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THE EFFECT OF ADDITIVES AND SOLVENTS ON THE HYDROGENOLYSIS OF 2-METHYL-2-PHENYLAZIRIDINE DERIVATIVES WITH PALLADIUM CATALYST

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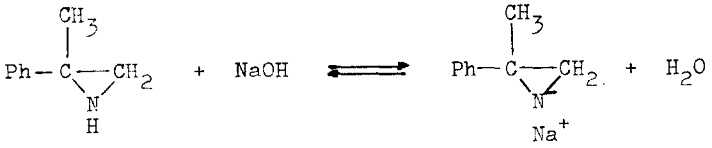
In the previous paper (1), we reported the stereoselectivity of several Group VIII transition metal catalysts on the hydrogenolysis of 2-methyl-2-phenylaziridine and suggested that the configuration of the product is determined by the free energy difference of the transition states to form the carbon metal bond, which depends on the affinity of the catalyst for the nitrogen, catalyst hindrance and others. In this paper, we report the effect of additives and solvents on the hydrogenolysis of optically active 2-methyl-2-phenylaziridine (Ia) and its derivatives: 1,2-dimethyl-2-phenylaziridine (Ib) and 1-acetyl-2-methyl-2-phenylaziridine (Ic) with palladium catalyst.

Table I summarizes the effect of sodium hydroxide and potassium iodide on the hydrogenolysis of Ia, Ib and Ic over palladium catalyst in ethanol. 2-Phenylpropylamine (IIa), N-methyl-2-phenylpropylamine (IIb) and N-2-phenylpropylacetoamide were obtained, respectively. The configuration of IIa was inverted in the absence of sodium hydroxide, while the percentage of the retained product was increased as the amount of sodium hydroxide was increased. Ia and Id co-exist at equilibrium in the presence of sodium hydroxide. Id would hardly undergo the hydrogenolysis *via* *A* since the nitrogen of Ia acts as an electron-donor. However, the hydrogenolysis *via* *B* or *C* would be less inhibited than that *via* *A* because the nitrogen in *B* and *C* are adsorbed on the catalyst. Therefore, Id would participate in the hydrogenolysis of Ia in the presence of sodium hydroxide. On the other



Ia Id

(1)

Table I.

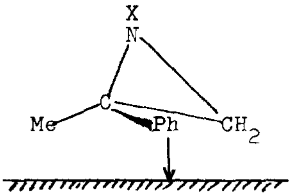
The Effect of Sodium Hydroxide and Potassium Iodide on the Hydrogenolysis of 2-Methyl-2-phenylaziridine (Ia) and its Derivatives (Ib and Ic)

I, 0.01 mol.; Solvent, Ethanol: 20 ml; Catalyst, $Pd(OH)_2$: 50 mg.

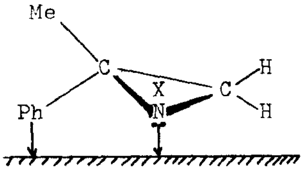
Exp. No.	Reactant	Additive ($1x10^{-4}$mol.)		Product	Maintained optical activity	Configuration
1	Ia	----		IIa	72	Inversion
2	Ia	NaOH	1.0	IIa	46	Inversion
3	Ia	NaOH	2.0	IIa	57	Retention
4	Ia	NaOH	5.0	IIa	79	Retention
5	Ia	NaOH	10.0	IIa	100	Retention
6	Ia	KI	0.1	IIa	34	Inversion
7	Ia	KI	0.2	IIa	35	Inversion
8	Ib	----		IIb	72	Inversion
9	Ib	NaOH	5.0	IIb	65	Inversion
10	Ib	NaOH	10.0	IIb	64	Inversion
11	Ic	----		IIc	75	Inversion
12	Ic	NaOH	5.0	IIc	94	Inversion

hand, such influence of sodium hydroxide could not be obsereved on the hydrogenolysis of Ib and Ic. These results would depend on no possibility of equilibrium like Eq. 1 in the case of Ib and Ic and support the participation of Id on the hydrogenolysis of Ia in the presence of sodium hydroxide.

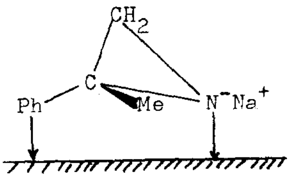
The hydrogenolysis of Ia and Ib over palladium catalyst occured predominantly with inversion of configuration when ethanol was used as solvent, while the



A



B



C

-X: a) -H, b) $-CH_3$, c) $-COCH_3$, d) Na configuration of IIa and IIb was predominantly retained in benzene. To determine how far the hydrogenolysis may be influenced by solvents, the hydrogenolysis of Ia in several kinds of solvent was carried out under ordinary pressure and temperature. The results are summarized in Table II. The percentage of the inverted product was increased in the order: benzene < toluene ≒ *o*-xylene < *m*-xylene < *p*-xylene < *t*-butylbenzene, which is associated with the strengths of π-adsorption of aromatic ring (2).

The hydrogenolysis of Ia and Ib would be retarded, because the strength of adsorption of the reactants and the nucleophilic character of the catalyst would diminish by adsorption of benzene, which acts as a weak catalyst poison. Here, the hydrogenolysis *via* *B* would be less inhibited than that *via* *A* because the nitrogen is adsorbed on the catalyst in the former state, but directed away in the latter. Consequently, the free energy of the transition state to form the carbon metal bond *via* *B* would become lower that that *via* *A* when benzene is used as solvent.

Table II.

The Effect of Solvents on the Hydrogenolysis of

2-Methyl-2-phenylaziridine (Ia) and its Derivatives (Ib and Ic)

I, 0.01 mol.; Solvent, 20 ml; Catalyst, Pd(OH)$_2$: 50 mg.

Exp. No.	Reactant	Solvent	Product	Maintained optical activity	Configuration
1	Ia	Benzene	IIa	35	Retention
2	Ia	Toluene	IIa	23	Inversion
3	Ia	*o*-Xylene	IIa	23	Inversion
4	Ia	*m*-Xylene	IIa	33	Inversion
5	Ia	*p*-Xylene	IIa	41	Inversion
6	Ia	*t*-Butylbenzene	IIa	48	Inversion
7	Ia	*n*-Hexane	IIa	75	Inversion
8	Ia	Ethanol	IIa	72	Inversion
9	Ib	Benzene	IIb	9	Retention
10	Ib	Ethanol	IIb	72	Inversion
11	Ic	Benzene	IIc	85	Inversion
12	Ic	Ethanol	IIc	75	Inversion

This interpretation is supported by the results that the inverted product was increased on the hydrogenolysis of Ia as the strengths of adsorption of the solvents was diminished, and similar variations of the maintained optical activity on the hydrogenolysis of Ib were observed in the presence of sodium hydroxide. The effect of potassium iodide on the hydrogenolysis of Ia can be explained by the similar considerations.

The hydrogenolysis of Ic occured with predominant inversion of configuration in both ethanol and benzene by contrast with that of Ia and Ib. The adsorption strength of the nitrogen of Ic would be smaller than that of Ia and Ib, for the electron-density of the nitrogen would become lower by electron-withdraw of the acetyl group. It seems, therefore, that the activation free energy to form the carbon metal bond increases by adsorption of benzene on the catalyst. However, since the acetyl group withdraws the electrons of the benzylic carbon-nitrogen bond of Ic, the stereoelectronic requirement of the transition state is filfilled in the state A, and the hydrogenolysis *via* this state would be less inhibited by adsorption of benzene. Consequently, the free energy of the corresponding transition state *via* A would become lower than that *via* B in both ethanol and benzene by contrast with the case of Ia and Ib. The maintained optical activity of IIc was increased on the hydrogenolysis od Ic in the presence of sodium hydroxide (Table I.). The difference of the free energy of the transition states to form the carbon metal bond would become larger by adsorption of sodium hydroxide.

Iijima and Mitsui reported similar solvent effect on the hydrogenolysis of 2-phenyl-2-butanol over palladium catalyst (3). Further, Grimm and Bonner also reported similar variations of configuration of the product on the Raney nickel desulfuration of 2-phenyl-2-benzenesulfonylpropinamide (4). These results may be explained consistently by the above-mentioned considerations.

References

1. S. Mitsui and Y. Sugi, Tetrahedron Letters, 1969,
2. C. P. Rader and H. A. Smith, J. Am. Chem. Soc., 84, 1443 (1962); H. A. Smith and W. E. Campbell, 3rd Inter. Congr. Catalysis, Amsterdam, 1373 (1964); J. L. Garnett and W. A. Sollich-Baumgartner, Advances in Catalysis, 16, 95 (1966).
3. K. Iijima and S. Mitsui, J. Chem. Soc. Japan, Pure Chem. Sect., 85, 686 (1964).
4. R. A. Grimm and W. A. Bonner, J. Org. Chem., 32, 3470 (1967).