CHEMISTRY LETTERS, pp. 2089 - 2090, 1984.

COMPLEX FORMATION OF CYCLODEXTRINS IN ALCOHOL SOLUTIONS

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β-Cyclodextrin(β-CD) was found to form inclusion complexes in ethylene glycol, diethylene glycol, triethylene glycol, 2-methoxyethanol, 2-ethoxyethanol, methanol, and glycerine solutions. γ-CD also formed complexes in ethylene glycol solution. The binding of ferrocene by β-CD is stronger in ethylene glycol than in dimethyl sulfoxide and dimethyl formamide.

Until recently it was generally believed that cyclodextrins form inclusion complexes only in aqueous solutions.[1] Water seemed to be intimately involved in the association process because attempts to induce precipitation of cyclodextrin adducts from organic solvents have failed.[2] Recently, however, Breslow et al. reported that inclusion complex formation also takes place in dimethyl sulfoxide and in dimethyl formamide.[3] To our knowledge, there are no reports of inclusion complex formation in organic solvents other than dimethyl sulfoxide and dimethyl formamide. Although cyclodextrins are almost insoluble in organic solvents, they are soluble in glycols, 2-methoxyethanol, 2-ethoxyethanol, and methanol. We have now found that cyclodextrins form inclusion complexes in such alcohols.

Figure 1 shows the absorption and circular dicroism spectra of ferrocene in the presence of β-CD and γ-CD in ethylene glycol. The solutions were prepared by adding β-CD or γ-CD to ethylene glycol solutions of ferrocene (10^{-2}M). β-CD caused a marked decrease in the absorption spectrum of ferrocene at about 440 nm and showed a large positive Cotton effect at about 460 nm with a small negative Cotton effect at about 340 nm. γ-CD caused a smaller but definite decrease in the absorption spectrum of ferrocene and showed a negative Cotton effect at about 460 nm. These results indicate that β-CD and γ-CD form inclusion complexes in ethylene glycol solutions. Similar results were obtained in diethylene glycol, triethylene glycol, 2-methoxyethanol, 2-ethoxyethanol, and glycerine solutions.

Plots of the uv absorption change at 440 nm and increase in the circular dicroism spectra at 460 nm as functions of the β-CD concentration gave saturation curves indicating that the spectral changes were due to complex formation. The dissociation constants of the complexes were obtained by Benesi Hildebrand plots. Table 1 summarizes the dissociation constants of the β-CD-substrate complexes in ethylene glycol and 2-methoxyethanol. The dissociation constants were confirmed by plotting the change in optical rotation of 0.5 mM β-CD solution as a function of

the concentration of added substrate. The dissociation constants obtained by these three methods were in good agreement. The binding of ferrocene by β-CD is stronger in ethylene glycol than in dimethyl sulfoxide, but the dissociation constants in 2-methoxyethanol and dimethyl sulfoxide are almost the same. β-CD was found to solubilize ferrocene in ethylene glycol. The ferrocene-β-CD complex was so stable that it could be recrystallized from ethylene glycol.[4] Ferrocene also bound to β-CD in methanol solution with a dissociation constant of 8mM. Bromobenzene, chlorobenzene, and trichloroethylene were shown by measurement of the optical rotation change of β-CD to be bound with β-CD.

Reversal of the signs of the circular dichroism spectra of ferrocene in the presence of β-CD and γ-CD is considered in terms of the orientation of the included component, which was discussed in another paper.[4]

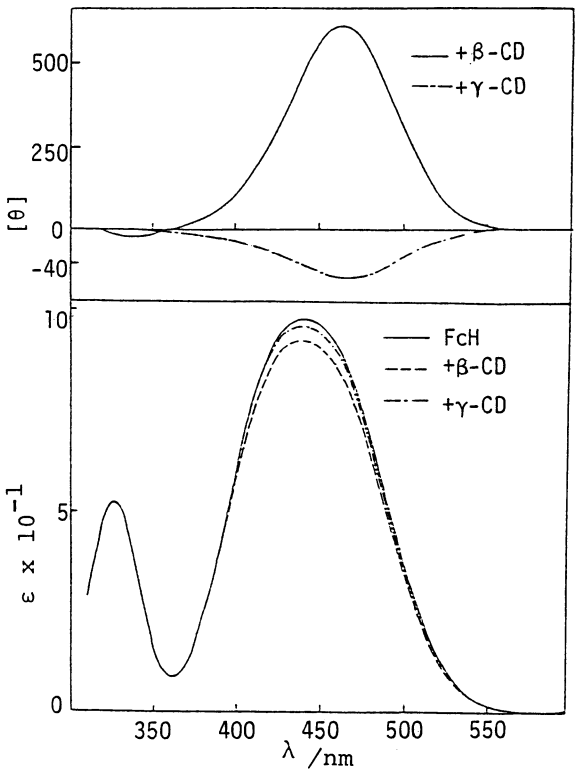

Fig.1. Absorption and c.d. spectra of ferrocene(FcH) in the presence of β-CD and γ-CD in ethylene glycol. [CD]=[FcH]=10^{-2} M

Table 1. Dissociation constants of β-CD-substrate complexes

Substrate	Kd/mM		
	in ethylene glycol	in 2-methoxyethanol	in DMSO
Ferrocene	12[a]	25[c]	21[d]
	13[b]		
	12[c]		
Toluene	60[c]	400[c]	444[d]
Anisole	66[c]		

a) Determined from circular dichroism spectrum.
b) Determined from UV spectrum.
c) Determined from optical rotation.
d) Ref. 3.

References

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(Received September 14, 1984)