

INDUCED CIRCULAR DICHROISM OF BENZOYLBenZOIC ACIDS IN β -CYCLODEXTRIN

Shunsuke Takenaka, Norio Matsuura and Niichiro Tokura

Department of Applied Chemistry, Faculty of Engineering,

Osaka University, Suita, Osaka, 565, Japan

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Phenomenon that an achiral molecule is induced to an optical active compound by the asymmetric perturbation of a chiral molecule to show the Cotton effect on the absorption of the chromophor in that molecule, has been named as an induced circular dichroism (icd).¹⁾ Cyclodextrins, on the other hand, having a hydrophobic cave in the center of the molecules,²⁾ have been used for studies of the primary process of enzyme reactions including the hydrophobic bond.³⁾ Gases and many organic molecules have been known to form inclusion compounds with cyclodextrins.⁴⁾ The inside of a cyclodextrin ring is assumed to be a chiral one since the cyclodextrin is constructed from a several number of chiral glucoses.

The present work was undertaken to obtain the informations on the inclusion phenomena of β -cyclodextrin and benzoylbenzoic acids with the icd spectra.

The icd spectrum of 4-benzoylbenzoic acid was observed between 300 and 370 nm with a maximum at 330 nm corresponding to $n-\pi^*$ band of the carbonyl group as shown in Fig. I

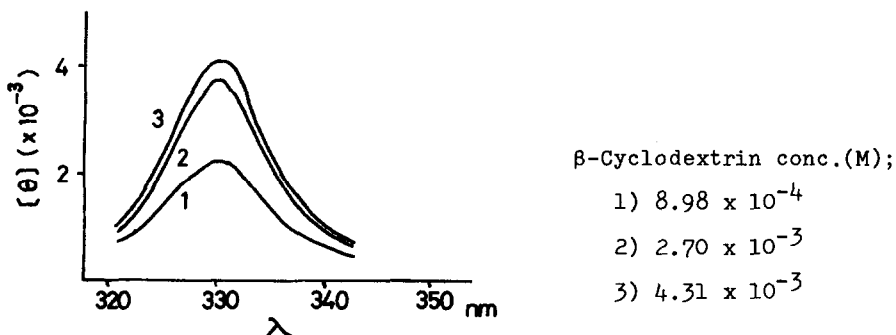


Fig. I Icd Spectra of 4-Benzoylbenzoic acid (9.15×10^{-4} M) at varying β -Cyclodextrin Concentrations

Addition of β -cyclodextrin gives rise to increase in the icd strength (Fig. I) and red shift of $n-\pi^*$ band with an isosbestic point at 334 nm in uv spectrum. The Benesi-Hildebrand relation,⁵⁾ eq (1), has been plotted in Fig. II,

$$\frac{\bar{C}_{BBA} \cdot \bar{C}_{\beta-CD}}{(\theta)} = \frac{K}{\Delta\theta} + \frac{\bar{C}_{\beta-CD}}{\Delta\theta} \quad (1)$$

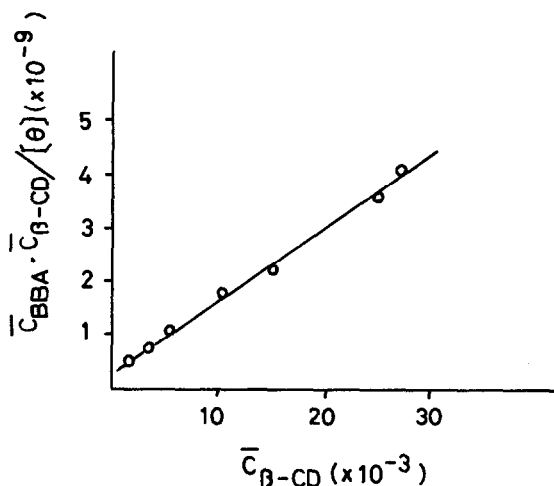


Fig. II. The Benesi-Hildebrand Plot of 4-Benzoylbenzoic Acid - β - Cyclodextrin Complex

where \bar{C}_{BBA} , $\bar{C}_{\beta-CD}$, K , (θ) and $\Delta\theta$ are the total concentration of 4-benzoylbenzoic acid, the total concentration of β -cyclodextrin, the dissociation constant for the complex, the icd strength and the difference of molar ellipticity for free and complexed 4-benzoylbenzoic acids, respectively. The plot exhibits an apparent linear relationship and the dissociation constant, $K=1.60 \times 10^{-3}$ M, is estimated from the intercept. The icd strength of benzoylbenzoic acids - β - cyclodextrin system is strongly dependent on the pH of the solvent water, as shown in Fig. III.

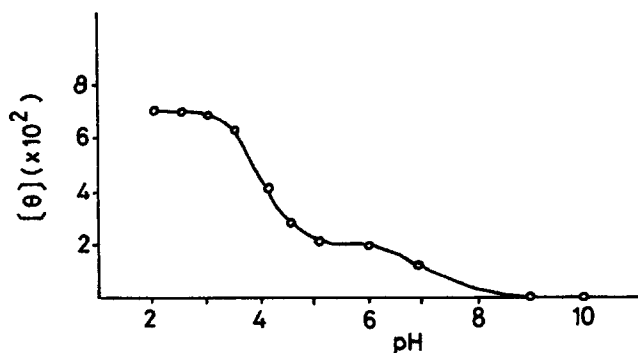


Fig. III. Icd Change with pH; β -Cyclodextrin (5.61×10^{-3} M)
2-Benzoylbenzoic acid (1.14×10^{-3} M) in Water

In case of 2-benzoylbenzoic acid- β -cyclodextrin system, Cotton effect is not observed under a basic condition and decrease of pH brings about the increase of the icd strength. Then, the pKa value of 2-benzoylbenzoic acid can be estimated as 4.08 from the titration curve. (lit.⁶) pKa; 3.43 at 25°C) The icd changes of benzoylbenzoic acid with pH are summarized in Table I.

Table I. Icd in β -cyclodextrin (1.86×10^{-3} M)

| | pH 8.2 | pH 4.0 |
|-----------------------|--------|--------|
| 2-Benzoylbenzoic Acid | 0 | 170.4 |
| 3-Benzoylbenzoic Acid | -691.9 | 276.8 |
| 4-Benzoylbenzoic Acid | 541.6 | 3237 |

It is assumed that the protonated benzoylbenzoic acid, in acidic media, is completely included in the ring of β -cyclodextrin to show the strong icd band. On the contrary, dissociated benzoylbenzoic acid, in basic media, is loosely included in the ring probably due to the strong solvation of water molecules to the carboxylate anion to show the weak icd band. Sterically favorable 4-benzoylbenzoic acid may be well included to give the most strongest icd band. Only 3-benzoylbenzoic acid in basic medium shows the negative Cotton effect. Though the reason is not clarified, such negative Cotton effect has been known in icd

system of 3-benzoylbenzoic acid-amphetamine in chloroform.⁷⁾ Furthermore, the icd of benzoylbenzoic acids with D-glucose were also examined, exhibiting weak and negative Cotton effects, as is seen in Table II.

Table II. Icd in D-glucose

| | 3.60×10^{-2} | 3.60×10^{-3} | 3.60×10^{-4} * |
|-----------------------|-----------------------|-----------------------|-------------------------|
| 2-Benzoylbenzoic Acid | -33.07 | 0 | 0 |
| 3-Benzoylbenzoic Acid | -219.9 | 0 | 0 |
| 4-Benzoylbenzoic Acid | -170.0 | 0 | 0 |

* concentrations of Glucose, M

Consequently, it may be concluded that the icd of benzoylbenzoic acids- β -cyclodextrin system originates from not the interaction of individual glucose units with the carbonyl group of benzoylbenzoic acids but that benzoylbenzoic acids is included inside of β -cyclodextrin ring and the carbonyl group is exposed to the chiral circumstance.

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