

## REACTION OF TRIPHENYLSULFONIUM SALT WITH ORGANOLITHIUM REAGENTS

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*The reaction of triphenylsulfonium trifluoromethanesulfonate with various nucleophilic, organolithium reagents gave ligand coupling products and the corresponding diaryl or di-heteroaryl sulfides. Moreover, ligand exchange reaction did not give any noticeable product in each reaction. Therefore, it was found that only the ligand coupling reaction proceeds in this reaction system.*

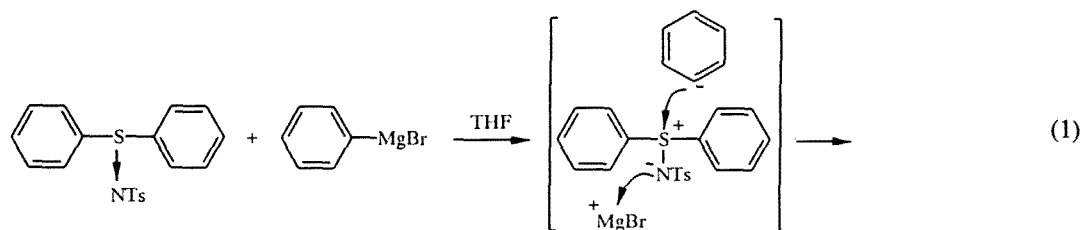
### INTRODUCTION

Since the introduction of the concept of ligand coupling within the sulfurane intermediates [1-5], numerous studies have been carried out, mainly by us. Until now, it has been reported that the reaction of the sulfonium salt with nucleophilic organolithium or the Grignard reagents [1, 6, 7] takes place to form the sulfurane as an intermediate, but few reaction examples have been reported.

New reactions of triphenylsulfonium trifluoromethanesulfonate with phenyl, 2-thenyl, 2-pyridyl, 2-quinolyl, 2-furyl, 2-pyrimidyl, n-buthyllithium as organometallic reagents were carried out, and reactivities of triphenylsulfonium trifluoromethane sulfonate have been examined.

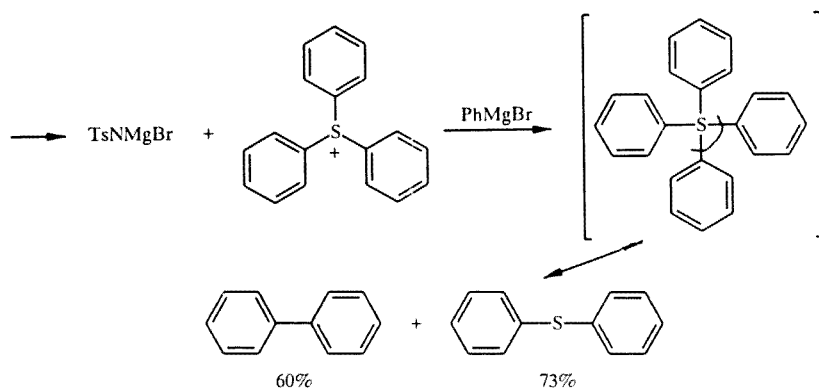
### RESULTS AND DISCUSSION

When diphenyl N-tosylsulfilimine was treated with phenylmagnesium bromide, the following coupling reaction took place as shown below. Using the <sup>14</sup>C-labeled starting material, diphenyl sulfide and diphenyl were found to have 2/3 and 1/3 of the original <sup>14</sup>C at the ipso positions [1]. Apparently, the ligand coupling took place faster than the pseudo-rotation within the  $\sigma$ -sulfurane, for if there were faster pseudo-rotation than ligand coupling, the resulting products would contain both 1/2 of <sup>14</sup>C at their ipso positions.



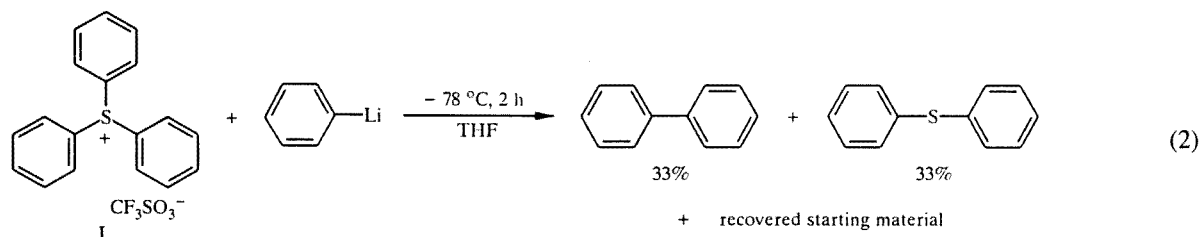
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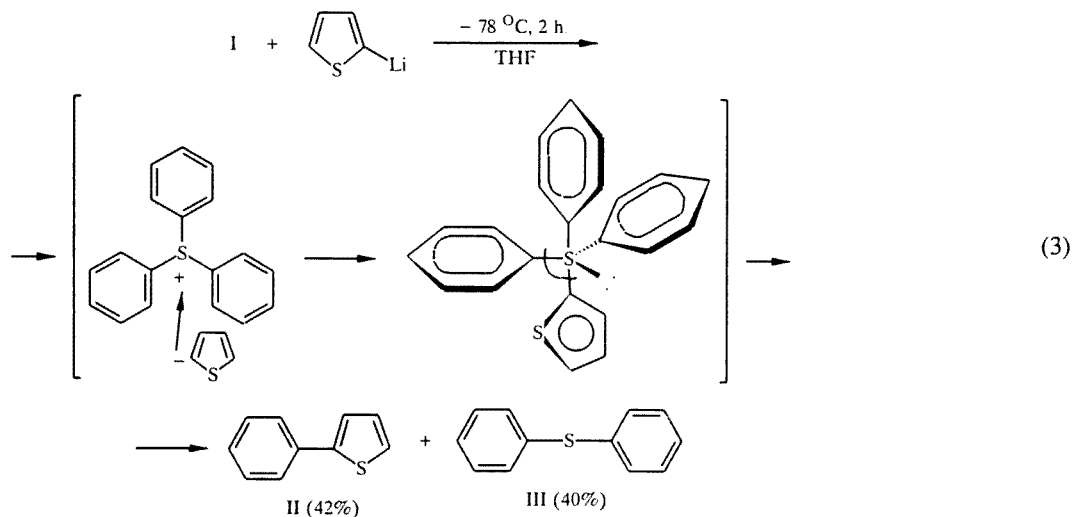
This experiment has stimulated our study on the reactions of various triarylsulfonium salts with organometallic reagents.

The first experiment we carried out is the reaction of triphenylsulfonium trifluoromethanesulfonate **1** with phenyllithium (Eq. 2). We had nearly the same result [1, 7].



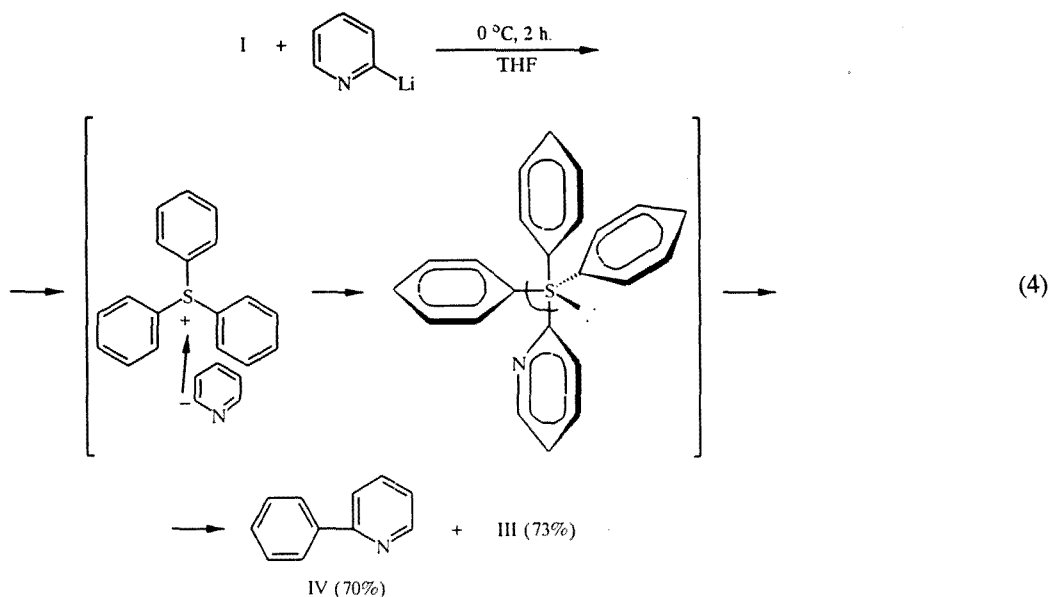
According to the expectation, the mixture of biphenyl and diphenyl sulfide is afforded, and it was confirmed that the reaction of sulfonium salt with phenyllithium proceeds as well as the Grignard reagent [4-6].

The reaction of **1** with 2-thienyllithium carried out in THF at  $-78^\circ\text{C}$  also gave 2-phenylthiophene **2** and diphenyl sulfide **3**. Upon obtaining only these products, we have considered that the reaction proceeds through the following ligand coupling route (Eq. 3).



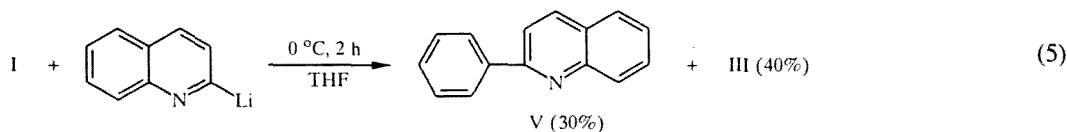
In other words, the reaction is believed to take place at a sulfur atom by the attack of 2-thienyl anion to form the sulfurane as an intermediate, and the ligand coupling reaction occurred by the interaction between the orbitals of ipso carbon atoms situated at axial and equatorial positions. Here again the ligand coupling reaction was found to take place after the nucleophilic attack to form the sulfurane, because biphenyl was not obtained by this reaction. There is not enough time for pseudo-rotation or ligand exchange.

The reaction of triphenylsulfonium salt **1** with 2-pyridyllithium, carried out in THF at  $0^\circ\text{C}$ , gave 2-phenylpyridine **4** as the only coupling product and diphenyl sulfide **3** (Eq. 4). Here again we did not observe the formation of biphenyl. This means that the ligand coupling is faster than either pseudo-rotation or ligand exchange.

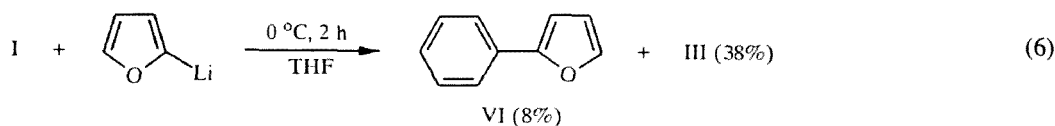


This result also indicates that only the attack of nucleophilic 2-pyridyllithium on the sulfur to form the sulfuran immediately leads to ligand coupling reaction just as 2-thienyllithium reacts.

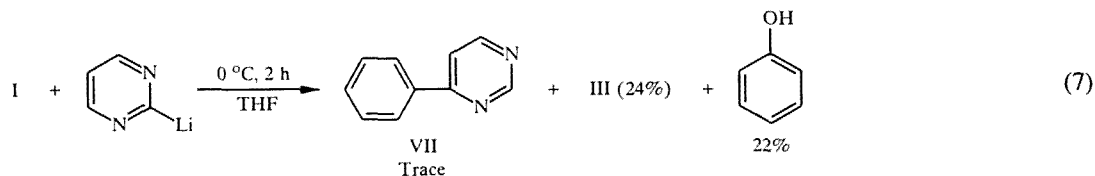
The reaction of **1** with 2-quinolyllithium also gave two products as we anticipated; it was found that the ligand coupling reaction proceeds as in the case with 2-pyridyllithium.



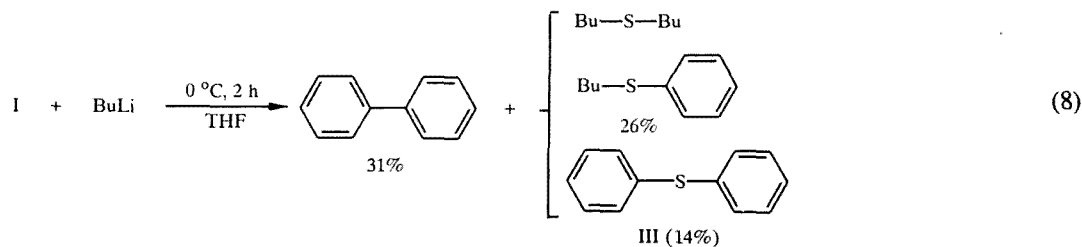
The reaction of triphenylsulfonium salt **1** with 2-furyllithium, also carried out in THF at  $0^\circ\text{C}$ , gave 2-phenylfuran **6** as coupling product in a very small amount. However, the yield of **3**, diphenyl sulfide, was not so small (Eq. 6).



The reaction of **1** with 2-pyrimidyllithium gave **3**, phenol, and a very small amount of coupling product **7**. Since 2-pyrimidyl anion is a rather strong base, the main reaction is probably the formation of benzyne, because of the formation of diphenyl sulfide and phenol, as in the case of tritolylsulfonium bromide and phenylmagnesium bromide [6].



It is interesting that *n*-buthyllithium also reacted with **1** as shown below (Eq. 8).



Apparently the formation of biphenyl and diphenyl sulfide is through ligand coupling. However, the ligand exchange obviously took place in this case.

As shown in these reactions, it was found that in most cases the ligand coupling reaction has a prior occurrence via forming sulfurane as an intermediate by the reaction of sulfonium salt with nucleophilic anion, which lead to the ligand coupling reaction.

## EXPERIMENTAL

### General

All melting points were uncorrected and taken on a Yanagimoto melting-point apparatus. NMR spectra were obtained on a JEOL-PMX60SI or a JEOL-GSX-270 FT-NMR spectrometer in  $\text{CDCl}_3$  using TMS as an internal standard. All reactions were monitored by TLC (Merck, Kieselgel 60F254), GLC (Hitachi 663-30, using a 3% Silicon OV-17 chromosorb W). The silica gel used for column chromatography was Wakogel C-200. Mass spectra were taken with a Shimadzu GCMS-QP1000(A) mass spectrometer. Element analyses were carried out by the Elemental Analysis Center of Wako Pure Chemical Industries, Ltd.

### Materials

All reagents were obtained from Wako Pure Chemical Industries Ltd., Tokyo Kasei Co., or Aldrich Chemical Co. The reagents and reaction solvents used were further purified by general methods.

**Preparation of Triphenylsulfonium Trifluoromethanesulfonate.** To a solution of phenyl sulfoxide (2.0 g, 9.9 mmol) in methylene chloride (20 ml), trimethylsilyl trifluoromethanesulfonate (2.3 ml, 12 mmol) was added dropwise for over 5 min at  $-78^\circ\text{C}$  under an argon atmosphere. After the solution had been stirred for an additional 10 min at  $-78^\circ\text{C}$ , the flask was warmed to  $0^\circ\text{C}$  and kept at that temperature for 30 min. The reaction mixture was recooled to  $-78^\circ\text{C}$  and treated dropwise with 10 ml of a 2.0 M (20 mmol) solution of phenylmagnesium chloride in THF. After an additional 30 min at  $-78^\circ\text{C}$ , the flask was warmed to  $0^\circ\text{C}$  and kept at that temperature for 30 min. The reaction mixture was quenched with 3% aqueous trifluoromethanesulfonic acid (30 ml) and diluted with ether (200 ml). The organic layer was washed with additional trifluoromethanesulfonic acid ( $2 \times 30$  ml). The combined aqueous layer was extracted with chloroform ( $3 \times 30$  ml), dried ( $\text{Na}_2\text{SO}_4$ ), and concentrated to give 1.2 g (30%) of a white solid (recrystallized from buthyl acetate/isopropyl alcohol, 3:1), mp:  $135\text{--}137^\circ\text{C}$ ;  $^1\text{H}$  NMR ( $\delta$ ): 7.65–7.80 (benzene  $\text{H}_{2,3,4,5,6}$ , 5H, m);  $^{13}\text{C}$  NMR (DEPT,  $\delta$ ): 124.2 ( $\text{C}_1$  of benzene), 131.1 ( $\text{C}_{2,6}$  of benzene), 131.7 ( $\text{C}_{3,5}$  of benzene), 134.7 ( $\text{C}_4$  of benzene); Anal. Calcd for  $\text{C}_{19}\text{H}_{15}\text{F}_3\text{S}_2\text{O}_3$ : C, 55.3; H, 3.6. Found: C, 55.2; H, 3.7.

**Reaction of 1 with 2-Thienyllithium.** A typical experiment procedure follows. A solution of 2-thienyllithium was prepared by adding 1.0 mmol of n-buthyllithium (as a 1.6 M solution in n-hexane) to a solution of 2-bromothiophene (0.10 ml, 1.0 mmol) in THF (5 ml). The solution was added to a stirred solution of 1 (0.41 g, 1.0 mmol) in THF (30 ml) at  $-78^\circ\text{C}$  under an argon atmosphere. After 2 h reaction at  $-78^\circ\text{C}$ , methanol was added to the reaction mixture. The product was extracted with chloroform. The chloroform layer was washed with water three times and dried over anhyd.  $\text{MgSO}_4$ . After the solvent had been evaporated, the residue was purified by silicagel column chromatography. The yields of 2 and 3 were 42% and 40%, respectively, based on determination of the amounts of 2 and 3 isolated.

**2-Phenylthiophene 2.** Oil;  $^1\text{H}$  NMR ( $\delta$ ): 7.04–7.08 (thiophene,  $\text{H}_4$ , 1H, t), 7.22–7.31 (benzene,  $\text{H}_4$ , 1H and thiophene,  $\text{H}_{3,5}$ , 2H, m), 7.32–7.40 (benzene,  $\text{H}_{3,5}$ , 2H, t), 7.57–7.64 (benzene,  $\text{H}_{2,6}$ , 2H, d);  $^{13}\text{C}$  NMR (DEPT,  $\delta$ ): 123.0, 124.8, 125.9, 127.4, 128.0, 128.8, 134.4 (ipso position in benzene ring), 144.4 (ipso position in thiophene ring); MS ( $m/z$ ): 160, 134, 115, 89.

**Reaction of 1 with 2-Pyridyllithium.** A solution of 2-pyridyllithium was prepared by adding 1.0 mmol of n-buthyllithium (as a 1.6 M solution in n-hexane) to a solution of 2-bromopyridine (0.1 ml, 1.0 mmol) in THF (5 ml). The solution was added to a stirred solution of 1 (0.41 g, 1.0 mmol) in THF (30 ml) at  $-78^\circ\text{C}$  under an argon atmosphere. After 2 h reaction at  $0^\circ\text{C}$ , methanol was added to the reaction mixture. The product was extracted with chloroform. The chloroform

layer was washed with water three times and dried over anhyd.  $\text{MgSO}_4$ . After the solvent had been evaporated, the residue was purified by silicagel column chromatography. The yields of **4** and **3** were 70% and 73%, respectively, based on determination of the amounts of **4** and **3** isolated.

**2-Phenylpyridine 4.** mp: 174-175°C;  $^1\text{H}$  NMR ( $\delta$ ): 7.03-7.30 (pyridine,  $\text{H}_4$ , 1H, m), 7.32-7.52 (benzene,  $\text{H}_4$ , 1H and pyridine,  $\text{H}_{3,5}$ , 2H, m), 7.60-7.72 (benzene,  $\text{H}_{3,5}$ , 2H, m), 7.84-8.04 (benzene,  $\text{H}_{2,6}$ , 2H, m), 8.67-8.70 (pyridine,  $\text{H}_6$ , 1H, m); MS ( $m/z$ ): 155, 127, 77, 51.

**Reaction of 1 with 2-Quinolylolithium.** A similar procedure to that described previously was followed with 1.6 M *n*-buthyllithium (0.63 ml, 1.0 mmol), quinoline (0.12 ml, 1.0 mmol) in THF (5 ml), and **1** (0.41 g, 1.0 mmol) in THF (30 ml) to give, **5**. **5** was determined by isolation.

**2-Phenylquinoline 5.** mp: 80°C;  $^1\text{H}$  NMR ( $\delta$ ): 7.73 (1H, td), 7.47-7.56 (5H, m), 7.84 (1H, dd), 7.89 (1H, d), 8.17 (1H, d), 8.18 (1H, td), 8.23 (1H, d); MS ( $m/z$ ): 207, 129, 102, 76, 51.

**Reaction of 1 with 2-Furyllithium.** A similar procedure to that described previously was followed with 1.6 M *n*-buthyllithium (0.63 ml, 1.0 mmol), furan (0.07 ml, 1.0 mmol) in THF (5 ml), and **1** (0.41 g, 1.0 mmol) in THF (30 ml) to give **6**. **6** was determined by isolation.

**2-Phenylfuran 6.** Oil;  $^1\text{H}$  NMR ( $\delta$ ): 6.45-6.49 (furan,  $\text{H}_4$ , 1H, dd), 6.63-6.66 (furan,  $\text{H}_3$ , 1H, d), 7.21-7.28 (benzene,  $\text{H}_4$ , 1H, t), 7.34-7.41 (benzene,  $\text{H}_{3,5}$ , 2H, t), 7.46 (furan,  $\text{H}_5$ , 1H, d), 7.64-7.70 (benzene,  $\text{H}_{2,6}$ , 2H, d);  $^{13}\text{C}$  NMR (DEPT,  $\delta$ ): 104.9 ( $\text{C}_4$  of furan), 111.6 ( $\text{C}_3$  of furan), 123.8 (2C, benzene), 127.2 ( $\text{C}_4$  of benzene), 128.6 (2C, benzene), 130.9 ( $\text{C}_1$  of benzene), 142.0 ( $\text{C}_5$  of furan), 154.0 ( $\text{C}_2$  of furan); MS ( $m/z$ ): 144, 115, 89, 63, 39.

**Reaction of 1 with 2-Pyrimidyllithium.** A similar procedure to that described previously was followed with 1.6 M *n*-buthyllithium (0.63 ml, 1.0 mmol), pyrimidine (0.07 ml, 1.0 mmol) in THF (5 ml), and **1** (0.41 g, 1.0 mmol) in THF (30 ml) to give phenol, **3** and **7**.

**Reaction of 1 with *n*-Buthyllithium.** A similar procedure to that described previously was followed with 1.6 M *n*-buthyllithium (0.63 ml, 1.0 mmol) and **1** (0.41 g, 1.0 mmol) in THF (30 ml) to give four kinds of products. Four kinds of products were determined by isolation.

## REFERENCES

1. S. Oae, T. Yoshimura, and N. Furukawa, *Bull. Chem. Soc. Jpn.*, **45**, 2019 (1972).
2. S. Oae, *Croat. Chem. Acta*, **59**, 129 (1986); S. Oae, *Phosphorus and Sulfur*, **27**, 13 (1986).
3. S. Oae, *Rev. Heteroatom Chem.*, Tokyo, **4**, 195 (1991).
4. S. Oae, *Rev. Heteroatom Chem.*, Tokyo, **1**, 304 (1988).
5. S. Oae and Y. Uchida, *Accounts of Chem. Res.*, **24**, 202 (1991).
6. Y. H. Khim and S. Oae, *Bull. Chem. Soc. Jpn.*, **42**, 1968 (1969).
7. R. W. LaRochelle and B. M. Trost, *J. Am. Chem. Soc.*, **93**, 6077 (1971).