Absolute Configuration of p-Substituted Benzoates of Panaxynol

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Exciton chirality method was applied for the determination of absolute configuration of panaxynol, a poly-yne compound from Panax ginseng roots for the first time. The circular dichroic spectra of panaxynol benzoates show the negative chirality at λ_{ext} indicating the S configuration of C-3 chiral center.

Introduction

Several C_{17} polyacetylenic compounds including panaxynol were isolated from Panax ginseng C. A. Meyer roots.[1-5] These acetylenic compounds have a secondary allylic alcohol group causing the chirality at C-3 position. However, the definite stereochemical data of these acetylenic compounds are not clarified yet because of the difficulty of structural unstability and scarcity of the compounds.

In order to deduce the absolute configurations of cyclic or acyclic secondary allylic alcohols, a circular dichroic exciton chirality method was applied to the alcohols which are converted into benzoates. This method induces the chiral interaction between two isolated but spatially close chromophores, which give rise to Davydov-split Cotton effects. This exciton chirality method is based on the coupled oscillator theory and the polarizability theory.[6-8]

Materials and Methods

Materials. Panaxynol prepared for these experiments was separated by the previousely published procedures. Kiesel Gel GF_{254} and Kiesel Gel G (70-230 mesh, Merck) were used for silica gel thin layer chromatography and column chromatography. 4-(Dimethylamino) pyridine, *p*-bromobenzoic acid, *p*-dimethylaminobenzoic acid, and dicyclohexylcarbodiimide were purchased from ALDRICH chemical company and used without fruther purification.

Spectroscopic Measurements. Ultraviolet absorption spectra were recorded with a Cary 17 spectrophotometer. Infrared spectra were recorded on a Perkin-Elmer 283B grating spectrophotometer. Pulsed proton NMR spectra were run on a Varian FT-80A NMR spectrometer at 79.542 MHz utilizing chloroform-d as internal lock signal and solvent. Circular dichroism spectra were recorded with a JASCO J-20 spectrophotopolarimeter.

p-Substituted Benzoates Formation of Panaxynol To a stirred solution of 0.24 mmol two p-substituted benzoic acid (p-bromo and p-dimethylamino) in 1 m*l* anhydrous methylene chloride was added 1-2 mg 4-(dimethylamino) pyridine as a catalyst and 0.08 mmol heptadeca-1,9-dien-4,6-diyn-3-ol. 1.5 Molar equivalents of dicyclohexylcarbodiimide were added to the reaction mixture at 0°C, which was then stirred for 5 min, at 0°C and 4 hours at room temperature. Precipitated urea was then filtered off and the filtrate dissolved in methylene chloride was treated with Sep-pak silica cartridge (Waters Associates). Thus obtained methylene chloride solution was washed twice with 1.5 N HCl and with saturated sodium bicarbonate solution, and separated by semi-preparative liquid chromatography.

Two panaxynol benzoates dissolved in methanol were used for measurements of circular dichrosim spectra in UV region.

Results and Discussion

In order to investigate the chirality of acyclic allylic alcohol where the conformations are dynamic, a circular dichroic exciton chirality method was applied to two *para*-benzoate derivatives of panaxynol.

The preparation of panaxynol benzoate derivatives were carried out with *p*-bromobenzoic acid and *p*-dimehtylaminobenzoic acid under the reaction system of dicyclohexylcarbodiimide and 4-(dimethylamino) pyridine as a catalyst. Two panaxynol benzoate derivatives were separated by low pressure preparative liquid chromatograpy.

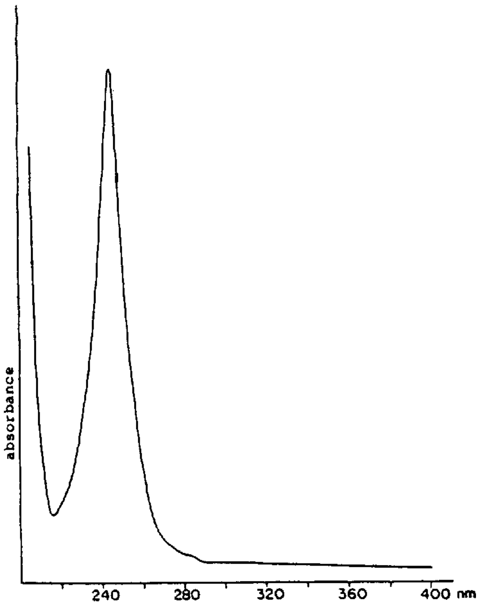

Figure 1-a. UV Spectra of panaxynol *p*-bromobenzoate.

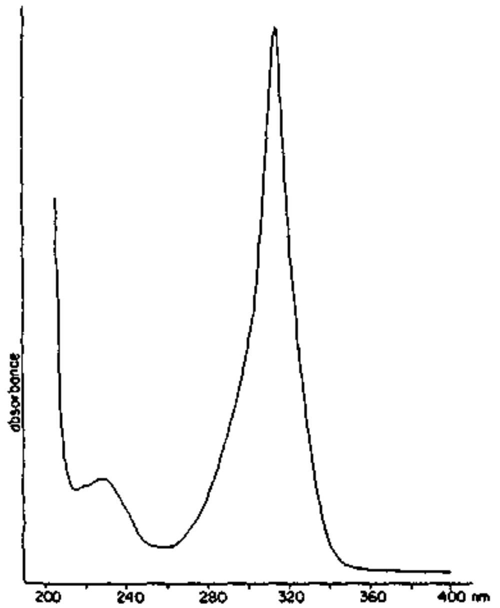

Figure 1-b. UV spectra of panaxynol p-dimethylaminobenzoate.

Table 1. Molar Circular Dichroism of Benzoates

	p-bromobenzoate	*p*-dimethylaminobenzoate
λ_{ext}(nm)	244	313
$\Delta\varepsilon$	-4.76	-4.45

Figure 1-a and 1-b show UV spectra of panaxynol *p*-bromobenzoate and p-dimethylaminobenzoate taken in methanol. Each UV spectrum shows λ_{max} at 244 nm for *p*-bromobenzoate and λ_{max} 313 nm for *p*-dimethylaminobenzoate. It indicates that secondary allylic alcohols are transformed into *p*-substituted benzoates, respectively.

^{1}H NMR spectra of panaxynol *p*-bromobenzoate show terminal methyl protons at 0.90 ppm, aliphatic methylene protons at 1.30 ppm allylic protons at 1.85~2.20 ppm, two protons between conjugated triple bond and internal double bond connected to a hydrocarbon chain at 3.06 ppm, terminal vinyl group at 5.32-6.00 ppm, protons of internal double bond at 5.42 ppm, allylic protons of terminal vinyl group at 6.15 ppm and ring protons of benzoate at 7.51-7.97 ppm. Those of p-dimethylaminobenzoate also show the proton peaks at 0.83 ppm, 1.20 ppm, 1.80-2.12 ppm, 3.00 ppm, 5.12-5.95 ppm, 5.38 ppm, 6.05 ppm and 6.50-7.88 ppm. Two methyl protons of dimethylamino group located in benzene ring appeared as the superimposed peak with two protons in 8-position at 3.00 ppm.

Infrared spectra of two benzoates of panaxynol show the typical carbonyl stretching of benzoates at 1730 cm^{-1} and conjugated two triple bonds at 2250 cm^{-1}.

The circular dichroic exciton chirality method, a nonempirical method based on the coupled oscillator theory, has been applied to various organic compounds for the determination of absolute configuration. The *p*-substituted benzoate chromophore exhibits an allowed π-π^* intramolecular charge-transfer band (^1L_a), while the C=C double bond chromophore shows an allowed π-π^* transition around 195 nm. If the two long axes of benzoate and double bond chromophores constitute a positive exciton chirality, that is, right handed screwness, the Cotton effect at ^1L_a band is positive. On the other hand, if the allylic benzoate constitutes a negative exciton chirality, ^1L_a benzoate Cotton effect should be negative.

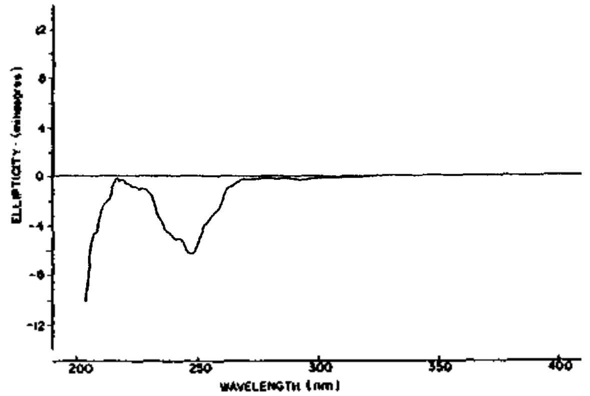

Figure 2-a. Circular dichroism spectra of panaxynol *p*-bromobenzoate in methanol.

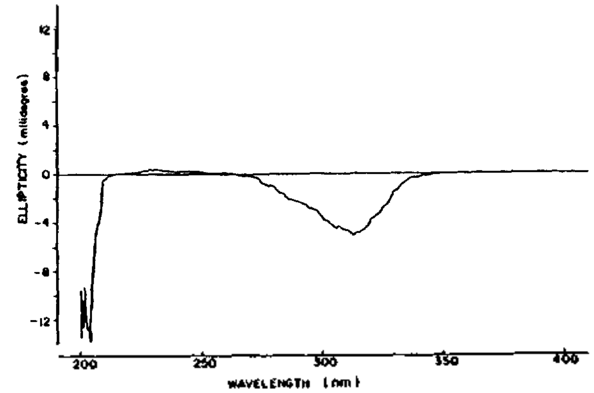

Figure 2-b. Circular dichroism spectra of panaxynol *p*-Dimethylaminobenzoate in methanol

The optical rotation of isolated panaxynol was determined to be $[\alpha]_D^{20°} = -2.83$.

Figure 2-a, 2-b, show the circular dichroism spectra of *p*-bromobenzoate and p-dimethylaminobenzoate. The ellipticity obtained from circular dichroism spectra was transformed into molar circular dichroism as shown below.

$\theta_\lambda = 33 \times \mathrm{OD}$

where $\mathrm{OD} = (\mathrm{OD})_l - (\mathrm{OD})_r$

$(\mathrm{OD})_l$: optical density of left handed circularly polarized light

$(\mathrm{OD})_r$: optical density of right handed circularly polarized light

Molar extinction coefficient is defined by the following formula.

$$\Delta\varepsilon = \frac{\mathrm{OD}}{C\,l}$$

C : mol/*l*

l : cell length (cm)

Table 1 represents the calculated molar circular dichroism at λ_{ext} of panaxynol p-bromobenzoate and p-dimethylaminobenzoate. From the results that the values of molar circular dichroism of two benzoates were negative, it is assumed that secondary allylic benzoates constitute negative exciton chirality indicating the S absolute configuration.

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Epr Spectra of α-1,2,3-$[H_nPV(IV)V_2W_9O_{40}]^{(7-n)-}$($n = 1,2$ or 3). The Effects of Protonation on the Electron Transfer Rate

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The solution epr spectra of α-1,2,3-$[H_nPV(IV)V_2W_9O_{40}]^{(7-n)-}$ were measured at various pH and three protonated species have been identified. The spectrum of $H_3PV(IV)V_2$ consisting of 8 lines indicates that the V-OH-V bridge prevents effectively the electron transfer between the vanadium atoms. The spectrum of $H_2PV(IV)V_2$ consisting of 15 lines can be interpreted by assuming that the electron is hopping fast between the two vanadium atoms in the V-O-V sequence. The multi-line spectrum of $HPV(IV)V_2$ is interpreted as a poorly resolved 43-line spectrum which originates from the electron hopping among the three vanadium atoms with the forward and backward transition probabilities of 4:1 in the OH-V-O-V sequence.

Introduction

In our previous epr study[1] we noted that a species in which the unpaired electron interacted with two vanadium nuclei only could be separated from one-electron reduction products of $[PV_3W_9O_{40}]^{6-}$. In order to identify this species we have measured epr spectra of $[PV(IV)V_2W_9O_{40}]^{7-}$ at various pH and obtained evidence that a protonated species $[H_2PV(IV)V_2W_9O_{40}]^{5-}$ shows a 15-line spectrum similar to that of $[PV(IV)VW_{10}O_{40}]^{6-}$.

The effect of protonation on epr spectra of mixed valence heteropoly anions was first reported by Pope *et al.*,[2,3] who investigated the epr spectra of $[SiV(IV)VW_{10}O_{40}]^{7-}$ and $[P_2V(IV)V_2W_{15}O_{62}]^{10-}$. The solution epr spectrum[4] of SiV(IV)V consisting of more than 40 equally spaced hyperfine lines was ascribed to a protonated species $[HSiV(IV)VW_{10}O_{40}]^{6-}$. The spectrum could be interpreted by assuming that it was split into eight equally intense lines($a_1 = 68G$) by one vanadium nucleus($I = 7/2$) and each line was split into 15 lines($a_2 = 17G$) with relative intensities 1:2:3...8...1 by the two equivalent vanadium nuclei. It was suggested that the unpaired electron is trapped on one vanadium atom but delocalized by about 17% on each of the other two.

The solution epr spectrum of $P_2V(IV)V_2$ at pH 11 consists of 22 equally spaced lines, indicating that the unpaired electron interacts equally with the three equivalent vanadium atoms.[3] This spectrum was ascribed to the unprotonated species. On the other hand, the spectrum at pH 4.7 shows 36 lines and it was ascribed to a protonated species, $[HP_2V(IV)V_2W_{15}O_{62}]^{9-}$. This spectrum could be interpreted by assuming that it was split into eight lines($a_1 = 63G$) and each line was again split into 15 lines($a_2 = 21G$). It was suggested that the electron transfer through the V-OH-V bridge is much slower than through V-O-V.

In this paper we present the solution epr spectra of $[H_nPV(IV)V_2W_9O_{40}]^{(7-n)-}$($n = 1,2$ or 3) and discuss the effect of protonation on the electron transfer rate in this mixed valence complex.

Experimental Section

Preparation of Compounds. α-1,2,3-$K_6[PV_3W_9O_{40}]$ was prepared according to the method of Domaille.[5] An aqueous solution of this compound at a desired pH was reduced to one-electron reduction state by adding hydrazine dihydrochloride. The pH of the solution was adjusted by adding hydrochloric acid or potassium hydroxide.

Epr Measurements. Epr spectra were recorded on a