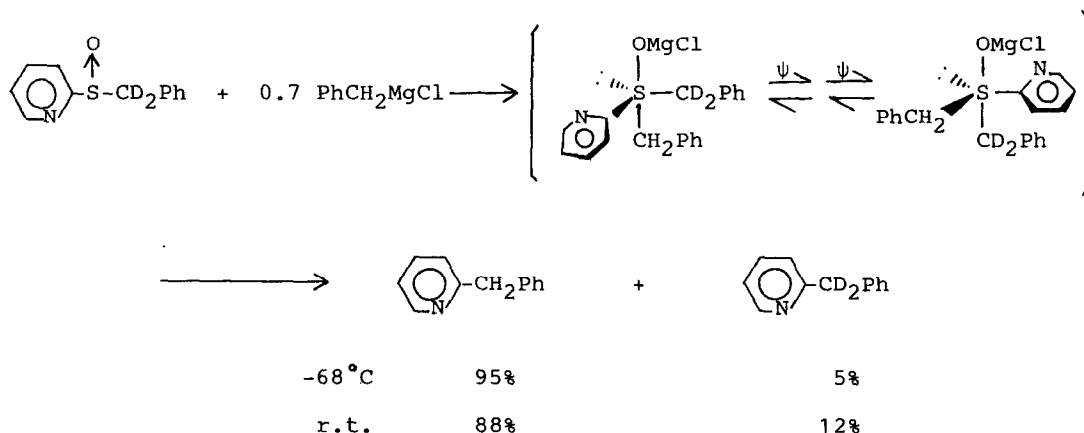


SENSITIVE NATURE OF LIGAND COUPLING AND PSEUDOROTATION TO
 ELECTRONIC EFFECT OF SUBSTITUENT---LIGAND COUPLING IN THE REACTIONS
 OF BENZYLIC ARYL SULFOXIDES WITH BENZYLIC GRIGNARD REAGENTS¹⁾

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Abstract: Unlike the reaction of benzylic 2-pyridyl sulfoxides with benzylic Grignard reagents, in the reaction of p-benzenesulfonylphenyl benzylic sulfoxides with benzylic Grignard reagents, benzylic groups bearing an electron-withdrawing group tends to couple with the aryl group preferentially. This change is considered to be due to a slight change of electronic environments which would effect on the ease of pseudorotation²⁾ of the incipient σ -sulfurane formed during the reaction.

Earlier, we have shown that in the reaction of benzyl-d₂ 2-pyridyl sulfoxide with unlabeled benzylmagnesium chloride the coupling product was predominantly unlabeled 2-benzylpyridine.³⁾ Even in the reaction of benzyl 2-pyridyl sulf oxide with p-methylbenzylmagnesium chloride, the incoming p-methylbenzyl group was found to couple preferentially with 2-pyridyl group. When the temperature of the reaction was raised, however, the relative amounts of coupled 2-benzylic-pyridines in which the benzylic groups are originated from the starting sulfoxides, were found to increase.



This was taken to indicate that pseudorotation of the intermediary σ -sulfuranes become more facile prior to coupling of the two ligands, i.e., benzylic group and 2-pyridyl group in the resulted σ -sulfuranes, as temperature is raised, though both ligand coupling and pseudorotation would take place nearly in the same ease.

Meanwhile, the energy barrier for pseudorotation of σ -sulfuranes bearing even electronegative heteroatom ligands is small, i.e., in the range of 7.4 to 13.5 kcal/mole for Martin's stable σ -sulfuranes.⁴⁾ Therefore, that for the unstable intermediary σ -sulfuranes bearing carbon-centered ligands, as in our case, would be much smaller than the above values. This may mean that both ligand coupling and pseudorotation would be quite sensitive to the small change of the electronic environment around the sulfur atom in the incipient σ -sulfurane.

In order to test this sensitivity, we have carried out ligand coupling reactions of substituted benzyl 2-pyridyl and p-benzenesulfonylphenyl sulfoxides with benzylic Grignard reagents, and found that the mode of coupling between the ligands around the central sulfur atom in the intermediary sulfurane changed sensitively by the change of electron-withdrawing property of the ligand involved in the coupling. Some representative data, obtained in the reaction (1), are listed in Table.

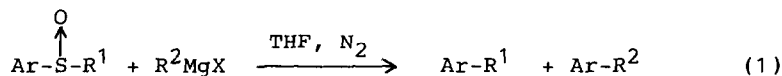


Table. Ratios of Coupling Products⁵⁾ in the Reaction (1)

Entry	Ar	R ¹	R ²	ArR ¹ :ArR ² Total ^{b)}		ArR ¹ :ArR ² Total ^{b)}	
				Ratio ^{a)} r.t.	yield/%	Ratio ^{a)} 50°C	yield/%
1	2-Py	p-CH ₃ C ₆ H ₄ CH ₂	PhCH ₂	16 : 84 ^{c)}	55.3	20 : 80	56.8
		PhCH ₂	p-CH ₃ C ₆ H ₄ CH ₂	44 : 56 ^{c)}	51.7	52 : 48	48.2
2	p-Bsp	p-CH ₃ C ₆ H ₄ CH ₂	PhCH ₂	20 : 80	53.3	19 : 81	47.5
		PhCH ₂	p-CH ₃ C ₆ H ₄ CH ₂	77 : 23	49.5	46 : 54	50.5
3	2-Py	o,p-(CH ₃) ₂ C ₆ H ₃ CH ₂	PhCH ₂	17 : 83	57.3		
		PhCH ₂	o,p-(CH ₃) ₂ C ₆ H ₃ CH ₂	41 : 59	44.3		
4	p-Bsp	o,p-(CH ₃) ₂ C ₆ H ₃ CH ₂	PhCH ₂	12 : 88	59.4		
		PhCH ₂	o,p-(CH ₃) ₂ C ₆ H ₃ CH ₂	47 : 53	57.8		

5	2-Py	p-ClC ₆ H ₄ CH ₂	PhCH ₂	65 : 35	48.3
	"	PhCH ₂	p-ClC ₆ H ₄ CH ₂	9 : 91	47.1
6	p-Bsp	p-ClC ₆ H ₄ CH ₂	PhCH ₂	65 : 35	53.8
	"	PhCH ₂	p-ClC ₆ H ₄ CH ₂	6 : 94	50.0
7	2-Py	o,p-Cl ₂ C ₆ H ₃ CH ₂	PhCH ₂	92 : 8	29.1
8	p-Bsp	Ph(CH ₃)CH	PhCH ₂	8 : 92	53.0
	"	PhCH ₂	Ph(CH ₃)CH	18 : 82	43.9
9	2-Py	Ph(CH ₃)CH	PhCH ₂	11 : 89	49.8
	"	PhCH ₂	Ph(CH ₃)CH	75 : 25	62.8

a) Determined by HPLC. b) Weight percent based on sulfoxide used. c) By GLC analysis.

(Py: pyridyl, Bsp: benzenesulfonylphenyl; Condition: Reaction of 2-Py sulfoxide---1/1mol, 15min. p-Bsp sulfoxide--- 1/1.5mol, 1h.)

Inspection of the data reveals clearly that the coupling mode between p-benzenesulfonylphenyl group and the benzylic group is quite different from that between 2-pyridyl and the benzylic group. In the reaction of benzyl p-benzenesulfonylphenyl sulfoxide with p-methylbenzylmagnesium chloride and also in that between p-methylbenzyl p-benzenesulfonylphenyl sulfoxide and benzyl Grignard reagent, benzyl group tends to couple preferentially with the aryl group. Substitution of an electron-donating methyl group at p-position of benzyl group clearly reduced the amount of the coupling product between the aryl and p-methylbenzyl groups. Whereas, the substitution of an electron-withdrawing chloro group at p-position of benzyl group was found to increase remarkably the amount of the coupling product between p-chlorobenzyl and the aryl group. Even in the reaction of p-chlorobenzyl 2-pyridyl sulfoxide with benzylmagnesium chloride, the major coupling product was 2-p-chlorobenzyl-pyridine (Entry 5). Here again, however, pseudorotation seems to be accelerated relative to coupling as temperature is raised (Entry 1 and 2).

Thus, a slight change of the electronic effect of the S-substituted ligand appears to change the mode of coupling, due to the change of the ease of pseudorotation of the intermediary σ -sulfurane. The facile change of pseudorotation by the slight variation of electronic environment of the involving ligand was also observed recently by Mikołajczyk⁶⁾ in the ligand exchange, i.e., the acid-catalyzed nucleophilic substitution, of optically active sulfinyl amides with alcohols.

References

- 1) see earlier paper of this series, S. Oae, T. Kawai, and N. Furukawa, *Tetrahedron Lett.*, **25**, 69 (1984); T. Kawai, N. Furukawa, and S. Oae, *ibid.*, **25**, 2549 (1984); S. Oae, *Croat. Chem. Acta*, **59**, 129 (1986); S. Oae, *Phosphorus and Sulfur*, **27**, 13 (1986); S. Oae, T. Kawai, N. Furukawa, and F. Iwasaki, *J. Chem. Soc., Perkin Trans. 2*, **1987**, 405.
- 2) We used this term for such a polytopal transformation just for the sake of simple expression, though turnstile rotation may also take place for the same transformation.
- 3) T. Kawai, N. Furukawa, S. Oae, and T. Takeda, *Phosphorus and Sulfur*, **34**, 133 (1987).
- 4) J. C. Martin and E. Perozzi, *Science*, 191 (1976); G. W. Astroges and J. C. Martin, *J. Am. Chem. Soc.*, **98**, 2895 (1976).
- 5) p-(p-Methylbenzyl)phenylsulfonylbenzene: mp 101.0-102.0°C; IR(KBr) 1150, 1300 cm^{-1} ; $^1\text{H NMR}(\text{CDCl}_3)$ $\delta=2.30(\text{s}, 3\text{H})$, 3.90(s, 2H), 6.98-8.20(m, 13H). 2-(o,p-Dimethylbenzyl)pyridine: pale yellow oil; IR(neat) 1425, 1595 cm^{-1} ; $^1\text{H NMR}$ $\delta=2.30(\text{d}, 3\text{H}\times 2, \text{J}=5\text{Hz})$, 4.18(s, 2H), 6.70-7.75(m, 6H), 8.32-8.73(m, 1H). p-(o,p-Dimethylbenzyl)phenylsulfonylbenzene: mp 95.0-96.0°C; IR(KBr) 1150, 1300 cm^{-1} ; $^1\text{H NMR}$ $\delta=2.13(\text{s}, 3\text{H})$, 2.28(s, 3H), 3.95(s, 2H), 6.70-7.05(m, 3H), 7.05-7.60(m, 5H), 7.60-8.10(m, 4H). 2-(p-Chlorobenzyl)pyridine: pale yellow oil, IR(neat) 1430, 1490 cm^{-1} ; $^1\text{H NMR}(\text{CDCl}_3)$ $\delta=4.07(\text{s}, 2\text{H})$, 6.29-7.71(m, 7H), 8.42-8.62(m, 1H). p-(p-Chlorobenzyl)phenylsulfonylbenzene: mp 148.0-149.0°C; IR(KBr) 1150, 1320 cm^{-1} ; $^1\text{H NMR}(\text{CDCl}_3)$ $\delta=4.06(\text{s}, 2\text{H})$, 6.88-8.32(m, 13H). 2-(o,p-Dichlorobenzyl)pyridine: pale yellow oil; IR(neat) 1470, 1595 cm^{-1} ; $^1\text{H NMR}(\text{CDCl}_3)$ $\delta=4.20(\text{s}, 2\text{H})$, 6.87-7.69(m, 6H), 8.29-8.57(m, 1H). p-(1-Phenylethyl)phenylsulfonylbenzene: mp 87.0-88.0°C; IR(KBr) 1150, 1310 cm^{-1} ; $^1\text{H NMR}(\text{CDCl}_3)$ $\delta=1.67(\text{d}, 3\text{H}, \text{J}=8\text{Hz})$, 3.78(q, 1H, $\text{J}=8\text{Hz})$, 6.08-8.80(m, 14H).
- 6) M. Mikołajczyk, Prenary lecture in 12th International Symposium on the Organic Chemistry of Sulphur, Nimegen, The Netherlands, June 29 - July 4, 1986; M. Mikołajczyk, J. Drabowicz, and B. Bujinicki, *Tetrahedron Lett.*, **26**, 5699 (1985).

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