, have a characteristic refractive index and can scatter oncoming photons [2]. However, the asymmetric molecules present additional interactions with circularly polarized radiations. For instance, when traveling through a chiral medium, the plane of linearly polarized light is rotated. This phenomenon is associated with the circular birefringence of the medium and it is strongly influenced by the spectral composition of the incident radiation. The left- or right-circularly polarized light components can be preferentially absorbed within the electronic transitions of an asymmetric compound [3].

In the past decades, the pharmaceutical industry paid a considerable interest on the preparation and characterization of enantiopure materials since metabolic and regulatory processes are sensitive to stereochemistry of the active substances [4–6]. In addition, physico-chemical characteristics of the drug encapsulant/carrier represent an essential factor influencing the release rate [7]. In this context, natural polymers, like cellulose derivatives, have received a special attention owing to their good biocompatibility and

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http://dx.doi.org/10.1016/j.molstruc.2014.12.069
0022-2860/

biodegradability. Hydroxypropyl cellulose (HPC) is water-soluble cellulose ether, which is commonly used as delivery matrix [8,9]. The main reasons for its widespread utilization in this field include (1) great solubility characteristics in most organic fluids, (2) noninterference with tablet disintegration and drug availability, (3) flexibility, chip resistance and lack of taste and odor, (4) stability in the presence of heat, light, air or reasonable levels of moisture, (5) ability to incorporate color and other additives into the film without difficulty [8,9].

The high asymmetry of the HPC molecules makes them optically active [10]. The optical rotatory dispersion (ORD) curve exhibit monotonic increase in negative rotation with decreasing wavelength for HPC solutions in isotropic state [11]. The ORD is a very useful characteristic in elucidating a number of structural problems in studying optically active polymer matrices. The method of channeled spectrum has been previously validated for the ORD of quartz and for the linear birefringence dispersion of thin solid polymer foils [12–15].

The paper develops a method for ORD evaluation of HPC transparent solution starting from its channeled spectrum recorded with a spectrophotometer equipped with a special device. This method is an extension of the one proposed by Geday et al. [16], where measurements at different wavelengths were combined with the rotating polarizer method [17] to identify optically anisotropic substances under the microscope.

Experimental details

Hydroxypropyl cellulose (HPC) (LF, Klucel™) (with the specifications molecular mass of approximate 100,000 g/mol and mole of stabilization of about 3.4) was purchased from Aqualon Company, Hopewell, Virginia, USA.

Bi-distilled water was obtained in our labs. Spectrally pure methanol and acetic acid were purchased from Merck Company.

A UV–Vis Carl Zeiss Jena spectrophotometer with data acquisition system was used to record channeled spectra. A cell of 2.5 dm with transparent windows was used for spectra recording and the concentration was kept constant at 30% for all studied HPC solutions.

In order to have a better discrimination of the points, the unknown parameters were estimated both for the two minima and the maximum between them and for two maxima and the minimum between them, respectively.

Linearly polarized light is obtained and analyzed usually with polarization filters which are main parts of the device (D) attached to the spectrophotometer in order to record channeled spectrum.

The device D (Fig. 1) consists from two identical crossed polarizers (P1 and P2) having between them a cell (C) full with polymer solution placed in the measure beam of the spectrophotometer and two identical polarizers (P3 and P4) with their transmission directions in parallel placed in the comparison beam.

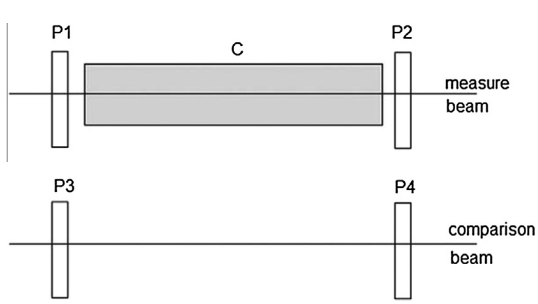

Fig. 1. Device D attached to spectrophotometer for obtaining channeled spectra; P1, P2, P3 and P4 – identical polarizing filters; C – cell containing HPC solution.

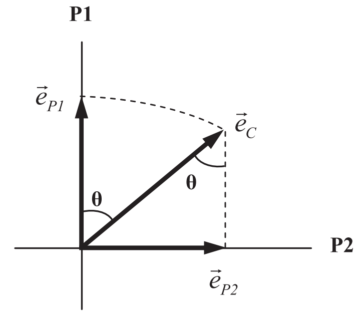

Fig. 2. Reciprocal directions of the light electric field intensities at the entrance ($\vec{e}_{P1}$), at the exit from cell ($\vec{e}_C$) and after the analyzer $\vec{e}_{P2}$.

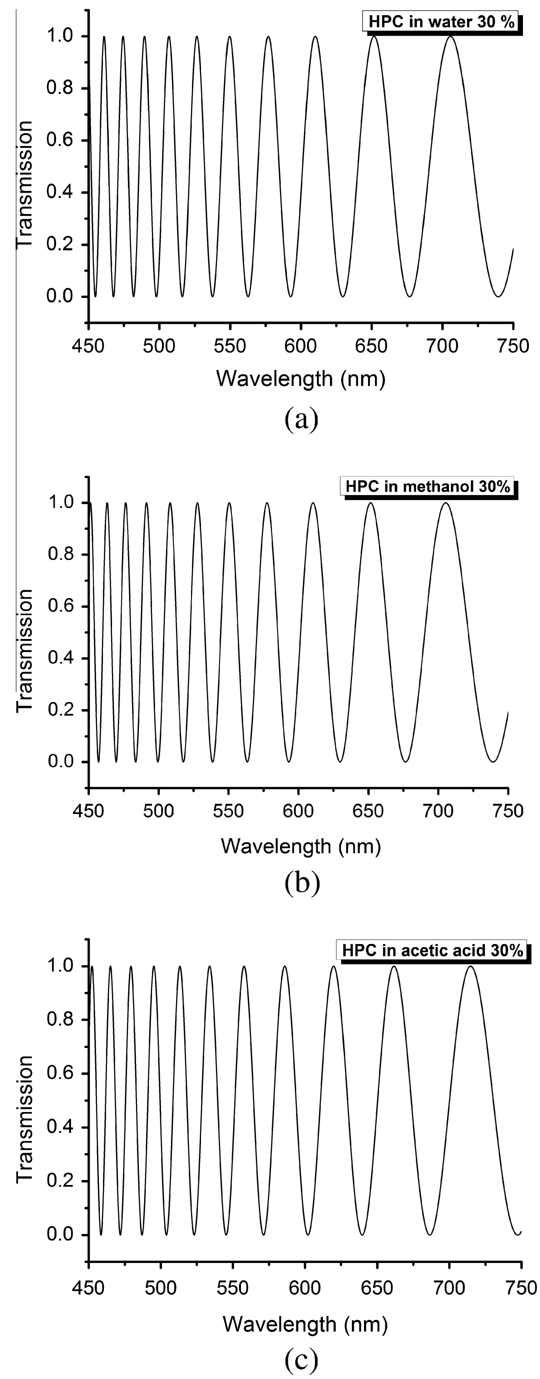

Fig. 3. Channeled spectrum of 30% HPC in (a) water, (b) methanol and (c) acetic acid, respectively.