Pergamon

Tetrahedron Letters 41 (2000) 4157–4160

TETRAHEDRON LETTERS

Diastereoselective reaction of 1-(arylsulfinyl)-2-naphthaldehydes

Shuichi Nakamura, Hiroki Yasuda, Yoshihiko Watanabe and Takeshi Toru *

Department of Applied Chemistry, Nagoya Institute of Technology, Gokiso, Showa-ku, Nagoya 466-8555, Japan

Received 6 March 2000; accepted 31 March 2000

Abstract

Reactions of various 1-sulfinyl-2-naphthaldehydes with Grignard reagents were examined. The naphthaldehyde having the 2,4,6-triisopropylphenylsulfinyl group gave the product with high stereoselectivity, possibly derived from the predominant rotamer around the C–S axis. The reaction of the chiral sulfinylnaphthaldehyde with PhMgBr and subsequent elimination of the sulfinyl group gave the enantiomerically pure 2-naphthyl carbinol.

Keywords: sulfoxides; atropisomerism; asymmetric reaction; Grignard reactions.

Recently, asymmetric reactions of nonbiaryl axially chiral compounds with a high rotational barrier around the C–N and C–C axes have been studied. High stereoselectivity has been achieved in the reactions of (*o-tert*-butylphenyl)maleimide,[1] *N*-acyl-*o-tert*-butylanilides[2] and *N*,*N*-diisopropylnaphthamide,[3] but prior resolution of the axially chiral substrate, that is not always feasible, is essential to achieve the asymmetric induction.[2c,e,g,i,4] The barriers to rotation about the C–S bond of 2-substituted 1-sulfinylnaphthalenes have been reported,[5] although they are generally lower than those around the C–N axis. We thought that the rotamers around the C–S axis would stay in different equilibrium depending on the steric or electronic demands of the chiral sulfinyl group, thus influencing the diastereoselectivity in the nucleophilic reaction. We herein report a new diastereoselective reaction of 1-(arylsulfinyl)-2-naphthaldehydes without prior resolution of the axially chiral or diastereomeric isomer, which is possibly derived from the predominantly formed rotamer around the C–S axis.

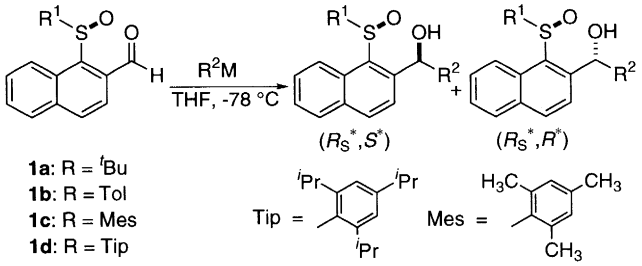
The reaction was carried out by adding 1.5 equiv. of Grignard reagents or PhLi to a THF solution of 1-sulfinyl-2-naphthaldehydes **1a**–**d** at −78°C, and the mixture was stirred for 30 min. General work-up gave the naphthyl carbinols. As expected, stereoselectivity depended upon the groups attached to the sulfinyl group. The results are shown in Table 1.

The reaction of the *tert*-butyl sulfoxide **1a** gave the product **2** in a ratio of 68:32 (entry 1). The ^{1}H NMR spectrum of **1a** measured at room temperature in DMSO-d_6 showed two sets of signals due to the *tert*-butyl protons (1.17 and 1.21 ppm), the *peri*-H^8 proton (8.45 and 9.63 ppm) and the formyl proton (10.8 and 11.4 ppm), which were obviously derived from the restricted rotation about the C_{nap}–S bond.

* Corresponding author. Tel 81-52-735-5217; Fax 81-52-735-5217; e-mail: toru@ach.nitech.ac.jp (T. Toru)

0040-4039/00/$ - see front matter
PII: S0040-4039(00)00557-8

Table 1
Addition of various nucleophiles to 1-sulfinyl-2-naphthaldehyde **1a–d**



entry	R^1	R^2M	product	yield (%)	ratio[a] $(R_S^*,S^*) : (R_S^*,R^*)$
1	^{t}Bu	PhMgBr	**2**	75	68 : 32
2	Tol	PhMgBr	**3**	80	61 : 39
3	Mes	PhMgBr	**4**	82	87 : 13
4	Tip	PhMgBr	**5**	96	98 : 2
5	Tip	PhLi	**5**	78	95 : 5
6	Tip	MeMgI	**6**	94	80 : 20
7	Tip	^{i}BuMgBr	**7**	60[b]	>98 : 2
8	Tip	AllylMgBr	**8**	80	74 : 26
9	Tip	PhMgBr[c]	**5**	80	30 : 70

[a] Determined by ^{1}H NMR. [b] The reduced product was obtained in 35% yield. [c] The reaction was carried out in the presence of 2.0 equiv of $Yb(OTf)_3$.

Thus, **1a** exists as two conformers, either having the sulfinyl oxygen close to the formyl group (A) or close to the *peri*-H^8 of the naphthalene (B) as shown in Fig. 1. The minor conformer was assigned to be the rotamer B, on the basis of the downfield shift of the *peri*-H^8 proton due to the anisotropy of the sulfinyl group.[6] By the ^{1}H NMR analysis, the A:B ratio was found to be 64:36 which is in good accord with the product ratio. The rotational barrier for **1a** was estimated to be 74.7 kJ/mol with a half-life time of 2450 h at −78°C,[7] showing that the ratio of the rotamers A and B reflects the diastereomer ratio of the product **2**.

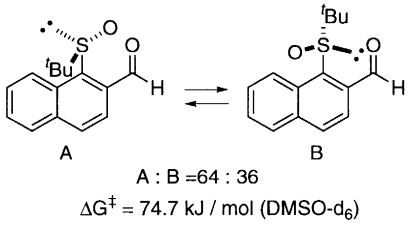


Fig. 1. The barrier to rotation of the C_{nap}–S bond for **1a**

Moderate and good stereoselectivities were obtained in the reactions of (*p*-tolylsulfinyl)- and (mesitylsulfinyl)naphthaldehydes **1b**,**c** with PhMgBr, respectively (entries 2 and 3). Notably, the reaction of 1-[(2,4,6-triisopropylphenyl)sulfinyl]-2-naphthaldehyde **1d** with PhMgBr gave the product **5** in a ratio of 98:2 (entry 4). The reaction of **1d** with PhLi gave the same diastereomer as the major product (entry 5).[8] The diastereoselectivity was higher, as the size of the nucleophile was bulkier (entries 6–8). Thus, the addition product **7** was obtained with complete selectivity in the reaction with *iso*-BuMgBr, although a significant amount of the 1-sulfinyl-2-naphthylmethanol was formed by the abnormal Grignard reaction.[9] The rotamers of the sulfoxides **1d** originated from the rotational barrier for the C–S bond could not be detected in the ^{1}H NMR spectra even at −95°C (CD_2Cl_2). The reaction with PhMgBr would proceed

through a non-chelated transition state. The X-ray crystallography of **1d** showed that the sulfoxide oxygen is placed away from the *peri*-H[8], the carbonyl group almost on the plane of the naphthalene ring, and the carbonyl oxygen away from the sulfoxide (Fig. 2).[10] In this structure, one of the faces of the formyl group is highly hindered by the 2,4,6-triisopropylphenyl group. A nucleophile approaches from the less hindered side to give (R_S^*,S^*)-**5**, the structure of which was determined by the X-ray crystallography (Fig. 2). Interestingly, the reaction of **1d** with PhMgBr in the presence of $Yb(OTf)_3$ gave the alcohol favoring (R_S^*,R^*)-**5** (entry 9). Predominant formation of (R_S^*,R^*)-**5** can be rationalized in terms of a chelated transition state between the sulfinyl and formyl oxygens with $Yb(OTf)_3$.[11]

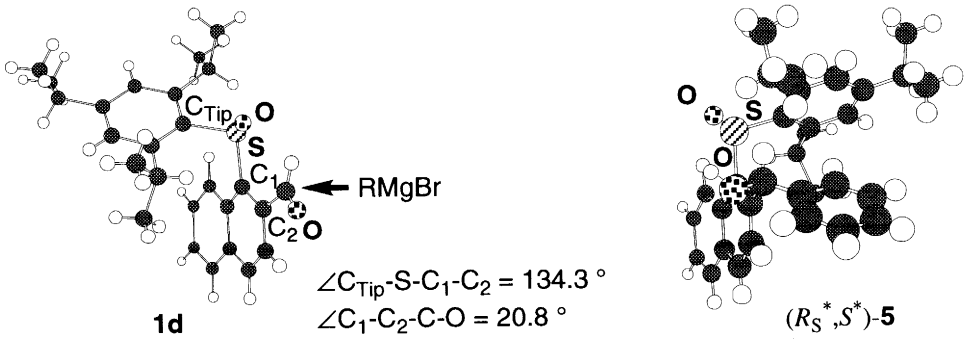
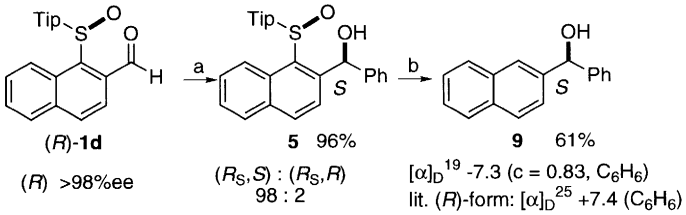


Fig. 2. The Chem 3D structure derived from the X-ray crystallography of **1d** and (R_S^*,S^*)-**5**

We also examined the reaction of (*R*)-**1d**[12] with PhMgBr which gave the product as an (R_S,*S*):(R_S,*R*) mixture of **5** in a ratio of 98:2. Purification by recrystallization gave the diastereomerically pure adduct (R_S,*S*)-**5**. Cleavage of the sulfinyl group using *n*-BuLi[13] gave the enantiomerically pure carbinol **9**.[14] The absolute configuration of **9** was assigned to be *S* by comparison of the specific rotation with the reported value as shown in Scheme 1.[15]



Scheme 1. (a) PhMgBr, THF, −78°C; (b) (i) recrystallization from hexane/ethyl acetate; (ii) *n*-BuLi, THF, −78°C

Acknowledgements

We thank Dr. Shinya Kusuda, Ono Pharmaceutical Co. Ltd., for X-ray crystallographic analyses. This work was partly supported by a Grant-in-Aid for Scientific Research (no. 11650890) from the Ministry of Education, Science, Sports and Culture of Japan.

References

1. (a) Curran, D. P.; Qi, H.; Geib, S. J.; Demello, N. C. *J. Am. Chem. Soc.* **1994**, *116*, 3131. (b) Kishikawa, K.; Tsuru, I.; Kohmoto, S.; Yamamoto, M.; Yamada, K. *Chem. Lett.* **1994**, 1605. (c) Curran, D. P.; Geib, S.; DeMello, N. *Tetrahedron* **1999**, *55*, 5681.

2. (a) Hughes, A. D.; Price, D. A.; Shishkin, O.; Simpkins, N. S. *Tetrahedron Lett.* **1996**, *37*, 7607. (b) Kitagawa, O.; Izawa, H.; Taguchi, T.; Shiro, M. *Tetrahedron Lett.* **1997**, *38*, 4447. (c) Kitagawa, O.; Izawa, H.; Sato, K.; Dobashi, A.; Taguchi, T.; Shiro, M. *J. Org. Chem.* **1998**, *63*, 2634. (d) Hughes, A. D.; Simpkins, N. S. *Synlett* **1998**, 967. (e) Hughes, A. D.; Price, D. A.; Simpkins, N. S. *J. Chem. Soc., Perkin Trans. 1* **1999**, 1295. (f) Fujita, M.; Kitagawa, O.; Izawa, H.; Dobashi, A.; Fukaya, H.; Taguchi, T. *Tetrahedron Lett.* **1999**, *40*, 1949. (g) Kitagawa, O.; Momose, S.; Fushimi, Y.; Taguchi, T. *Tetrahedron Lett.* **1999**, *40*, 8827. (h) Bach, T.; Schröder, J.; Harms, K. *Tetrahedron Lett.* **1999**, *40*, 9003. (i) Curran, D. P.; Liu, W.; Chen, C. H. *J. Am. Chem. Soc.* **1999**, *121*, 11012.
3. (a) Clayden, J.; Westlund, N.; Wilson, F. X. *Tetrahedron Lett.* **1996**, *37*, 5577. (b) Clayden, J.; Westlund, N.; Wilson, F. X. *Tetrahedron Lett.* **1999**, *40*, 3329. (c) Clayden, J. *Angew. Chem., Int. Ed. Engl.* **1997**, *36*, 949. (d) Bragg, R. A.; Clayden, J. *Tetrahedron Lett.* **1999**, *40*, 8323. (e) Bragg, R. A.; Clayden, J. *Tetrahedron Lett.* **1999**, *40*, 8327. (f) Clayden, J.; Westlund, N.; Wilson, F. X. *Tetrahedron Lett.* **1999**, *40*, 7883.
4. (a) Thayumanavan, S.; Beak, P.; Curran, D. P. *Tetrahedron Lett.* **1996**, *37*, 2899. (b) Clayden, J.; Lai, L. W. *Angew. Chem., Int. Ed.* **1999**, *38*, 2556.
5. (a) Casarini, D.; Foresti, E.; Gasparrini, F.; Lunazzi, L.; Macciantelli, D.; Misiti, D.; Villani, C. *J. Org. Chem.* **1993**, *58*, 5674. (b) Casarini, D.; Lunazzi, L.; Gasparrini, F.; Villani, C.; Cirilli, M.; Gavuzzo, E. *J. Org. Chem.* **1995**, *50*, 97. (c) Jennings, W. B.; Kochanewycz, M. J.; Lunazzi, L. *J. Chem. Soc., Perkin Trans. 2* **1997**, 2271. (d) Baker, R. W.; Kyasnoor, R. V.; Sargent, M. V. *J. Chem. Soc., Perkin Trans. 2* **1998**, 1333.
6. Lett, R.; Marquet, A. *Tetrahedron Lett.* **1974**, *30*, 3379.
7. (a) Oki, M. *In Applications of Dynamic NMR Spectroscopy to Organic Chemistry*; VCH: Deerfield Beach, FL, 1985, 160. (b) Ahmed, A.; Bragg, R. A.; Clayden, J.; Lai, L. W.; McCarthy, C.; Pink, J. H.; Westlund, N.; Yasin, S. A. *Tetrahedron* **1998**, *54*, 13 277.
8. In contrast with our results, Clayden et al. have reported the reversal in stereoselectivity in each reaction of 2-formyl-1-naphthamides with RMgX or RLi, which can be ascribed to a chelated (RMgX) or non-chelated (RLi) transition state, see: Ref. 3a.
9. Imamoto, T.; Takiyama, N.; Nakamura, K.; Hatajima, T.; Kamiya, Y. *J. Am. Chem. Soc.* **1989**, *111*, 4392.
10. The MO calculation by the MOPAC93/PM3 method showed a similar optimized structure for **1d**, the energy difference of which from the less stable conformer was 1.81 kcal/mol.
11. The chelated transition state was also supported by the Mukaiyama aldol reaction of **1d** in the presence of $TiCl_4$ in contrast to the result in the presence of monodentate $BF_3{\cdot}OEt_2$. These results will be reported in due course.
12. Prepared from the reaction of 1-lithio-2-dimethoxymethylnaphthalene and the DAG-sulfinate and subsequent hydrolysis. For the preparation of the DAG-sulfinate, see: (a) Mase, N.; Watanabe, Y.; Ueno, Y.; Toru, T. *J. Org. Chem.* **1997**, *62*, 7794. (b) Watanabe, Y.; Mase, N.; Tateyama, M.; Toru, T. *Tetrahedron: Asymmetry* **1999**, *10*, 737.
13. (a) Lockard, J. P.; Schroeck, C. W.; Johnson, C. R. *Synthesis* **1973**, 485. (b) Durst, T.; LeBelle, M. J.; Elzen, R. V.; Tin, K.-C. *Can. J. Chem*. **1974**, *52*, 761. (c) Sato, T.; Kaneko, Y.; Yamakawa, K. *Tetrahedron Lett.* **1986**, *27*, 2379. (d) Furukawa, N.; Ogawa, S.; Matsumura, K.; Fujihara, H. *J. Org. Chem.* **1991**, *56*, 6341.
14. The optical purity was confirmed by the HPLC analysis (Chiralcel OD-H).
15. (a) Seebach, D.; Beck, A. K.; Roggo, S.; Wonnacott, A. *Chem. Ber*. **1985**, *118*, 3673. (b) Soai, K.; Kawase, Y.; Oshio, A. *J. Chem. Soc. Perkin Trans. 1* **1991**, 1613.