Novel Synthesis of 1,3-Disubstituted Alkyl- and Aralkylnaphthalenes from Methylenetriphenylphosphorane, 1,1-Disubstituted Epoxides, Paraformaldehyde, and Trimethylsilyl Triflate

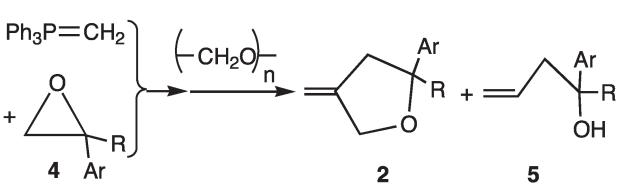
Kentaro Okuma,* Yoshitaka Hirose, and Kosei Shioji
Department of Chemistry, Faculty of Science, Fukuoka University, Jonan-ku, Fukuoka 814-0180

(Received January 10, 2002; CL-020035)

A novel approach toward the synthesis of 3-methylnaphthalenes is achieved by the reaction of 3-methylene-5,5-disubstituted tetrahydrofurans derived from methylenetriphenylphosphorane, 1,1-disubstituted epoxides and paraformaldehyde with trimethylsilyl trifluoromethanesulfonate in the presence of diisopropylethylamine.

Naphthalenes are important substances for their structural and biological aspects and their industrial uses.[1] The synthetic methods of naphthalenes include a thermal dehydroaromatization of hydrocarbons by using catalysts,[2] annulation initiated by the addition of a benzylic sulfone anion to methyl crotonate,[3] ring-closure reaction of *o*-allylbenzamides with MeLi or LDA,[4] and cycloaddition reaction of tetraarylcyclopentadienone with benzyne.[3,5] These methods require higher reaction temperature (300–500 °C) or multi-step reactions. Recently, we have reported the novel formation of tetrahydropyrans from methylene-1,3-dioxepanes.[6] In the course of the synthetic application of 2,2,2-triphenyl-2,1λ^5-oxaphospholanes (**1**), we have found unusual formation of exomethylenetetrahydrofurans (**2**) in the reaction with paraformaldehyde. We report herein a regiospecific synthesis of 1,3-disubstituted naphthalenes (**3**) from **2**, trimethylsilyl trifluoromethanesulfonate, and diisopropylethylamine.

2,2-Disubstituted 4-methylenetetrahydrofurans (**2**) were synthesized by the reaction of methylenetriphenylphosphorane, 1,1-diphenylethylene oxide (**4a**), and paraformaldehyde. Treatment of methylenetriphenylphosphorane with **4a** followed by the addition of paraformaldehyde in refluxing benzene resulted in the formation of **2a** in 54% yield (Scheme 1). Other reactions were carried out in a similar manner (Table 1). In every cases, the corresponding homoallylic alcohols (**5**), normal Wittig reaction products, were obtained as side products.



Scheme 1.

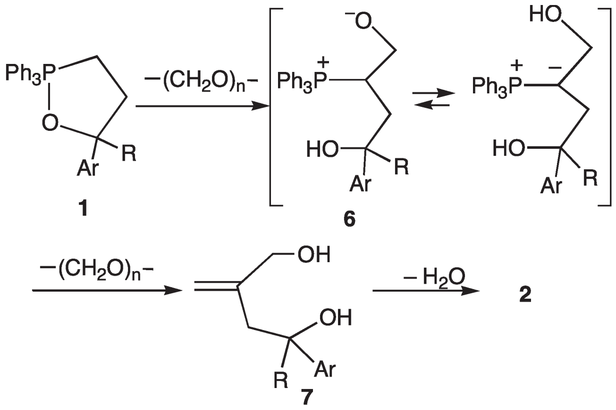
The reaction might proceed as follows: In refluxing benzene, ylide reacted with epoxide to give the corresponding oxaphospholane **1**, which reacted with paraformaldehyde to give the corresponding betaine (**6**). Diol **7** was produced by attacking of another molar of formaldehyde, which finally dehydrated to afford **2** (Scheme 2).

Oxaphospholane **1** plays an important role for the formation of **2**. If the present reaction was carried out by using γ-oxideylide (**8**) produced from 3,3-ditolyl-3-hydroxypropyltriphenylphosphonium iodide (**9**) and butyllithium, only the corresponding homoallylic alcohol **5b** was obtained in 86% yield (Scheme 3).

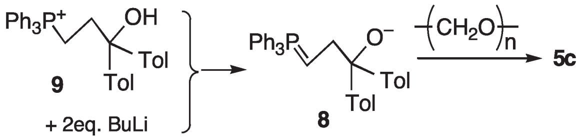
Table 1. One-pot synthesis of 4-methylenetetrahydrofurans **2**[a]

Epoxide **4**			Products (Yields/%)			
Ar	R	Reaction Time/h	**2**		**5**	
Ph	Ph	1	**2a**	54	**5a**	21
p-Tol	*p*-Tol	3	**2b**	42	**5b**	47
p-ClC_6H_4	*p*-ClC_6H_4	2	**2c**	42	**5c**	36
Ph	Me	3	**2d**	50	**5d**	31
3,4-$(MeO)_2C_6H_3$	Me	3	**2e**	43	**5e**	25

[a]The reaction was carried out in refluxing benzene.

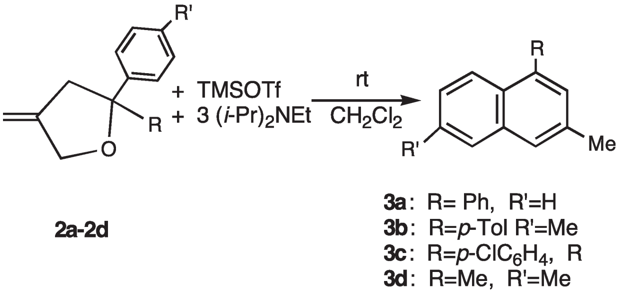


Scheme 2.



Scheme 3.

We first attempted ring opening reaction of **2** in the hope of obtaining diols. By using catalytic amount of HCl, trifluoromethanesulfonic acid, and trifluoroacetic acid, THF **2** led to unidentified polymeric mixtures. Gassman *et al.* found that the reaction of acetals with trimethylsilyl trifluoromethanesulfonate (TMSOTf) in the presence of diisopropylethylamine gave vinyl enol ethers in good yields.[7] In view of these results, we then applied this method to tetrahydrofurans. THF **2a** was treated with TMSOTf in the presence of diisopropylethylamine at room temperature to give the corresponding naphthalene **3a** in 82% yield (Scheme 4). The results were summarized in Table 2. Three equivalent of diisopropylethylamine must be required for completion. Other bases such as triethylamine gave **3** in much



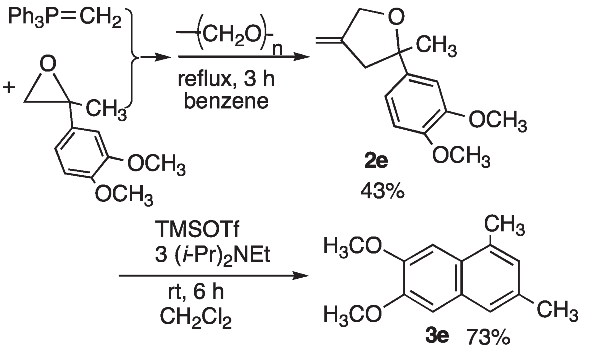
Scheme 4.

Table 2. Reaction of **1** with TMSOTf[8]

2			Conditions		Product (Yield/%)	
	R	R′	Time/h	Base/equiv		3
2a	Ph	H	6	2	**3a**	36
2a	Ph	H	6	3	**3a**	82
2b	*p*-Tol	Me	6	3	**3b**	90
2c	*p*-ClC_6H_4	Cl	6	3	**3c**	86
2d	Me	H	6	3	**3d**	73

lower yields.

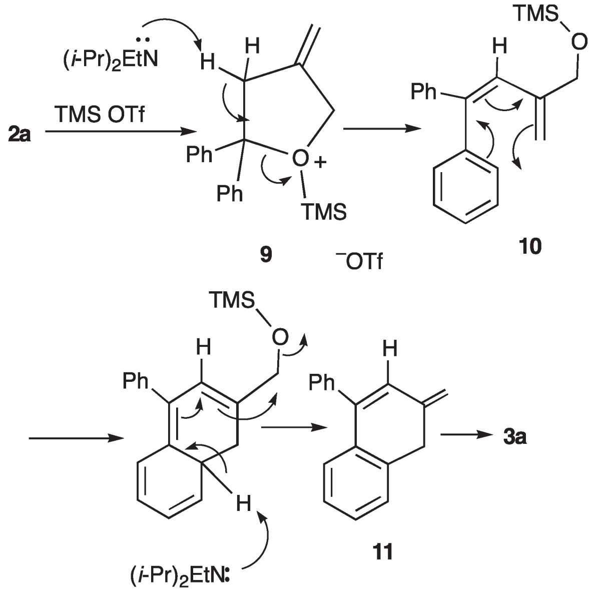
During the investigation on lignan group, Haworth and Atkinson reported the synthesis of 6,7-dimethoxy-1,3-dimethylnaphthalene (**3e**) via six-step reactions from veratrylacetyl chloride.[9] We then applied the present method to the synthesis of **3e** starting from 3,4-dimethoxyacetophenone. As shown in Scheme 5, naphthalene **3e** was synthesized regiospecifically.



Scheme 5.

A tentative mechanistic rationalization for the observed novel benzoannelation involves the initial attack of **1** with TMSOTf. The oxonium ion intermediate (**9**) thus formed was further attacked by a base to give diene (**10**). Rearrangement of **10** followed by proton abstraction gave an exomethylene compound (**11**), which finally produced naphthalene, **3** (Scheme 6).

We are currently continuing further investigation on the reaction and synthetic application of these compounds.



Scheme 6.

References and Notes

1 R. W. Alde, P. S. Bowman, W. R. Steele, and D. R. Winterman, *J. Chem. Soc., Chem. Commun.*, **1968**, 723. For a review, see N. Campbell, "Rodd's Chemistry of Carbon Compounds," ed. by S. Coffey, Elzsevier, Amsterdam (1978), Vol. IIIg, Chap. 27.

2 R. P. Linstead and S. L. S. Thomas, *J. Chem. Soc.*, **1940**, 1127; H. M. Liu, B. L. Tian, and Y. D. Xu, *Appl. Catal., A*, **213**, 103 (2001); A. T. Mathauser and A. V. Teplyakov, *Catal. Lett.*, **73**, 207 (2001).

3 T. T. Hoye, M. Chen, B. Hoang, L. Mi, and O. P. Priest, *J. Org. Chem.*, **64**, 7184 (1999).

4 M. P. Sibi, J. W. Dankwardt, and V. Snieckus, *J. Org. Chem.*, **51**, 271 (1986).

5 F. M. Beringer and S. J. Huang, *J. Org. Chem.*, **29**, 445 (1964).

6 K. Okuma, S. Hayano, K. Shioji, and H. Matsuyama, *Tetrahedron Lett.*, **41**, 2171 (2000).

7 P. G. Gassman, S. J. Burns, and K. B. Pfister, *J. Org. Chem.*, **58**, 1449 (1993).

8 Satisfactory mass spectra and/or elemental analyses were obtained for all new compounds. Selected ^{1}H NMR data of **2b** and **3c**. **2b**: ^{1}H NMR ($CDCl_3$) $\delta = 2.29$ (s, 6 H, ArMe), 3.22 (br s, 2 H, CH_2), 4.43 (br s, 2H, CH_2), 4.83 (br s, 1 H, = $C\underline{H}H$), 4.99 (br s, 1 H, = $C\underline{H}H$), 7.09 (d, 4 H, J = 8 Hz, p-Tol), 7.29 (d, 4 H, J = 8 Hz, p-Tol). **3c**: ^{1}H NMR ($CDCl_3$) $\delta = 2.53$ (s, 3 H, ArMe), 7.22 (br s, 1 H, Ar), 7.29 (dd, 1 H, $J = 2$ and 8 Hz, Ar), 7.38 (d, 2 H, $J = 8$ Hz, *p*-ClC_6H_4-), 7.45 (d, 2 H, $J = 8$ Hz, *p*-ClC_6H_4-), 7.54 (s, 1 H, Ar), 7.70 (d, 1 H, J = 8 Hz, Ar), 7.79 (s, 1 H, Ar). **3e**: ^{1}H NMR ($CDCl_3$) $\delta = 2.43$ (Me), 2.60 (Me), 3.99 (OMe), 4.01 (OMe), 7.04 (br s, Ar-H), 7.06 (br s, Ar), 7.16 (br s, Ar), 7.34 (br s, Ar).

9 R. D. Haworth and J. R. Atkinson, *J. Chem. Soc.*, **1938**, 767.