

HIGHLY ENANTIOSELECTIVE CATALYTIC ASYMMETRIC HYDROGENATION OF ITACONIC ACID¹⁾

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Itaconic acid(1) has been of much interest as a target for the catalytic asymmetric hydrogenation²⁻⁴⁾ mainly because the enantioselectivity of the hydrogenation of this simple α,β -unsaturated acid can be accounted for only by the structural difference between the carboxyl and the carboxymethyl group, and also the resulting product, optically active α -methylsuccinic acid(2) has the well-functionalized structure of the chiral tertiary carbon atom and is useful as a starting material for the preparation of optically active homologs.

We wish to describe here the highly effective homogeneous catalytic asymmetric hydrogenation of itaconic acid(1) using new chiral pyrrolidinephosphines (3), [BPPM⁵⁾, BZPPM⁶⁾, PCPPM⁷⁾, NPPM⁷⁾, INPPM⁷⁾] as ligands, to give optically active α -methylsuccinic acid(2). PCPPM(3c), NPPM(3d) and INPPM(3e) were newly synthesized by the reaction of (2S,4S)-4-diphenylphosphino-2-diphenylphosphino-methylpyrrolidine(PPM)^{5,8)} with the corresponding acyl chlorides in benzene at room temperature, expecting to clarify the N-substituent effect and the base effect on the optical yields^{5,6,8-11)}. The new nitrogen atoms of their N-substituents which are located at different distances may interact with the carboxyl groups of itaconic acid in the manner different from each other resulting in the corresponding optical yields, when the direct interactions between the carboxyl groups of substrate and the N-substituent of the chiral ligand is present.

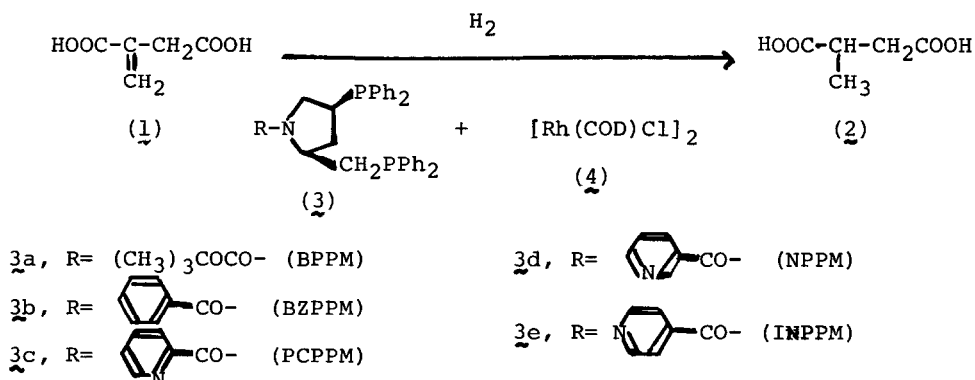


Table I. Asymmetric hydrogenation of itaconic acid^{a)}

Chiral reagent (3) (R)	Solvent	$[\alpha]_D^{20}$ (EtOH)	Optical y. (conf.) ^{b)} (%)
(CH ₃) ₃ COCO- (BPPM)	methanol	-12.0	71.1 (S)
C ₆ H ₅ CO- (BZPPM)	methanol	-14.1	83.5 (S)
α -C ₅ H ₄ NCO- (PCPPM)	methanol	-11.8	69.9 (S)
β -C ₅ H ₄ NCO- (NPPM)	methanol	-11.9	70.5 (S)
γ -C ₅ H ₄ NCO- (INPPM)	methanol	-12.1	71.1 (S)
(CH ₃) ₃ COCO- (BPPM)	benzene-methanol (2:1)	- 8.4	49.8 (S)
C ₆ H ₅ CO- (BZPPM)	benzene-methanol (2:1)	-10.6	62.8 (S)
α -C ₅ H ₄ NCO- (PCPPM)	benzene-methanol (2:1)	- 7.1	42.1 (S)
β -C ₅ H ₄ NCO- (NPPM)	benzene-methanol (2:1)	- 5.0	29.6 (S)
γ -C ₅ H ₄ NCO- (INPPM)	benzene-methanol (2:1)	- 5.9	35.0 (S)

a) All hydrogenations were carried out with 5 mmole of substrate, 0.025 mmole of [Rh(1,5-cyclooctadiene)Cl]₂ and 0.06 mmole of bisphosphine in 10 ml of solvent at 20°C for 20 h under an initial hydrogen pressure of 50 atm. b) Calculated on the basis of the reported value for optically pure R-2; $[\alpha]_D^{20} + 16.88$ (c 2.16, EtOH) (E. Berner and R. Leonardsen, Ann. 538, 1 (1939)).

Table I shows clearly that BZPPM-rhodium complex gave the better optical yields than the others both in methanol and benzene-methanol, and also PCPPM-, NPPM- and INPPM-rhodium complexes gave almost the same optical yields in methanol solution whereas their different effects on the optical yield were observed in benzene-methanol. These facts may suggest that at least in methanol, the nitrogen atoms of the N-substituents of PCPPM, NPPM and INPPM do not interact directly with the carboxyl groups of substrate but effect only as bases on the rhodium metal to change the optical yields of the product to the same extent.

Table I also indicates that our new pyrrolidinephosphines are highly effective chiral ligands for the homogeneous catalytic asymmetric synthesis of some optically active acids as well as for the synthesis of R-(-)-pantolactone¹¹⁾, although the reaction conditions have not been optimized.

Further investigations of the N-substituents and the base effects on the stereoselectivity using a series of pyrrolidinephosphines are actively under way.

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