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ASYMMETRIC HYDROGENATION WITH CHIRAL PHOSPHINE LIGAND HAVING C-PPh_2 BONDING DERIVED FROM $\underline{\underline{D}}$-GLUCOSE

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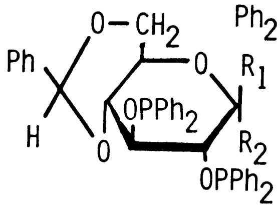
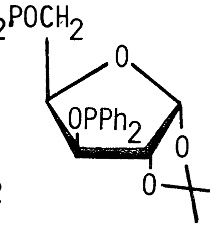
Rh-complex of 6S-cyano-5R-diphenylphosphino-3R,4S-O-isopropylidene-2-oxa-bicyclo[3.2.0]heptane showed the relatively high enantioselectivity (S-configuration) in the hydrogenation of α-acetamidocinnamic acid, whereas Rh-complex of the 6S-aminomethyl compound, the reduction product of the former, gave the reversed enantioselectivity (R-configuration) in the reaction.

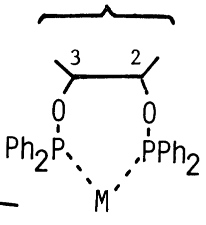
Sugars have useful several asymmetric carbons and thus, could be used for the syntheses of chiral ligands. The syntheses of sugar phosphine ligands such as I and II,1) and III2) have been reported, but they are known to be easily susceptible to hydrolysis because of their O-P bondings. Moreover, the rigidities of the Rh-complexes of these cannot be high because of the seven (IV) or the eight (V) membered ring nature.



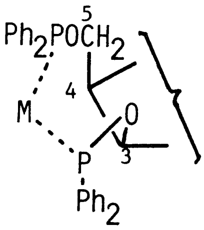
(I) $R_1=OCH_3, R_2=H$
(II) $R_1=H, R_2=OCH_3$



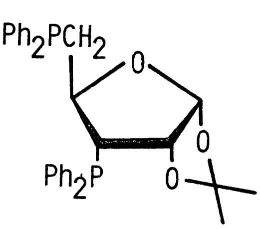
(III)



(IV)



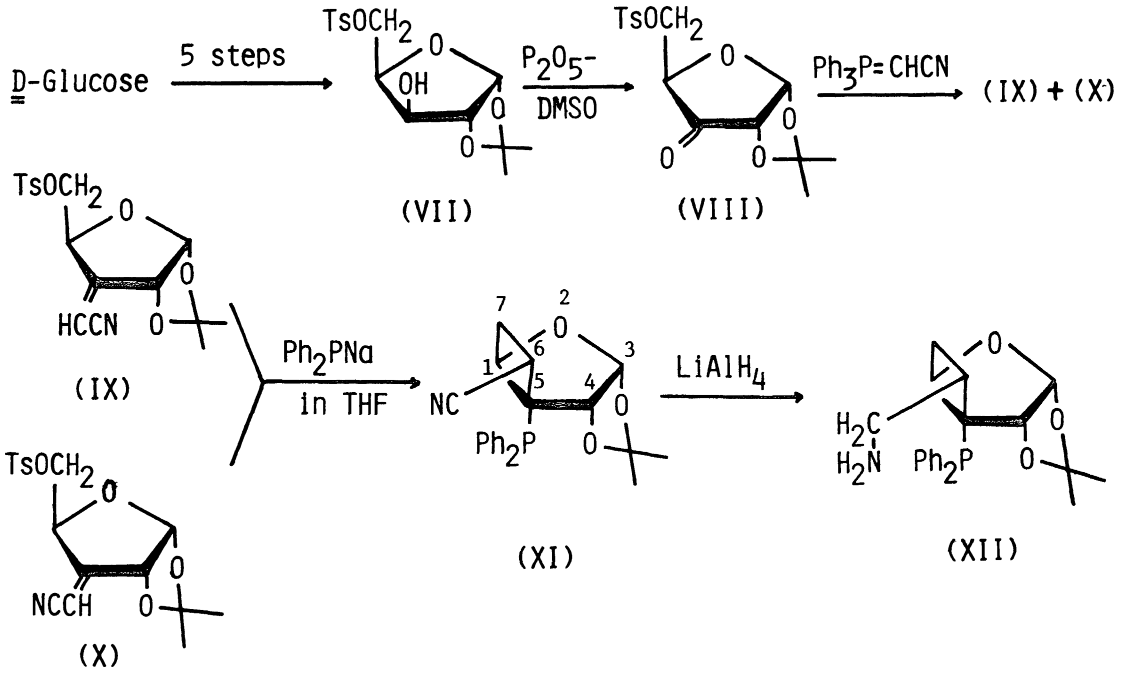
(V)



(VI)

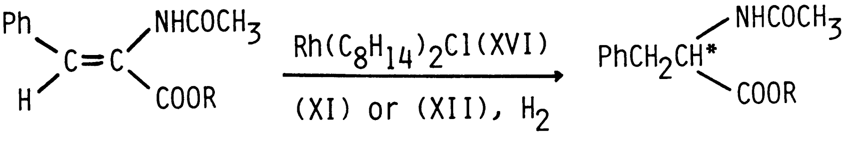
During our trial work to synthesize the sugar bisdiphenyl phosphine ligand such as VI, which has C-P bondings and forms six membered ring complex with Rh, a novel skeletal compound XI was obtained.³⁾ In this communication, the enantioselectivities of XI and its reduction product XII, when they were used as the chiral ligands in the hydrogenation of olefins, are presented in comparison with the result of (-)-DIOP (XIII) catalyzed hydrogenation.

The phosphine ligand XI was synthesized by the routes drawn in Scheme 1. 1,2-O-Isopropylidene-5-O-tosyl-D-xylose (VII) was obtained in 5 steps from D-glucose.$^{4)}$ Then, VII was oxidized with P_2O_5-DMSO$^{5)}$ and the obtained syrupy product (VIII) was treated with Wittig reagent, $Ph_3P=CHCN$, to give two olefins (IX; mp. 113-5°, 67%, and X; 24%). 6S-Cyano-5R-diphenylphosphino-3R,4S-O-isopropylidene-2-oxa-bicyclo[3.2.0]heptane (XI), mp. 174-6°, $[\alpha]_D^{28°} = +141°$ (benzene), was obtained from the both olefins, IX and X, as the major product by the reaction with Ph_2PNa.$^{6)}$ Reduction of XI with $LiAlH_4$ gave the corresponding amine (XII), mp. 125-7°, $[\alpha]_D^{28°} = +90°$ (benzene).



Scheme 1. Syntheses of (XI) and (XII)

The asymmetric hydrogenations of Z-α-acetamidocinnamic acid (XIV) and its methyl ester (XV) to N-acetyl phenylalanine (XVII) and N-acetyl phenylalanine methyl ester (XVIII), respectively, were carried out by the use of the neutral Rh-complex, which was generated from Rh(cyclooctene)$_2$Cl (XVI) and the ligand XI or XII, under various conditions as shown in Table I and II.

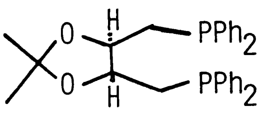


(XIV) R = H

(XV) R = CH_3

(XVII) R = H

(XVIII) R = CH_3



(-)-DIOP(XIII)

Table I. Catalytic hydrogenations of XIV and XV with XI-Rh complex[a]

Substrate	XI/Rh	Pressure (atm)	Conversion (%)	Time (h)	Optical Yield (% ee)	Conf.
XIV	2/1	1	83.7	72	91.6[b]	S
	1/1	1	100	1w	30.7	S
	2/1	15	100	10	85.6	S
	2/1	30	100	10	60.1	S
XV	2/1	1	51.4	72	70.6[c]	S
	2/1	15	100	10	53.8	S
	2/1	30	100	10	42.9	S

a) The hydrogenation reactions were carried out under the following conditions; substrate/Rh = 50, [XI] = 1.07 x 10^{-4}mol, 20 ml C_6H_6-MeOH (1:4) as solvent, room temp.

b) The DIOP-Rh complex gave 75% ee(R) under the same conditions with 100% conversion in 8h (cf., lit.$^{7)}$ 72% ee(R)).

c) The DIOP-Rh complex gave 53% ee(R) under the same conditions with 100% conversion in 16h (cf., lit.$^{7)}$ 55% ee(R)).

Table II. Catalytic hydrogenations of XIV and XV with XII-Rh complex[d]

Substrate	XII/Rh	Pressure (atm)	Conversion (%)	Time (h)	Optical Yield (% ee)	Conf.
XIV	1/1	1	100	72	39.0	R
	2/1	1	100	72	34.8	R
	1/1	15	100	10	14.8	R
XV	1/1	1	100	72	15.5	R
	1/1	15	100	10	5.3	R

d) [XII] = 1.07 x 10^{-4}mol and the other conditions are same as in a).

The optical yields of the products under 1 atm of H_2 in each series carried the highest values, although the reaction rates were low compared with those of the reactions under elevated pressures. The XI-Rh complex gave far better optical yields than those of the DIOP-complex in the reductions of XIV and XV, although the reaction rates under 1 atm were lower (Table I).

The better optical yield (91.6%) by the XI/Rh(2/1)-complex compared with the optical yield by the XI/Rh(1/1)-complex (30.7%) in the hydrogenation of XIV under 1 atm suggests that the XI-catalyst is constructed with 2 mol of XI and 1 mol of XVI (Table I). On the other hand, the XII-catalyst might consist of 1 mol of XII and 1 mol of XVI, because no marked optical yield change was observed for the different ratio of XII to XVI in the hydrogenation of XIV [39.0% in the case of XII/Rh(1/1) and 34.8% in the case of XII/Rh(2/1) (Table II)]. The result shows the bidentate nature of XII, which has a diphenylphosphino- and an amino-group in the molecule to coordinate with Rh as a neutral catalyst.8)

Furthermore, S-configuration of the product by the use of the nitrile ligand (XI) makes a sharp contrast with R-configuration of the product by the use of the amine ligand (XII) together with the higher optical yield in the former.

References

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