SHORT PAPER

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Microwave assisted regioselective opening reaction of epoxides with diphenyl diselenides†

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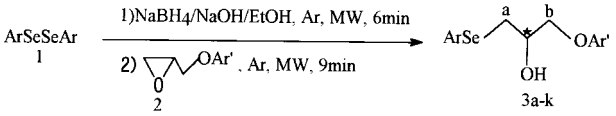
A simple,rapid, preparation of reactive benzeneselenolate ion and its highly regioselective opening reaction with epoxides under microwave irradiation is described.The reaction of diphenyl diselenides with $NaBH_4$/NaOH give phenylselenolate ion which reacts in turn with epoxypropoxyphenols to afford the substituted glycerol selenide ethers in good to excellent isolated yields.

The opening of the oxirane ring[1] with various nucleophiles is an important synthetic transformation to allow easy access to a large number of functionalised intermediates that are required during the synthesis of natural products.[2–3] The opening of the oxirane ring with nucleophiles can be performed by several methods:[4] using Lewis acids, such as boron trifluoride etherate, lanthanide chlorides, lithium perchlorate, cobalt(II) chloride, neutral alumina, tetrabutylammonium fluoride, quaternary onium salts,[5,6] organic and inorganic bases.[2,7]

The reaction of epoxides with the phenylselenolate ion gave organic selenides[8,9,10] which were formed via *trans* opening of the epoxides with the selenolate ion. However, many of these reactions suffer from lack of generality, poor regioselectivity and low temperature (–78 C).[10] The phenylselenolate ion can be obtained by reaction of diphenyl diselenide with sodium borohydride,[11,12] sodium metal,[13] alkali metal hydroxide,[14] sodium formaldehyde sulfoxylate,[15] hypophosphoros acid,[16] and tributylphosphine in NaOH/THF.[10]

In recent years interest has been shown in the study of microwave assisted organic reactions,[17] and some important reviews have been published.[17,18,19] Microwave irradiation has also been applied to several organic reactions.[17] However, few practical applications have been devised for the synthesis of organoselenium compounds. Recently, we have reported the synthesis of dibenzyl diselenide,[20] diaroyl diselenides,[21] aromatic ethers,[22,23] chiral glycerol sulfide ethers[24] and chiral glycerol selenide ethers[25] under phase-transfer catalysis and microwave irradiation conditions.

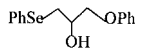
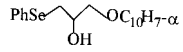
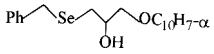
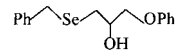
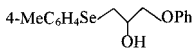
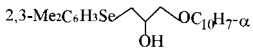
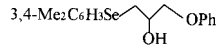
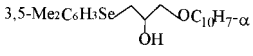
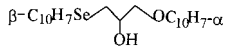
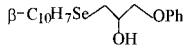
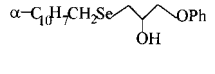
We have found that diphenyl diselenide can be rapidly reduced to the phenylselenolate ion by $NaBH_4$/NaOH under microwave irradiation, and then the phenylselenolate ion may also rapidly react with epoxypropoxyphenols under microwave irradiation to afford the 1-phenylseleno-3-phenoxy-2-propanol. This method is very simple, rapid, and has a high regioselectivity affords a good yield of the substituted glycerol selenide ethers.The reactions are shown in Scheme 1 and the results are summarized in Table 1.



Scheme 1

The efficiency of microwave irradiation on the formation of phenylslenolate ion and substituted glycerol selenide ethers was studied. The results show that the microwave irradiation not only assisted in production of the phenylselenolate ion in solution, but also assisted in the epoxypropoxylphenols ring opening with phenylselenolate ion. In order to elucidate the action of microwave irradiation, we have investigated the reduction of diphenyl diselenide without irradiation. The reduction of diphenyl diselenide was finished in $NaBH_4$/NaOH/C_2H_5OH system for 3h at 85–90°C under normal conditions. However, the reduction was finished in 6 minutes under microwave irradation conditions. Table 1 shows the yield of **3c** is 91%. Under normal conditions but without the microwave irradiation for 10h, the yield of **3c** is only 70%. We have also found that the conversion of epoxyproxyphenols to the corresponding 1-phenylseleno-3-phenoxy-2-propanol were successfully achieved without affecting the ether function under microwave irradiation condition. The regioisomer 2-phenylseleno-3-phenoxy-1-propanol, was not detected.

Table 1 Preparation of 1-phenylseleno-3-phenoxy-2-propanol **3a–k**

Entry	Product[a–c]	Yield[d] /%
3a		89
3b		89
3c		91
3d		90
3e		88
3f		89
3g		88
3h		86
3i		90
3j		87
3k		86

[a]Mol ratio (Arse)2: epoxypropoxylphenol: $NaBH_4$: NaOH = 4.05: 8:16:7.5. [b]Irradiation conditions: power, 750 W;time, 15 min. [c]Absolute ethanol used as solvent. [d]Isolated yield.

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† This is a Short Paper, there is therefore no corresponding material in *J Chem. Research (M).*

Table 2 Effect of solvent on the synthesis of **3a**

Entry	Solvent[a]	Irradiation power /W	Irradiation time /min	Yield[b] /%
1	Benzene	750	15	0
2	Toluene	750	15	0
3	Dichloromethane	750	15	0
4	Tetrahydrofuran	750	15	0
5	Methylcyanide	750	15	32
6	N,N-Dimethylformamide	750	15	76
7	Absolute ethanol	750	15	89

[a]Mol ratio: $(ArSe)_2$:epoxypropoxylphenol: $NaBH_4$: NaOH = 4.05 : 8 : 16 : 7. 5. [b]Isolated yield.

The efficiency of various solvents on the formation of 1-phenylseleno-3-phenoxy-2-propanol was studied using microwave irradiation. The results show that the EtOH is the best solvent for the reaction. No reaction occus when C_6H_6, CH_2Cl_2, PhCH and THF are used as solvents, since they cannot stabilize the alkyl selenide ions (see Table 2).

We have also investigated the effects of irradiation power time, and operation method on the reactions. It was found that the high yields of compounds **3** can be obtained in 750W power for 15 min continuous irradiation conditions. In conclusion, we have investigated the possiblity of one-pot synthesis of substituted glycerol selenide ethers. The yield of **3c** was only 50% lower than that of the two-step continuous irradiation method.

Experimental

The melting points were determined on a X_4 micro-melting point apparatus, and are uncorrected. IR spectra were recorded on a Alpha centauri FT-IR spectrometer. ^{1}H-NMR spectra were measured on a FT-80 spectrometer at 80 MHz. Mass spectra were recorded on GC-MS QP-1000. Elemental analyses were carried out with a Carlo Erba Model 1106 Elemental Analyzer. Microwave irriadition are carred out with an improved reflux microwave oven using an inert gases protector.

General procedure for preparation of 1-phenylseleno-3-phenoxy-2-propanol **3a-k***:* To a solution of diphenyl diselenide (4.05 ml) in EtOH (30 ml) were added in succession NaOH (7.5 mmol), $NaBH_4$ (16.0 mmol) and the mixture was irradiated with 750W for 6 min under Ar protection. Then epoxypropoxyphenols (8.0 mmol) in ethanol (10 ml) solution were added dropwise to above mixture over about 5min under the same irradiation conditions and then irradiation was continued for 4min. After completion of the reaction,the solvent was removed by evaporation under reduced pressure and the residue was acidified with hydrogen chloride (10%).The organic phase was extracted with benzene (3×20ml), dried ($MgSO_4$), and concentrated. The pure solid products were obtained by recrystallization from ethanol, and the pure liquid products were isolated by a short silica gel column using petroleum ether:ethylacetate (18:1, V/V) as an eluent. Chromatographic optical resolution of compounds **3a-j** by HPLC on chiralcel OD column.

1-Phenylseleno-3-phenoxy-2- propanol **3a:** Oil; ^{1}HNMR(C_6D_6) δ1.7 (s, 1H, OH), 2.9(d, 2H, CH_2^a), 3.6(d, 2H, CH_2^b), 3.7(m, 1H, CH), 6.6-7.4(m, 10H, ArH); IR ν (KBr) 3434, 3050, 2920, 1599, 1495, 1240, 730; MS(*m/e*, %): 307(M+), 215(15), 171(20), 133(45), 109(100). (Found: C, 58.95; H,5.13; O, 10.64; Se, 25.28. Calcd. for $C_{15}H_{16}O_2Se$: C, 59.19; H,5.30; O, 10.52; Se,24.99%).

1-Phenylseleno-3-(α-naphthyloxy)-2-propanol **3b:** Oil; ^{1}HNMR(C_6D_6) δ1.7 (s, 1H, OH), 3.0(d, 2H, CH_2^a), 3.8(d, 2H, CH_2^b), 3.9–4.2 (m, 1H, CH), 6.5–7.5(m, 12H, ArH); IR ν (KBr) 3422, 3054, 2930, 1620, 1595, 1588, 1509, 1240, 772; MS(*m/e*, %) 358(M+1), 281(17), 265(22), 207(100). (Found: C,63.92; H,4.99; O,8.81; Se,22.28. Calcd. for $C_{19}H_{18}O_2Se$: C, 63.84; H, 5.08; O, 8.96; Se, 22.12%).

1-Benzylseleno-3-(α-naphthoxy)-2-propanol **3c***:* m.p. 53.5–54°C; ^{1}HNMR(C_6D_6) δ 1.2(s, 1H, OH), 2.2(s, 2H, CH_2), 2.9(d, 2H, CH_2^a), 3.6(d, 2H, CH_2^b), 3.9(m, 1H, CH), 6.7–7.4(m, 12H, ArH); IR ν (KBr) 3243, 3035, 2923, 1599, 1500, 1381, 1244, 801; *MS(m/e* %) 371(M+), 280(6.3), 156(27). (Found: C, 64.82; H, 5.55; O, 8.50; Se, 21.13 Calcd. for $C_{20}H_{20}O_2Se$: C, 64.66; H, 5.43; O, 8.62; Se, 21.29%).

1-Benzylseleno-3-phenoxy-2-propanol **3d***:* m.p. 67.5–68°C; ^{1}HNMR(C_6D_6) δ1.2(s, 1H, OH), 2.1(d, 2H, CH_2^a), 2.5(d, 2H, CH_2^b), 3.3(s, 2H, CH_2), 3.6–3.8(m, 1H, CH), 6.7–7.4(m, 10H, ArH); IR ν(KBr) 3384, 3061, 2925, 1590, 1566, 746; MS(*m/e*, %) 321(M+), 228(5.4), 133(13.3), 91(100), 77(19).(Found: C, 59.93; H, 5.71; O, 10.00; Se, 24.36. Calcd. for $C_{16}H_{18}O_2Se$: C, 59.79; H, 5.65; O, 9.96; Se, 24.60%).

1-(4-Methyphenylseleno)-3-phenoxy-2-propanol **3e:** Oil; ^{1}HNMR(C_6D_6) δ 1.9(s, 3H, CH_3), 2.2(s, 1H, OH), 2.9(d, 2H, CH_2^a), 3.6(d, 2H, CH_2^b), 3.9(m, 1H, CH), 6.7–7.4(m, 9H, ArH); IR ν (KBr) 3421, 3035, 2923, 1599, 1500, 1381, 1244, 801; MS(*m/e*, %): 322(M+1,) 212(25),134(95), 105(100). (Found: C, 59.82; H, 5.47; O, 10.01; Se, 24.70. Calcd. for $C_{16}H_{18}O_2Se$: C, 59.79; H, 5.65; O, 9.96; Se, 24.60%).

1-(2,3-Dimethyl phenylseleno)-3-(α-naphoxy)-2-propanol **3f:** Oil; ^{1}HNMR(C_6D_6) δ 1.7(s, 3H, CH_3), 2.0(s, 1H, OH), 2.3(s, 3H, CH_3), 3.0(d, 2H, CH_2^a), 3.8(d, 2H, CH_2^b),3.9-4.1(m, 1H, CH),6.3–8.3(m, 10H, ArH); IR ν (KBr) 3421, 3053, 3010, 2926, 1730, 1620, 1595, 1580,1509, 791. MS(*m/e*, %) 386(M+1,), 263(10), 243(55); 199(30), 183(27), 119(86), 109(100). (Found: C, 65.44; H, 5.66; O, 8.36; Se, 20.54. Calcd. for $C_{21}H_{22}O_2Se$: C, 65.42; H, 5.76; O, 8.31; Se, 20.51%).

1-(3,4-Dimethyl phenylseleno)-3-phenoxy-2-propanol **3g:** Oil; ^{1}HNMR(C_6D_6) δ1.6(s, 3H, CH_3), 2.0(s, 3H, CH_3), 2.3(s, 1H, OH), 2.9(d, 2H, CH_2^a), 3.7(d, 2H, CH_2^b),3.8-4.2(m, 1H, CH), 6.6–7.3(m, 8H, ArH); IR ν (KBr)3412, 3037, 2926, 1590, 1500, 1245, 754; MS(*m/e*, %) 336(M+1), 243(20), 213(25), 199(35), 185(46), 133(95), 119(100). (Found: C, 60.95; H, 6.03; O, 9.60; Se, 23.42. Calcd. for $C_{17}H_{20}O_2Se$: C, 60.87; H, 6.02; O, 9.54; Se, 23.57%).

1-(3,5-Dimethyl phenylseleno)-3-(α-naphthoxy)-2-propanol **3h***:* Oil; ^{1}HNMR(C_6D_6) δ1.70(s, 1H, OH), 2.0(s, 3H, CH_3), 2.4(s, 3H, CH_3), 3.0(d, 2H, CH_2^a), 3.8(d, 2H, CH_2^b), 3.9–4.2(m, 1H, CH), 6.5–7.5(m, 10H, ArH); IR ν (KBr) 3427, 2930, 2922, 1599, 1500, 1377, 1244, 754; MS(*m/e*, %) 386(m+1,),336(80),243(35),213(65), 185(100). (Found: C, 65.45; H, 5.58; O, 8.39; Se, 20.58. Calcd. for $C_{21}H_{22}O_2Se$: C, 65.42; H, 5.76; O, 8.31; Se, 20.51%).

1-(β-Naphthseleno)-3-(α-naphthoxy)-2-propanol **3i:** Oil; ^{1}HNMR(C_6D_6) δ1.2(s, 1H, OH), 2.4(d, 2H, CH_2^b), 3.5(s, 2H, CH_2^a), 3.6-3.7(m, 1H, CH), 6.8-7.3(m, 14H, ArH) ;IR ν (KBr) 3430, 3050, 3020, 2925, 1607, 1600, 579; MS(*m/e*, %) 408(M+1), 309(100), 229(20), 211(25), 181(27). (Found: C, 67.75; H, 5.08; O, 8.02; Se, 19.15. Calcd. for $C_{23}H_{20}O_2Se$: C, 67.79; H, 4.95; O, 7.86; Se, 19.40%).

1-(β-Naphthseleno)-3-phenoxy-2-propanol **3j:** Oil; ^{1}HNMR(C_6D_6) δ2.3(s, 1H, OH), 3.1(d, 2H, CH_2^a), 3.4(d, 2H, CH_2^b), 3.8(m, 1H, CH), 6.9–7.9(m, 12H, ArH); IR ν (KBr) 3401, 3057, 2920, 1640, 1590, 1497, 1456, 1240,754; MS(*m/e*, %) 358(M+1), 281(17), 265(22), 221(55), 207(100). (Found: C, 63.88; H, 5.17; O, 8.83; Se, 22.12. Calcd. for $C_{19}H_{18}O_2Se$: C, 63.84; H, 5.08; O, 8.96; Se, 22.12%).

1-(α-Naphthalseleno)-3-phenoxy-2-propanol **3k:** Oil; ^{1}HNMR(C_6D_6) δ1.3(s, 1H, OH), 2.5(d, 2H, CH_2^b), 3.6(d, 2H, CH_2), 3.7(d, 2H, CH_2^a), 3.8(m, 1H, CH), 6.7–7.7(m, 12H, ArH). IR ν (KBr) 3400, 3057, 2925, 1675, 1585, 1500, 1465, 1240,476; MS(*m/e*, %) 372(M+1), 141(100), 140(99), 101(1), 77(2). Found: C, 64.67; H, 5.46; O, 8.59; Se, 21.28 Calcd. for $C_{20}H_{20}O_2Se$: C, 64.66; H, 5.43; O, 8.62; Se, 21.29%).

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References

1 A.S. Rao, S.K. Paknikar and J.G.Kirtane, *Tetrahedron*, 1983, **39**, 2333.
2 M. Chini, P. Crotti, E. Giovani, F. Macchia and M. Pineschi, *Synlett*, 1992, **303**.
3 P. Meffre, L. Vo Quang, Y. Vo Quang and F. Le Goffic, *Tetrahedron Lett*., 1990, **31**, 2291.
4 D. Albanese, D. Landini and M. Penso, *Synthesis*, 1994, **34** and references therein.
5 T. Iizawa, A. Goto and T. Nishikubo, *Bull. Chem. Soc. Jpn.*, 1989, **62**, 597.
6 T. Nishikubo, T. Iizawa, M. Shimojo, T. Kato and A. Shiina, *J. Org. Chem.*, 1990, **55**, 2536.
7 S. Apparao, R.R. Schmidt, *Synthesis*, 1987, **896**.
8 A. Toshimitsu, T. Aoai, H. Owada, S. Uemura and M. Okano, *Tetrahedron*, 1985, **41**, 5301; D.L.J. Clive, V.N. K$\bar{\alpha}$l, *J. Org.Chem. Soc.*, 1981, **46**, 231.
9 M. Sakakibara, K. Katsumata, Y. Watanabe, T. Toru, Y. Ueno, *Synthesis*, 1992, **377**; S. V. Ley, I. A. O˙Nell, C.M.R. Low, *Tetrahedron*, 1986, **42**, 5363; A. Cravador and A. Krief, *Tetrahedron Lett*., 1981, **22**, 2491; N. Miyosh, K. Kondo, S. Murai and N. Sonoda, *Chem. Lett*., 1979, 909; K.B. Sharpless, R. F. Lauer, *J. Am. Chem. Soc*. 1973, **95**, 2697; N.Y. Derkach, N.A. Pasmurtseva and E.S. Levchenko, *Zh. Org. Khim*., 1971, **7**, 154
10 Y. Nishiyama, H. Ohashi, K. Itoh and N. Sonoda, *Chem. Lett*., 1998, **159**.
11 K.B. Sharpless and R.F. Lauer, *J. Am. Chem. Soc*. 1973, **95**, 2697.
12 K.B. Sharpless, R.F. Lauer and A.N. Teranishi, *J. Am. Chem. Soc*., 1973, **95**, 6137.
13 D. Liotta, W. Markiewcz and H. Santiesteban, *Tetrahedron Lett*., 1977, **50**, 4365.
14 J.V. Comasseto, J.T.B. Ferreira, C.A. Brandt and N. Petragnani, *J. Chem. Res., (S)* 1982, 212.
15 H.J. Reich, F. Chow and S.K. Shah, *J. Am. Chem. Soc*., 1979, **101**, 6638.
16 W.H.H. Gunther, *J. Org. Chem.* 1966, **31**, 1202.
17 L. Henriksen and N. Stuhr-Hansen, *J. Chem. Soc. Perkin Trans. 1*, 1999, 1915.
18 R. S. Varma, *Green Chem*., 1999, 43–55.
19 S. A.Galema, Microwave Chemistry, *Chem. Soc. Rev.* 1997, **26**, 233–238.
20 Jin-Xian Wang ,Wenfeng Cui and Yulai Hu, *J. Chem. Soc. Perkin Trans. 1*, 1994, 2341.
21 Jin-Xian Wang, Wenfeng Cui , Yulai Hu, and Shu-Sheng Zang, *J. Chem. Res.(S)* 1990, 230.
22 Jin-Xian Wang, Manli Zhang, ZhiLiang Xing and Yulai Hu, *Synth. Commun*. 1996, **26**, 301.
23 Jin-Xian Wang, Manli Zhang and Yulai Hu, *Synth. Commun.* 1998, **28**, 2407.
24 Jin-Xian Wang, Yumei Zhang,Danfeng Huang and Yulai Hu, *J. Chem. Res. (S)* 1998, 216.
25 Jin-Xian Wang, Xiaowei Wu, Hulai Hu,Kai Zhao and Zhanxiang Liu *J. Chem. Res. (S)* , 1999, 688; *(M)*, 3038–3045.