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SUBSTITUTION REACTIONS OF 2-BENZENESULPHONYL CYCLIC ETHERS WITH CARBON NUCLEOPHILES

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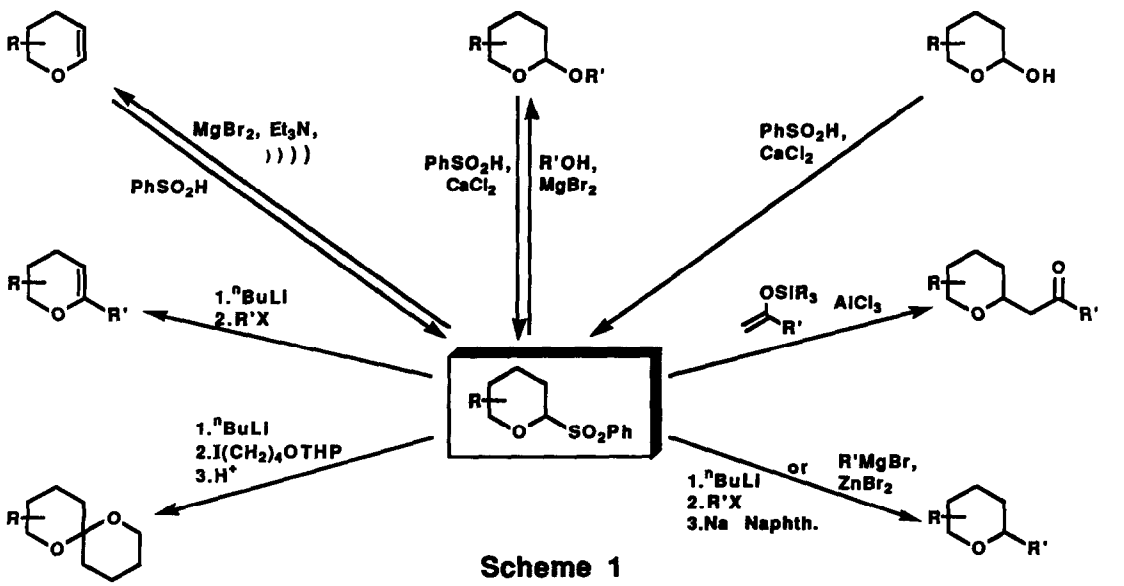
Abstract: *Direct substitution of 2-benzenesulphonyl cyclic ethers was studied using a variety of carbon nucleophiles. These nucleophiles included organozinc reagents (derived from aryl, vinyl and alkynyl Grignard reagents) or silyl enol ethers, silyl ketene acetals, allylsilanes and trimethylsilylcyanide in the presence of aluminium chloride. A general selectivity for the formation of the trans-product was observed using 6-substituted sulphones.*

Many biologically active natural products comprise of tetrahydropyran or tetrahydrofuran units with substituents adjacent to the ring oxygen atom. Consequently, methods for introducing groups into this anomeric position are strategically important in synthesis. Although there are now many solutions to the problem[2] there is still a need for improved versatility and selectivity, especially when carbon-carbon bonds are being formed.

Lactols and their derivatives are attractive starting materials for these reactions since they are readily available and can be converted efficiently into the corresponding stable and often crystalline 2-benzenesulphonyl cyclic ethers. We have been exploring a dual role of these sulphones for the formation of bonds at this anomeric position.[3-6] On the one hand the sulphonyl group facilitates deprotonation allowing subsequent reaction with electrophiles.



Scheme 1

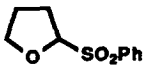
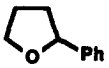
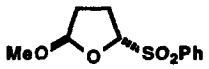
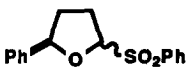
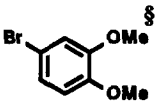
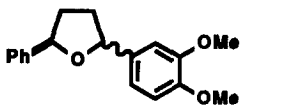
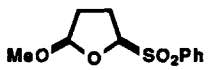
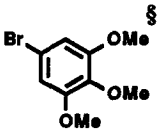
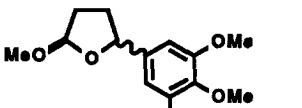
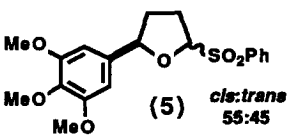
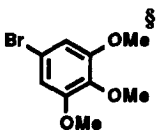
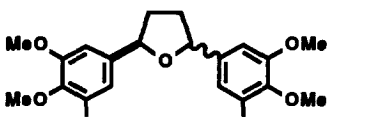
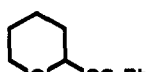
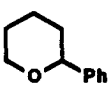
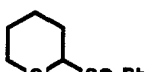
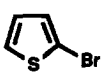
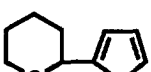
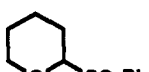
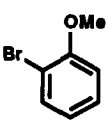
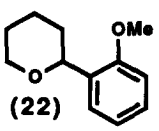
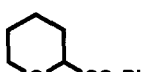
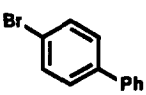
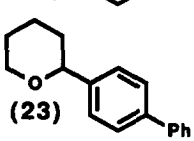
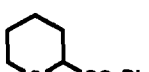
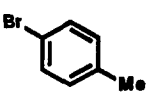
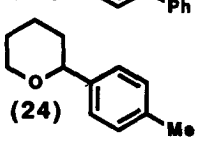
Alternatively it functions as a leaving group for direct nucleophilic displacement. Spiroacetals and other 2-substituted tetrahydro- and dihydro-pyrans are readily prepared from these benzenesulphonylpyran anions.[3,4] Additionally these sulphones serve as precursors for tetrahydrofuranyl and tetrahydropyranyl ethers by treatment of the sulphone with alcohols in the presence of magnesium bromide (Scheme 1).[5] Here we describe a new series of reactions which lead to carbon-carbon bond formation by direct nucleophilic substitution.[2,6]

The sulphones (1-14) used in this study were all prepared from dihydrofurans, dihydropyrans, lactols and lactol ethers by treatment with benzenesulphinic acid under conditions previously reported for the preparation of 2-(benzenesulphonyl)tetrahydro-2*H*-pyran (6).[3] Using this procedure the sulphone (11) was obtained in only a 35% yield. However we found that an improvement could be made by pretreating tri-*O*-acetyl-D-glucal with boron trifluoride etherate at -78°C followed by reaction with benzenesulphinic acid to afford the two sulphone diastereoisomers in 84% yield. Related 2-benzenesulphonyl cyclic ethers are also available *via* oxidation of the corresponding phenylsulphide derivatives.[7]

In the first series of experiments we investigated the direct nucleophilic displacement of the sulphone moiety using organometallic reagents (Table 1). Optimum yields were obtained from treatment of the appropriate Grignard reagent (generated from the aryl or vinyl halide or from the acetylene by deprotonation using *iso*-propyl magnesium bromide) with zinc bromide[8] in dry tetrahydrofuran and this species stirred with the sulphone for several hours at room temperature. In these reactions it was necessary to use tetrahydrofuran as the solvent since for example no product was observed with diethyl ether. The role of the magnesium in these reactions is unclear but it is obviously an essential element since the reaction fails using organozinc species prepared directly from the corresponding organolithium reagents. In cases where the Grignard reagent cannot be prepared, the corresponding organolithium may be used provided magnesium bromide is also added to the reaction mixture. For example in the entries **3-5**, the aryl halides were first metallated using t-butyl lithium and subsequently reacted with zinc bromide and magnesium bromide etherate. The sulphone was then added to give the desired products (17-19). From table **1** it should be noted that in the reaction of 5-substituted tetrahydrofuran sulphones (Entries 2-5) poor stereoselectivity was generally observed unless relatively large groups were involved, as in entry **5** which gave predominantly the *trans*-product. For reactions with 6-substituted tetrahydropyran sulphones there is a much clearer stereoselectivity observed providing the *trans*-product irrespective of the initial sulphone geometry (Entries 12-17 and 21). This last observation implies the presence of a common reaction intermediate such as an oxonium ion which is trapped by preferred axial bond formation.

It is further noteworthy from the examples cited in table **1** that aryl, heteroaryl, vinyl and ethynyl substituents can be introduced with good to very high yield. Functionalities such as acetals, esters and tetrahydropyranyl protection are also compatible with the reaction conditions. Since the acetal functionality in some of the products (compounds 16,18 and 28) can be exchanged with benzenesulphinic acid to give the corresponding sulphones (3,5 and 7 respectively), subsequent substitution provides a method for selectively controlling substituents on either side of the cyclic ether oxygen atom. This process is highlighted by the synthesis of *trans*-2,6-disubstituted pyrans (26,27 and 34) from the methoxypyran sulphones (8 and 9). Similarly the preparation of 2,5-disubstituted furans is

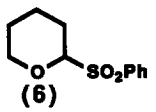
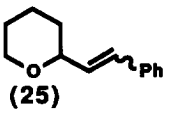
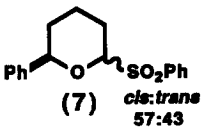
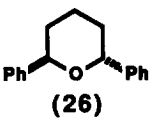
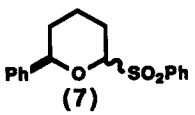
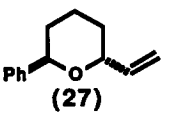
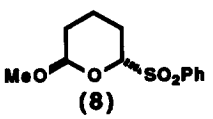
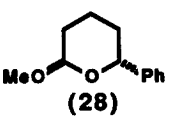
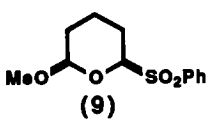
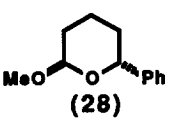
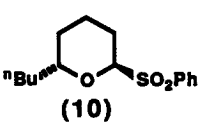
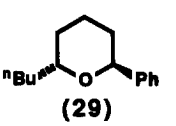
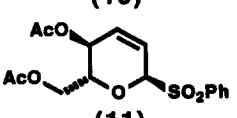
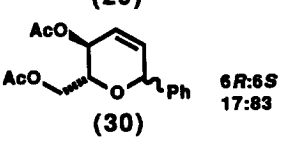
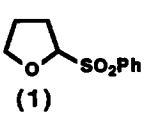
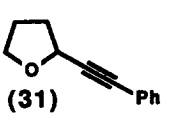
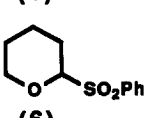
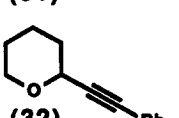
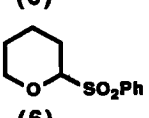
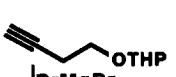
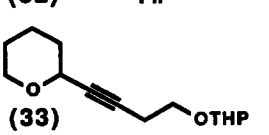
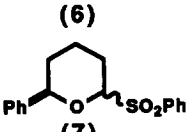
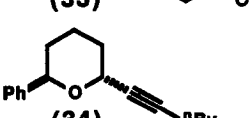
Table 1 Reaction of Sulphones with Organozinc Reagents.

	Sulphone	StartingReagent	Product(s)	Yield
1	 (1)	PhBr	 (15)	78%
2	 (2)	PhBr	 (16) *cis:trans* 50:50	91%
3	 (3) *cis:trans* 53:47	 §	 (17) *cis:trans* 50:50	91%
4	 (4)	 §	 (18) *cis:trans* 32:68	69%
5	 (5) *cis:trans* 55:45	 §	 (19) *cis:trans* 15:85	64%
6	 (6)	PhBr	 (20)	90%
7	 (6)		 (21)	95%
8	 (6)		 (22)	58%
9	 (6)		 (23)	81%
10	 (6)		 (24)	64%

§ Bromide lithiated then treated with $ZnBr_2$ and $MgBr_2$:Et_2O

Cont...

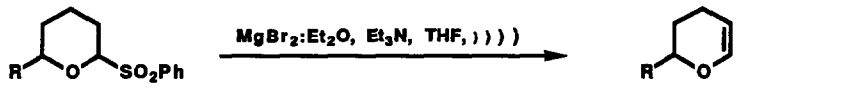
Table 1 (continued).

	Sulphone	Starting Reagent	Product(s)	Yield
11	 (6)	 *E*:*Z* 15:85	 (25) *E*:*Z* 22:78	80%
12	 (7) *cis*:*trans* 57:43	PhBr	 (26)	87%
13	 (7)		 (27)	82%
14	 (8)	PhBr	 (28)	80%
15	 (9)	PhBr	 (28)	77%
16	 (10)	PhBr	 (29)	94%
17	 (11)	PhBr	 (30) 6*R*:6*S* 17:83	71%†
18	 (1)	HC≡CPh, ^{i}PrMgBr	 (31)	88%
19	 (6)	HC≡CPh, ^{i}PrMgBr	 (32)	97%
20	 (6)		 (33)	83%
21	 (7)	HC≡C^{n}Bu, ^{i}PrMgBr	 (34)	81%

† Yield based on recovered starting material (23%).

illustrated by the combination of entries **4** and **5** which leads to the symmetrically substituted *trans*-isomer of compound **19**. This compound is identical to L-652,731 a recently reported potent platelet activating factor (PAF) antagonist.[9] Obviously this method would be applicable to the efficient synthesis of unsymmetrical analogues of **19**.

In the absence of suitable nucleophiles, treatment of the above sulphones with magnesium bromide and triethylamine affords glycals. This is not always an easy elimination process with other substituents. The use of ultrasound in these reactions increased the yields significantly (Scheme 2).



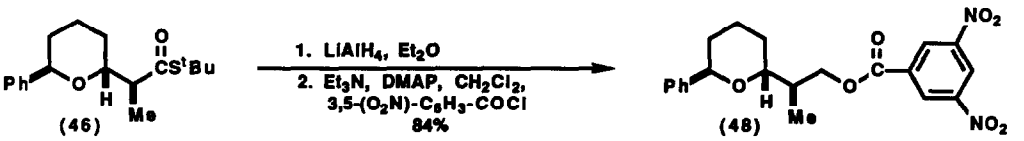
(7) R=Ph (*cis*:*trans* 57:43)
(12) R=CH_2OAc (*trans*)

Scheme 2

(35) R=Ph 89%
(36) R=CH_2OAc 76%

In other studies (Table 2) we have explored the reaction of cyclic ether sulphones with silyl enol ethers and silyl ketene acetals. While many related reactions of this type are known it still remains an important carbon-carbon bond forming process. The aluminium chloride promoted reactions reported below are reminiscent of the related Mukaiyama process.[10,11] The products of the reactions contain potentially useful functionality and are formed with a high degree of stereochemical control, once again favouring the *trans* stereochemistry. Only in one case (Entry 3) did the *cis*-product predominate but in this particular example we believe that initial formation of the *trans*-isomer occurs and this undergoes ring opening and reclosure to form the more thermodynamically stable *cis*-diequatorial product. Evidence supporting this view is shown in entry **4** where similar ring opening is now impossible due to the presence of a methyl group replacing the easily lost acidic proton in compound **39**.

The reactions reported in table **2** often afford sterically demanding products and with some degree of stereochemical selectivity (Entry 8). The structure of the product (46) was proved by X-ray single crystal analysis on the dinitrobenzoyl derivative (48) (Scheme 3).[12] Although we have restricted the above studies to simple silyl enol ethers, β-ketoester silyl enol ethers and ketene silyl acetals the range is sufficiently broad to suggest that the reactions would be more generally applicable.

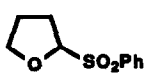
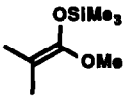
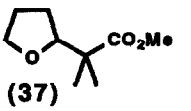
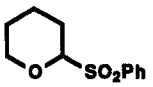
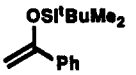
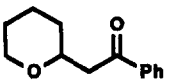
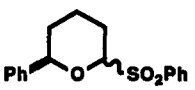
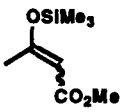
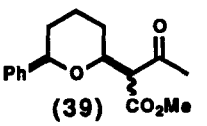
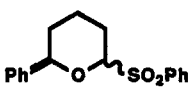
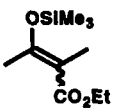
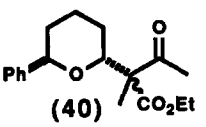
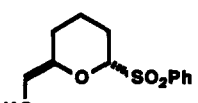
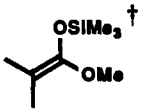
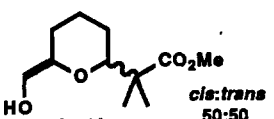
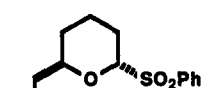
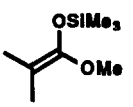
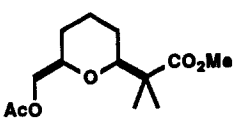
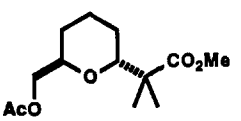
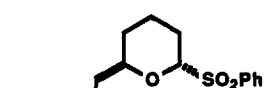
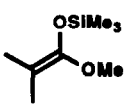
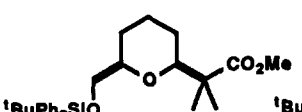
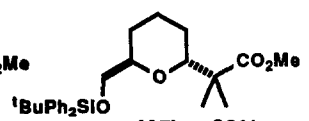
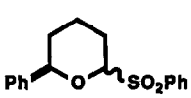
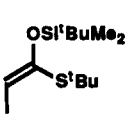
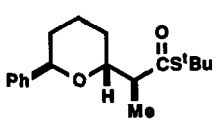
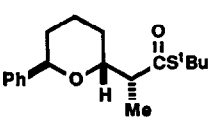


(46) (48)

Scheme 3

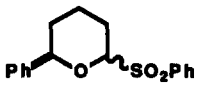
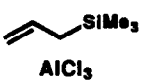
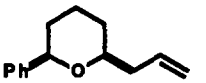
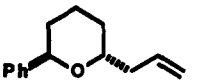
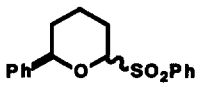
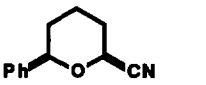
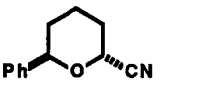
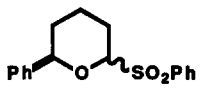
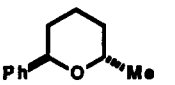
Finally a brief study of other nucleophilic carbon species which may participate in the substitution of these sulphones has been undertaken (Table 3). We have found that both allyltrimethylsilane and trimethylsilylcyanide react in the presence of aluminium chloride at -35°C to give mainly the *trans*-product along with some of the *cis*-isomer whilst reaction with trimethylaluminium gives exclusively the *trans*-isomer. Related angular methylation *via* displacement of a sulphone using trimethylaluminium has been previously reported in an isolated example by Nicolaou.[13]

Table 2 Reaction of Sulphones with $AlCl_3$ and Silyl Reagents.

	Sulphone	Silyl Reagent	Product(s)	Yield
1	 (1)		 (37)	87%
2	 (6)		 (38)	90%
3	 (7) *cis:trans* 57:43		 (39)	70%
4	 (7)		 (40)	77%
5	 (13)	 †	 (41)	79% §
6	 (12)		 (42) 33%  (43) 64%	
7	 (14)		 (44) 35%  (45) 62%	
8	 (7)		 (46) 61%  (47) 37%	

† 3.0 Equiv. of silyl ketene acetal and 1.05 equiv. of $AlCl_3$ were used. § 10% Starting material was also recovered.

Table 3 Reaction of Sulphones with other Carbon Nucleophiles.

	Sulphone	Reagents	Products and Yields	
1	 (7) *cis:trans* 57:43	 $AlCl_3$	 (49) 11%	 (50) 80%
2	 (7)	Me_3SiCN, $AlCl_3$	 (51) 36%	 (52) 60%
3	 (7)	$AlMe_3$	 (53) 98%	

In summary we believe the above reactions further demonstrate the versatility of cyclic ether sulphones as useful precursors for the formation of carbon-carbon bonds at the 2-position of cyclic ethers. Application of the methodology to more challenging systems and a more detailed study of ring substituent effects is currently underway.

Acknowledgements: *We thank the SERC (Instant Award to DSB) and Schering Agrochemicals Ltd for financial support and Drs. G. Kneen and P. Dudfield for useful discussions.*

Experimental:

Solutions were dried over anhydrous sodium sulphate or anhydrous magnesium sulphate and solvents by standard methods. The products were purified by column chromatography on Merck silica gel 60 (Art. 9385 230-400 mesh) under pressure using 40-60 petrol / diethyl ether as the solvent unless otherwise stated. HPLC was carried out on a 21.4mm Dynamax-60A 8μm silica gel column using 4% ^{i}PrOH in 40-60 petrol as the eluent. Melting points were measured on a Kofler hot-stage apparatus and are uncorrected. IR spectra were recorded on a Perkin-Elmer 983G spectrophotometer as liquid films or chloroform solutions. ^{1}H NMR spectra were recorded in $CDCl_3$ on Bruker WM-250, Jeol GSX-270 or Bruker AM-500 spectrometers. Mass spectra were recorded on a VG Micromass 7070B instrument.

Preparation of the Sulphones:

2-(Benzenesulphonyl)tetrahydrofuran (1).- A solution of 2,3-dihydrofuran (1.51 ml, 1.40 g, 20 mmol) and benzenesulphinic acid (3.1 g, 22 mmol) in dry dichloromethane (80 ml) was stirred at room temperature under argon for 2 hours. Aqueous sodium carbonate work up and purification of the resulting solid by recrystallisation (Et_2O : 40-60 petrol) gave compound 1 (3.60 g, 85%) as a white crystalline solid, m.p. 61-61.5°C; ν_{max} ($CHCl_3$) 3019, 2894, 1446, 1314, 1147, 1068, 928, 716, and 687 cm^{-1}; δ_H (270 MHz) 1.90-2.37 (3H, m, 3-H 4-H), 2.63-2.75 (1H, m, 3-H), 3.95-4.03 (1H, m, 5-H), 4.14 (1H, dd, *J* 15.3, 7.2 Hz, 5-H), 4.89 (1H, dd, *J* 8.1, 3.9 Hz, 2-H), 7.50-7.60 (2H, m, *m*-H), 7.63-7.70 (1H, m, *p*-H), and 7.90-7.95 (2H, m, *o*-H); m/z 71 (M^{+}-$PhSO_2$, 100%), and 28; (Found: C,56.74; H,5.74. $C_{10}H_{12}O_3S$ requires C,56.58; H,5.70%).

***trans*-2-(Benzenesulphonyl)tetrahydro-5-methoxyfuran (2).-** A mixture of 2,5-dimethoxytetrahydrofuran (6.24 ml, 6.34 g, 48 mmol), benzenesulphinic acid (27.4 g, 190 mmol) and anhydrous calcium chloride (32 g) in dry dichloromethane (200 ml) was stirred at room temperature for 24 hours under argon. Aqueous sodium hydroxide work up and purification by silica gel chromatography (CH_2Cl_2 : Et_2O : 40-60 petrol) gave compound **2** (6.70 g, 58%) as a white crystalline solid, m.p. 82-84°C; ν_{max} ($CHCl_3$) 3022, 3018, 2963, 2841, 1449, 1308, 1153, 1089, 1050, 923, 758, and 687 cm^{-1}; δ_H (270 MHz) 1.87 (1H, dddd, *J* 13.0, 8.5, 2.3, 1.0 Hz, 4-H), 1.99 (1H, dddd, *J* 13.0, 11.0, 9.0, 5.0 Hz, 4-H), 2.42 (1H, ddt, *J* 14.0, 11.0, 8.5 Hz, 3-H), 2.59 (1H, ddt, *J* 14.0, 9.0, 2.3 HZ, 3-H), 3.30 (3H, s, OCH_3, irradiation at either 4.99 or 5.22 p.p.m. gave a n.O.e. enhancement), 4.99 (1H, dd, *J* 8.5, 2.3 Hz, 2-H), 5.22 (1H, dd, *J* 5.0, 1.0 Hz, 5-H), 7.53-7.63 (2H, m, *m*-H), 7.63-7.73 (1H, m, *p*-H), and 7.90-7.95 (2H, m, σ-H); m/z 101 (M^+-$PhSO_2$, 100%), and 69; (Found: C,54.47; H,5.89. $C_{11}H_{14}O_4S$ requires C,54.53; H,5.82%). Further elution of the column gave ***cis*-2-(benzenesulphonyl)tetrahydro-5-methoxyfuran (4)** (3.30 g, 28 %) as a white crystalline solid, m.p. 66.5-68°C; ν_{max} ($CHCl_3$) 3017, 2931, 2838, 1447, 1321, 1147, 1090, 1051, 918, 839, 717, and 687 cm^{-1}; δ_H (270 MHz) 1.98 (1H, dddd, *J* 13.2, 10.0, 8.3, 4.9 Hz, 4-H), 2.10 (1H, dddd, *J* 13.2, 7.3, 3.7, 1.7 Hz, 4-H), 2.31 (1H, dddd, *J* 13.2, 8.3, 7.3, 3.7 Hz, 3-H), 2.63 (1H, ddt, *J* 13.2, 10.0, 7.3 HZ, 3-H), 3.36 (3H, s, OCH_3), 4.94 (1H, t, *J* 7.3 Hz, 2-H), 5.09 (1H, dd, *J* 4.9, 1.7 Hz, 5-H), 7.53-7.63 (2H, m, *m*-H), 7.63-7.73 (1H, m, *p*-H), and 7.90-7.95 (2H, m, σ-H); m/z 101 (M^+-$PhSO_2$, 100%), and 69; (Found: C,54.31; H,5.86. $C_{11}H_{14}O_4S$ requires C,54.53; H,5.82%).

2-(Benzenesulphonyl)tetrahydro-5-phenylfuran (3).- A mixture of tetrahydro-2-methoxy-5-phenylfuran (16) (1.51 g, 8.5 mmol), benzenesulphinic acid (3.70 g, 26 mmol) and anhydrous calcium chloride (2.9 g, 26 mmol) in dry dichloromethane (35 ml) was stirred at room temperature for 22 hours under argon. Aqueous sodium carbonate work up and purification gave compound **3** (2.29 g, 94%) (*cis*:*trans*, 53:47) as a white solid, m.p. 47-49°C; ν_{max} ($CHCl_3$) 3020, 1447, 1309, 1149, 1067, 716, 699, and 687 cm^{-1}; δ_H (270 MHz) 1.88-3.00 (4H, m, *cis*/*trans* 3-H 4-H), 4.97-5.05 (0.94H, m, *trans* 2-H 5-H), 5.14 (0.53H, dd, *J* 7.8, 4.6 Hz, *cis* 5-H), 5.38 (0.53H, dd, *J* 8.3, 6.1 Hz, *cis* 2-H), and 7.23-8.00 (10H, m, *cis*/*trans* ArH); m/z 147 (M^+-$PhSO_2$, 100%); (Found: C,66.59; H,5.59. $C_{16}H_{16}O_3S$ requires C,66.64; H,5.59%).

2-(Benzenesulphonyl)tetrahydro-5-(3,4,5-trimethoxyphenyl)furan (5).- A mixture of tetrahydro-2-methoxy-5-(3,4,5-trimethoxyphenyl)furan (18) (805 mg, 3.0 mmol), benzenesulphinic acid (1.28 g, 9 mmol) and anhydrous calcium chloride (1.0 g, 9 mmol) in dry dichloromethane (12 ml) was stirred at room temperature for 20 hours under argon. Aqueous sodium carbonate work up and purification by silica gel chromatography (EtOAc : 40-60 petrol) gave compound **5** (1.07 g, 94%) (*cis*:*trans*, 55:45) as a white foam; ν_{max} ($CHCl_3$) 3006, 2939, 1594, 1463, 1308, 1234, 1148, 1129, 1070, 716, and 687 cm^{-1}; δ_H (270 MHz) 1.85-3.03 (4H, m, *cis*/*trans* 3-H 4-H), 3.81 (2.7H, s, *trans m*-OCH_3), 3.83 (3.3H, s, *cis m*-OCH_3), 3.87 (1.35H, s, *trans p*-OCH_3), 3.91 (1.65H, s, *cis p*-OCH_3), 4.95-5.03 (0.9H, m, *trans* 2-H 5-H), 5.14 (0.55H, dd, *J* 7.6, 4.9 Hz, *cis* 5-H), 5.30 (0.55H, dd, *J* 8.8, 5.9 Hz, *cis* 2-H), 6.48 (1.1H, s, *cis* σ-H), 6.85 (0.9H, s, *trans* σ-H), and 7.47-8.00 (5H, m, *cis*/*trans* Ar-H); m/z 378 (M^+, 9%), 237, 236, 207, 176, and 77; (Found: C,60.04; H,5.86. $C_{19}H_{22}O_6S$ requires C,60.30; H,5.86%).

2-(Benzenesulphonyl)tetrahydro-6-phenyl-2*H*-pyran (7).- A mixture of *trans*-tetrahydro-2-methoxy-6-phenyl-2*H*-pyran (28)(2.88 g, 15 mmol), benzenesulphinic acid (4.27 g, 30 mmol) and anhydrous calcium chloride (4.94 g, 45 mmol) in dry dichloromethane (60 ml) was stirred at room temperature for 26 hours under argon. Aqueous sodium carbonate work up and purification gave compound **7** (3.73 g, 83%) (*cis*:*trans*, 57:43) as a white solid, m.p. 98-100°C; ν_{max} ($CHCl_3$) 3066, 3019, 2949, 2863, 1447, 1308, 1142, 1084, 1028, 730, 699, and 687 cm^{-1}; δ_H (250 MHz) 1.40-2.70 (6H, m, *cis*/*trans* 3-H 4-H 5-H), 4.41 (0.57H, dd, *J* 11.5, 2.0 Hz, *cis* 6-H), 4.59 (0.57H, dd, *J* 11.0, 2.5 Hz, *cis* 2-H), 4.80 (0.43H, dd, *J* 6.5, 2.5 Hz, *trans* 6-H), 5.49 (0.43H, dd, *J* 10.5, 3.0 Hz, *trans* 2-H), and 7.20-8.00 (5H, m, *cis*/*trans* ArH); m/z 161 (M^+-$PhSO_2$, 17%), 160, 104, and 77; (Found: C,67.31; H,5.99. $C_{17}H_{18}O_3S$ requires C,67.52; H,6.00%).

***trans*-2-(Benzenesulphonyl)tetrahydro-6-methoxy-2*H*-pyran (8).-** A solution of 3,4-dihydro-2-methoxy-2*H*-pyran (11.41 g, 100 mmol) and benzenesulphinic acid (14.2 g, 100 mmol) in dry dichloromethane (200 ml) was stirred at room temperature for 2 hours under argon. Aqueous sodium carbonate work up and purification gave compound **8** (16.96 g, 66%) as a white crystalline solid, m.p. 77-78°C; ν_{max} ($CHCl_3$) 3019, 2938, 2838, 1446, 1319, 1152, 1125, 1023, 947, 720, and 687 cm^{-1}; δ_H (250 MHz) 1.60-1.80 (5H, m, 3-H 4-H 5-H), 2.13-2.20 (1H, m, 3-H), 2.95 (3H, s, OCH_3), 4.63 (1H, dd, *J* 10.5, 2.5 Hz, 2-H), 4.76 (1H, t, *J* 2.5, Hz, 6-H), 7.53-7.58 (2H, m, *m*-H), 7.63-7.68 (1H, m, *p*-H), and 7.93-7.98 (2H, m, σ-H); m/z 225 (M^+-OCH_3, 4%), 115, and 71; (Found:

C,56.34; H,6.15. $C_{12}H_{16}O_4S$ requires C,56.23; H, 6.29%). Further elution of the column gave ***cis*-2-(benzenesulphonyl)tetrahydro-6-methoxy-2*H*-pyran (9)** (2.30 g. 9%) as a white crystalline solid, m.p. 87-88°C; ν_{max} ($CHCl_3$) 3019, 2960, 2935, 2866, 1447, 1316, 1172, 1152, 1020, 952, 913, 718, and 687 cm^{-1}; δ_H (250 MHz) 1.35-1.80 (4H, m, 4-H 5-H), 1.98-2.18 (2H, m, 3-H), 3.27 (3H, s, OCH_3), 4.26 (1H, dd, *J* 8.0, 2.0 Hz, 6-H), 4.41 (1H, dd, *J* 10.0, 2.5 Hz, 2-H), 7.53-7.58 (2H, m, *m*-H), 7.63-7.68 (1H, m, *p*-H), and 7.93-7.98 (2H, m, σ-H); m/z 225 (M^+-OCH_3, 1%), 115, and 71; (Found: C,56.03; H,6.33. $C_{12}H_{16}O_4S$ requires C,56.23; H, 6.29%).

(2*R*,3*S*,6*R*)-3-Acetoxy-6-(benzenesulphonyl)-3,6-dihydro-2*H*-pyran-2-methanol acetate (11)[12].- Boron trifluoride etherate (0.27 ml, 312 mg, 2.2 mmol) was added to a stirred solution of tri-*O*-acetyl-D-glucal (525 mg, 2.0 mmol) in dry dichloromethane (5 ml) at -78°C under argon. The mixture was warmed to 10°C and a solution of benzenesulphinic acid (569 mg, 4.0 mmol) in dry dichloromethane (5 ml) was added and the mixture stirred at room temperature for 2 hours. Aqueous sodium hydroxide work up and purification by silica gel chromatography (CH_2Cl_2:Et_2O:40-60 petrol) gave a mixture of the sulphone isomers (325 mg, 46%) 6*R*:6*S*, 50:50) as a white solid. Further elution gave compound **11** (267 mg, 38%) as a white crystalline solid, m.p. 144-145°C; $[\alpha]_D^{25}$ +194° (c 0.50 in $CHCl_3$); ν_{max} ($CHCl_3$) 3028, 1742, 1449, 1371, 1319, 1309, 1230, 1158, 1146, 1081, 1048, 763, 686, and 671 cm^{-1}; δ_H (250 MHz) 2.09 (3H, s, CH_3), 2.10 (3H, s, CH_3), 4.16 (2H, d, *J* 4.5 Hz, α-H), 4.65 (1H, dt, *J* 9.5, 4.5 Hz, 2-H), 5.12 (1H, s, 6-H), 5.28 (1H, d, *J* 9.5 Hz, 3-H), 6.28 (2H, s, 4-H 5-H), 7.55-7.63 (2H, m, *m*-H), 7.67-7.75 (1H, m, *p*-H), and 7.95-8.00 (2H, m, σ-H); m/z 234 (M^+-2AcOH, 1%), 213, 153, 111, and 43; (Found: C,54.47; H,5.03. $C_{16}H_{18}O_7S$ requires C,54.23; H, 5.12%).

***trans*-6-(Benzenesulphonyl)tetrahydro-2*H*-pyran-2-methanol acetate (12).**- A solution of 3,4-dihydro-2*H*-pyran-2-methanol acetate (10.0 g, 64 mmol) and benzenesulphinic acid (11.3 g, 80 mmol) in dry dichloromethane (350 ml) was stirred at room temperature for 24 hours under argon. Aqueous sodium carbonate work up and purification gave compound **12** (14.0 g, 73%) as a white crystalline solid, m.p. 75-76°C; ν_{max} ($CHCl_3$) 3019, 2952, 1737, 1446, 1369, 1236, 1147, 1123, 1084, 1049, 720, 687, and 648 cm^{-1}; δ_H (270 MHz) 1.30-2.30 (5H, m, 3-H 4-H 5-H), 2.02 (3H, s, CH_3), 2.58-2.65 (1H, m, 5-H), 3.90-4.10 (2H, m, α-H), 4.68-4.78 (2H, m, 2-H 6-H), 7.55-7.60 (2H, m, *m*-H), 7.65-7.70 (1H, m, *p*-H), and 7.90-7.95 (2H, m, σ-H); m/z 157 (M^+-$PhSO_2$, 89%), 97, and 43; (Found: C,56.53; H,6.12. $C_{14}H_{18}O_5S$ requires C,56.36; H,6.08%). Further elution of the column gave ***cis*-6-(benzenesulphonyl)tetrahydro-2*H*-pyran-2-methanol acetate** (1.2 g, 6%) as a colourless gum; ν_{max} ($CHCl_3$) 3019, 2951, 2867, 1734, 1446, 1370, 1320, 1236, 1151, 1083, 1048, 720, and 687 cm^{-1}; δ_H (270 MHz) 1.10-2.10 (6H, m, 3-H 4-H 5-H), 1.93 (3H, s, CH_3), 3.53-3.63 (1H, m, 2-H, irradiation at 4.0 p.p.m. gave dd, *J* 11.6, 1.8 Hz), 3.98-4.10 (2H, m, α-H), 4.36 (1H, dd, *J* 11.1, 2.3 Hz, 6-H), 7.50-7.58 (2H, m, *m*-H), 7.65-7.70 (1H, m, *p*-H), and 7.90-7.95 (2H, m, σ-H); m/z 157 (M^+-$PhSO_2$, 61%), 97, and 43; (Found: C,56.69; H,6.43. $C_{14}H_{18}O_5S$ requires C,56.36; H,6.08%).

***trans*-6-(Benzenesulphonyl)tetrahydro-2*H*-pyran-2-methanol (13).**- **Method a).** A mixture of potassium carbonate (1.4 g, 20 mmol) and *trans*-6-(Benzenesulphonyl)tetrahydro-2*H*-pyran-2-methanol acetate (12) (2.98 g, 10 mmol) in methanol (50 ml) was stirred at room temperature for 3 hours and then concentrated *in vacuo*. Aqeous work up and purification by silica gel chromatography (MeOH : Et_2O) gave compound **13** (2.48 g, 97%) as a white crystalline solid, m.p. 93-94.5°C; ν_{max} ($CHCl_3$) 3593, 3011, 2952, 1446, 1307, 1146, 1123, 1083, 1043, 720, 687, and 647 cm^{-1}; δ_H (270 MHz) 1.35-2.30 (6H, m, OH 3-H 4-H 5-H), 2.58-2.68 (1H, m, 5-H), 3.43 (1H, dd, *J* 11.8, 6.8 Hz, α-H), 3.56 (1H, dd, *J* 11.8, 3.0 Hz, α-H), 4.57 (1H, ddt, *J* 11.3, 6.8, 3.0 Hz, 2-H), 4.71 (1H, dd, *J* 6.3, 0.5 Hz, 6-H), 7.55-7.70 (3H, m, *m*-H, *p*-H), and 7.93-7.98 (2H, m, σ-H); m/z 115 (M^+-$PhSO_2$, 100%), 97, and 79; (Found: C,56.40; H,6.32. $C_{12}H_{16}O_4S$ requires C,56.23; H,6.29%).

Method b). A solution of 3,4-dihydro-2*H*-pyran-2-methanol (4.15 ml, 4.57 g, 40 mmol) and benzene sulphinic acid (6.26 g, 44 mmol) in dry dichloromethane (160 ml) was stirred at room temperature for 2 hours. Aqueous sodium carbonate work up and purification gave compound **13** (1.08 g, 11%) as a white solid, m.p. 88-90°C; ν_{max} ($CHCl_3$) 3592, 3009, 2952, 1446, 1307, 1146, 1124, 1083, 1043, 720, 687, and 647 cm^{-1}; δ_H (270 MHz) 1.35-2.33 (6H, m, OH 3-H 4-H 5-H), 2.63 (1H, br d, *J* 15 Hz, 5-H), 3.43 (1H, dd, *J* 11.8, 6.8 Hz, α-H), 3.56 (1H, dd, *J* 11.8, 2.8 Hz, α-H), 4.52-4.62 (1H, m, 2-H), 4.71 (1H, dd, *J* 6.8, 0.5 Hz, 6-H), 7.55-7.70 (3H, m, *m*-H *p*-H), and 7.93-7.98 (2H, m, σ-H); m/z 115 (M^+-$PhSO_2$, 100%), 97, and 79.

***trans*-2-(Benzenesulphonyl)-6-[(*tert*-butyldiphenylsilyloxy)methyl]tetrahydro-2H-pyran (14).**- tert-

Butylchlorodiphenylsilane (0.57 ml, 605 mg, 2.2 mmol) was added to a stirred solution of *trans*-6-(Benzenesulphonyl)tetrahydro-2*H*-pyran-2-methanol (13) (513 mg, 2.0 mmol), triethylamine (0.33 ml, 243 mg, 2.4 mmol) and 4-(dimethylamino)pyridine (5 mg, 0.04 mmol) in dry dichloromethane (20 ml) at O°C under argon, the mixture was allowed to warm to room temperature and stirred for 18 hours. Aqueous sodium hydrogen carbonate work up and purification gave compound **14** (763 mg, 77%) as a colourless gum; ν_{max} ($CHCl_3$) 3008, 2955, 2858, 1446, 1307, 1147, 1113, 1048, 704, and 687 cm^{-1}; δ_H (270 MHz) 0.85-2.28 (5H, m, 3-H 4-H 5-H), 1.04 (9H, s, $C(CH_3)_3$), 2.58-2.68 (1H, m, 3-H), 3.55 (1H, d, *J* 4.6, α-H), 3.56 (1H, d, *J* 5.4, α-H), 4.58-4.68 (1H, m, 6-H, irradiation at 3.55 p.p.m. gave dd, *J* 11.0, 2.2 Hz,), 4.69 (1H, br d, *J* 5.0 Hz, 2-H), 7.28-7.65 (13H, m, ArH), and 7.85-7.93 (2H, m, ArH); m/z 295 (M^+-$PhSO_2$-^{t}Bu, 100%), 239, and 199; (Found: C,68.00; H,7.04. $C_{28}H_{34}O_4SSi$ requires C,67.98; H,6.93%).

General Method for 2-Substitution of Cyclic Ethers with Aryl- or Vinyl-zinc Reagents.- The Grignard Reagent prepared from the appropriate aryl or vinyl bromide (2.0 equiv.) and magnesium (2.1 equiv.) in dry tetrahydrofuran (4 ml/mmol) was treated with anhydrous zinc bromide (1.2 equiv., 1M solution in tetrahydrofuran[8]) at room temperature for 30 minutes under argon to afford the organozinc species. The sulphone (1.0 equiv.) was added to this suspension as a solution in dry tetrahydrofuran (4 ml/mmol) and the reaction mixture stirred at room temperature for 3-24 hours. Acidic work up and purification gave the product.

Tetrahydro-2-phenylfuran (15).- Reaction of 2-(benzenesulphonyl)tetrahydrofuran (1) (425 mg, 2.0 mmol) with the organozinc prepared from bromobenzene gave compound **15** (230 mg, 78%) as a colourless oil; ν_{max} (film) 2973, 2868, 1450, 1367, 1168, 1060, 1027, 754, and 700 cm^{-1}; δ_H (250 MHz) 1.75-2.38 (4H, m, 3-H 4-H), 3.92 (1H, dt, *J* 8.0, 7.0 Hz, 5-H), 4.08 (1H, dt, *J* 8.0, 7.0 Hz, 5-H), 4.88 (1H, t, *J* 7.0 Hz, 2-H), and 7.20-7.35 (5H, m, ArH); m/z 148 (M^+, 86%), 147, 105, and 77; (Found: C,80.79; H,8.03. $C_{10}H_{12}O$ requires C,81.04; H,8.16%).

Tetrahydro-2-methoxy-5-phenylfuran (16).- Reaction of *trans*-2-(benzenesulphonyl)tetrahydro-5-methoxyfuran (2) (2.42 g, 10.0 mmol) with the organozinc prepared from bromobenzene gave compound **16** (1.62 g, 91%) (*cis*:*trans* 50:50) as a colourless oil; ν_{max} (film) 3029, 2902, 2828, 1450, 1205, 1102, 1043, 954, 760, and 700 cm^{-1}; δ_H (270 MHz) 1.55-2.47 (4H, m, *cis*/*trans* 3-H 4-H), 3.42 (1.5H, s, OCH_3), 3.46 (1.5H, s, OCH_3), 5.00-5.14 (1.5H, m, *cis*/*trans* 5-H *trans* 2-H), 5.25 (0.5H, dd, *J* 5.3, 1.8 Hz, *cis* 2-H), and 7.27-7.43 (5H, m, *cis*/*trans* ArH); m/z 147 (M^+-MeO 6%), and 72; (Found: C,73.68; H,8.02. $C_{11}H_{14}O_2$ requires C,74.13; H,7.92%).

***cis*- & *trans*-2-(3,4-Dimethoxyphenyl)tetrahydro-5-phenylfuran (17).-** ^{t}Butyl lithium (2.47 ml, 4.2 mmol, 1.7 M in pentane) was added dropwise to a stirred solution of 4-bromoveratrole (0.26 ml, 434 mg, 2.0 mmol) in dry tetrahydrofuran (2 ml) at -90°C under argon. The mixture was stirred at -90°C for 10 minutes then anhydrous zinc bromide (1.2 ml, 1.2 mmol, 1M solution in tetrahydrofuran) and magnesium bromide etherate (517 mg, 2.0 mmol) were added. The mixture was allowed to warm to room temperature, stirred for 30 minutes and a solution of 2-(benzenesulphonyl)tetrahydro-5-phenylfuran (3) (288 mg, 1.0 mmol) in dry tetrahydrofuran (5 ml) was added. The reaction was stirred for 20 hours, then acidic work up and purification by silica gel chromatography (Et_2O : 40-60 petrol) gave compound **17** (258 mg, 91%) (*cis*:*trans* 50:50) as a white solid. The two isomers were seperated by HPLC to give the pure *trans*-isomer; ν_{max} (film) 3003, 2936,1513, 1463 1260, 1236, 1138, 1028, and 700 cm^{-1}; δ_H (500 MHz) 1.95-2.05 (2H, m, 3-H 4-H), 2.40-2.53 (2H, m, 3-H 4-H), 3.88, (3H, s, OCH_3), 3.91 (3H, s, OCH_3), 5.22 (1H, dd, *J* 8, 6 Hz, 2-H), 5.26 (1H, t, *J* 7 Hz, 5-H, irradiation at either 6.94 or 6.98 p.p.m. gave a n.O.e. enhancement), 6.86 (1H, d, *J* 8 Hz, 5'-H), 6.94 (1H, dd, *J* 8, 2 Hz, 6'-H), 6.98 (1H, d, *J* 2 Hz, 2'-H), 7.23-7.33 (1H, m, *p*-H), 7.36 (2H, t, *J* 7 Hz, *m*-H), and 7.41 (2H, d, *J* 7 Hz, σ-H); m/z 284 (M^+, 78%), 166, and 164; (Observed M^+, 284.1411. Calc. for $C_{18}H_{20}O_3$ M, 284.1413); and the pure *cis*-isomer; ν_{max} (film) 3003, 2937,1515, 1463 1262, 1236, 1138, 1028, and 700 cm^{-1}; δ_H (500 MHz) 1.95-2.05 (2H, m, 3-H 4-H), 2.37-2.47 (2H, m, 3-H 4-H), 3.87, (3H, s, OCH_3), 3.88 (3H, s, OCH_3), 5.02 (1H, t, *J* 7 Hz, 2-H), 5.06 (1H, t, *J* 7 Hz, 5-H), 6.86 (1H, d, *J* 8 Hz, 5'-H), 6.97 (1H, dd, *J* 8, 2 Hz, 6'-H), 7.00 (1H, d, *J* 2 Hz, 2'-H), 7.23-7.30 (1H, m, *p*-H), 7.36 (2H, t, *J* 7 Hz, *m*-H), and 7.44 (2H, d, *J* 7 Hz, σ-H); m/z 284 (M^+, 59%), 166, and 164; (Observed M^+, 284.1411. Calc. for $C_{18}H_{20}O_3$ M, 284.1413).

***Tetrahydro-2-methoxy-5-(3,4,5-trimethoxyphenyl)furan* (18).-** Reaction of *cis*-2-(benzenesulphonyl)tetrahydro-5-methoxyfuran (4) (1.21 g, 5.0 mmol) with the organozinc prepared by lithiation of 1-bromo-3,4,5-trimethoxybenzene using the procedure in the above experiment gave compound **18** (0.92 g, 69%) (*cis*:*trans* 32:68) as a colourless oil; ν_{max} (film) 2942, 2831,

1592, 1505, 1457, 1419, 1360, 1326, 1236, 1127, 1034, 940, 845, and 694 cm^{-1}; δ_H (270 MHz) 1.67-2.47 (4H, m, *cis/trans* 3-H 4-H), 3.42 (0.96H, s, *cis* 2-OCH_3), 3.48 (2.04H, s, *trans* 2-OCH_3), 3.82 (0.96H, s, *cis* *p*-OCH_3), 3.83 (2.04H, s, *trans* *p*-OCH_3), 3.87 (6H, s, *cis/trans* *m*-OCH_3), 4.93-5.03 (1H, m, *cis/trans* 5-H), 5.10 (0.68H, br d, *J* 3.9 Hz, *trans* 2-H), 5.24 (0.32H, dd, *J* 5.2, 1.8 Hz, *cis* 2-H), 6.56 (0.64H, s, *cis* σ-H), and 6.64 (1.36H, s, *trans* σ-H); m/z 268 (M^+, 100%), 237, 196, 168, and 72; (Found: C,62.91; H,7.70. $C_{14}H_{20}O_5$ requires C,62.67; H,7.51%).

***cis*- & *trans*-Tetrahydro-2,5-bis(3,4,5-trimethoxyphenyl)furan (19)**[9].- Reaction of 2-(benzenesulphonyl)tetrahydro-5-(3,4,5-trimethoxyphenyl)furan (5) (719 mg, 1.9 mmol) with the organozinc prepared by lithiation of 1-bromo-3,4,5-trimethoxybenzene using the previous procedure gave compound **19** (492 mg, 64%) (*cis:trans* 15:85) as a white solid. The two isomers were seperated by HPLC to give the pure *trans*-isomer as a white solid, m.p. 139-140°C; ν_{max} ($CHCl_3$) 3018, 1592, 1504, 1462, 1417, 1216, 1130, 760, and 667 cm^{-1}; δ_H (270 MHz) 1.90-2.07 (2H, m, 3-H 4-H), 2.40-2.55 (2H, m, 3-H 4-H), 3.83 (6H, s, *p*-OCH_3), 3.88 (12H, s, *m*-OCH_3), 5.20 (2H, t, *J* 6.6 Hz, 2-H 5-H), and 6.63 (4H, s, σ-H); m/z 404 (M^+, 37%), 210, and 194; (Found: C,65.43; H,6.99. $C_{22}H_{28}O_7$ requires C,65.33; H,6.98%); and the pure *cis*-isomer as a white solid, m.p. 130-131°C; ν_{max} ($CHCl_3$) 2939, 1592, 1504, 1462, 1417, 1234, 1130, and 748 cm^{-1}; δ_H (270 MHz) 1.93-2.10 (2H, m, 3-H 4-H), 2.35-2.50 (2H, m, 3-H 4-H), 3.84 (18H, s, *p*-OCH_3 *m*-OCH_3), 5.03 (2H, t, *J* 5.5 Hz, 2-H 5-H), and 6.66 (4H, s, σ-H); m/z 404 (M^+, 100%), 208, 195, and 194; (Observed M^+, 404.1829. Calc. for $C_{22}H_{28}O_7$ M, 404.1835).

Tetrahydro-2-phenyl-2*H*-pyran (20).- Reaction of 2-(benzenesulphonyl)tetrahydro-2*H*-pyran (6)[3] (452 mg, 2 mmol) with the organozinc prepared from bromobenzene gave compound **20** (293 mg, 90%) as a colourless oil; ν_{max} (film) 2936, 2845, 1450, 1264, 1090, 1041, 752, and 698 cm^{-1}; δ_H (250 MHz) 1.50-2.00 (6H, m, 3-H 4-H 5-H), 3.63 (1H, td, *J* 12.0, 3.0 Hz, 6-H_{ax}), 4.16 (1H, br dd, *J* 12.0, 4.0 Hz, 6-H_{eq}), 4.34 (1H, dd, *J* 11.0, 2.0 Hz, 2-H), and 7.20-7.40 (5H, m, ArH); m/z 162 (M^+, 100%), 161, 105, and 77; (Found: C,81.55; H,9.02. $C_{11}H_{14}O$ requires C,81.44; H,8.70%).

Tetrahydro-2-thien-2-yl-2*H*-pyran (21).- Reaction of 2-(benzenesulphonyl)tetrahydro-2*H*-pyran (6) (452 mg, 2.0 mmol) with the organozinc prepared from 2-bromothiophene gave compound **21** (320 mg, 95%) as a colourless oil; ν_{max} (film) 3102, 3071, 2941, 2843, 1437, 1268, 1204, 1087, 1039, and 699 cm^{-1}; δ_H(270 MHz) 1.50-2.05 (6H, m, 3-H 4-H 5-H), 3.62 (1H, td, *J* 11.2, 2.7 Hz, 6-H_{ax}), 4.07-4.13 (1H, m, 6-H_{eq}), 4.59 (1H, dd, *J* 10.4, 2.3 Hz, 2-H), 6.95-6.98 (2H, m, 3'-H 4'-H), and 7.20-7.25 (1H, m, 5'-H); m/z 168 (M^+,100%), 111, and 84; (Found: C,64.52; H,7.31. $C_9H_{12}OS$ requires C,64.25; H,7.19%).

Tetrahydro-2-(2-methoxyphenyl)-2*H*-pyran (22).- Reaction of 2-(benzenesulphonyl)tetrahydro-2*H*-pyran (6) (565 mg, 2.5 mmol) with the organozinc prepared from 2-bromoanisole gave compound **22** (280 mg, 58%) as a colourless oil; ν_{max} (film) 3005, 2935, 2845, 1608, 1460, 1255, 1095, 1050, 758, and 740 cm^{-1}; δ_H (270 MHz) 1.37-1.93 (6H, m, 3-H 4-H 5-H), 3.63 (1H, td, *J* 10.7 2.9 Hz, 6-H_{ax}), 3.80 (3H, s, OCH_3), 4.14 (1H, br dd, *J* 10.7 3.1 Hz, 6-H_{eq}), 4.71 (1H, dd, *J* 10.7, 2.0 Hz, 2-H), 6.83 (1H, d, *J* 7.8 Hz, 3'-H), 6.96 (1H, t, *J* 7.8 Hz, 5'-H), 7.21 (1H, t, *J* 7.8 Hz, 4'-H), and 7.46 (1H, d, *J* 7.8 Hz, 6'-H); m/z 192 (M^+, 100%), 135, 121, and 107; (Found: C,74.67; H,8.45. $C_{12}H_{16}O_2$ requires C,74.97; H,8.39%).

2-[1,1'-Biphenyl]-4-yltetrahydro-2*H*-pyran (23).- Reaction of 2-(benzenesulphonyl)tetrahydro-2*H*-pyran (6) (565 mg, 2.5 mmol) with the organozinc prepared from 4-bromobiphenyl gave compound **23** (483 mg, 81%) as a white solid, m.p. 52-53°C; ν_{max} (nujol mull) 3020, 2925, 1098, 1053, 836, 770, and 708 cm^{-1}; δ_H (270 MHz) 1.50-1.93 (6H, m, 3-H 4-H 5-H), 3.57 (1H, td, *J* 10.7, 3.0 Hz, 6-H_{ax}), 4.10 (1H, br dd, *J* 10.7, 2.4 Hz, 6-H_{eq}), 4.31 (1H, dd, *J* 10.8, 2.0 Hz, 2-H), and 7.23-7.50 (9H, m, ArH); m/z 238 (M^+, 100%), 237, 181, 154, and 153; (Found: C,86.03; H,7.58. $C_{17}H_{18}O$ requires C,85.67; H,7.61%).

Tetrahydro-2-(4-methylphenyl)-2*H*-pyran (24).- Reaction of 2-(benzenesulphonyl)tetrahydro-2*H*-pyran (6) (565 mg, 2.5 mmol) with the organozinc prepared from 4-bromotoluene gave compound **24** (282 mg, 64%) as a colourless oil; ν_{max} (film) 3010, 2945, 2840, 1440, 1207, 1087, 1040, and 810 cm^{-1}; δ_H (270 MHz) 1.55-2.97 (6H, m, 3-H 4-H 5-H), 2.33 (3H, s, CH_3), 3.60 (1H, td, *J* 11.2, 2.7 Hz, 6-H_{ax}), 4.12 (1H, ddd, *J* 11.2, 3.5, 2.3 Hz, 6-H_{eq}), 4.28 (1H, dd, *J* 10.5, 2.4 Hz, 2-H), 7.13 (2H, d, *J* 8.1 Hz, ArH), and 7.23 (2H, d, *J* 8.1 Hz, ArH); m/z 176 (M^+, 100%), 175, 161, 119, and 91; (Found: C,81.92; H,9.39. $C_{12}H_{16}O$ requires C,81.77;

H,9.15%).

Tetrahydro-2-(2-phenylethenyl)-2*H*-pyran (25).- Reaction of 2-(benzenesulphonyl)tetrahydro-2*H*-pyran (6) (452 mg, 2.0 mmol) with the organozinc prepared from β-bromostyrene (*E*:*Z*, 15:85) gave compound **25** (302 mg, 80%) (*E*:*Z*, 22:78) as a colourless oil; ν_{max} (film) 2935, 2845, 1599, 1084, 1036, 966, 746, and 694 cm^{-1}; δ_H (250 MHz) 1.40-2.00 (6H, m, *E*/*Z* 3-H 4-H 5-H), 3.55-3.75 (1H, m, *E*/*Z* 6-H_{ax}), 3.90-4.10 (1.56H, m, *Z* 2-H *Z* 6-H_{eq}), 4.18 (0.22H, td, *J* 9.9, 2.5 Hz, *E* 6-H_{eq}), 4.50 (0.22H, dd, *J* 8.5, 3.0 Hz, *E* 2-H), 5.65 (0.22H, dd, *J* 11.5, 8.5 Hz, *E* C<u>H</u>=CHPh), 6.19 (0.78H, dd, *J* 15.5, 5.5 Hz, *Z* C<u>H</u>=CHPh), 6.53 (0.22H, br d, *J* 11.5 Hz, *E* CH=C<u>H</u>Ph), 6.57 (0.78H, dd, *J* 15.5, 1.0 Hz, *Z* CH=C<u>H</u>Ph), and 7.20-7.50 (5H, m, *E*/*Z* ArH); m/z 188 (M^+,100%), 131, and 104; (Found: C,82.83; H,8.64. $C_{13}H_{16}O$ requires C,82.94; H,8.57%).

***trans*-Tetrahydro-2,6-diphenyl-2*H*-pyran (26)[14].-** Reaction of 2-(benzenesulphonyl)tetrahydro-6-phenyl-2*H*-pyran (7) (151 mg, 0.5 mmol) with the organozinc prepared from bromobenzene gave compound **26** (103 mg, 87%) as a colourless oil; ν_{max} (film) 3058, 3027, 2938, 1491, 1447, 1219, 1067, 1031, 755, 728, and 698 cm^{-1}; δ_H (270 MHz) 1.75-2.25 (6H, m, 3-H 4-H 5-H), 4.88 (2H, dd, *J* 6.1, 4.4 Hz, 2-H 6-H), and 7.25-7.45 (10H, m, ArH); m/z 238 (M^+, 4%), 132, 120, 117, and 104; (Found: C,85.47; H,7.84. $C_{17}H_{18}O$ requires C,85.67; H,7.61%).

***trans*-2-Ethenyltetrahydro-6-phenyl-2*H*-pyran (27).-** Reaction of 2-(benzenesulphonyl)tetrahydro-6-phenyl-2*H*-pyran (7) (151 mg, 0.5 mmol) with the organozinc prepared from vinyl bromide gave compound **27** (77 mg, 82%) as a colourless oil; ν_{max} (film) 3082, 2937, 1447, 1214, 1089, 1041, 921, 754, and 699 cm^{-1}; δ_H (270 MHz) 1.65-1.90 (6H, m, 3-H 4-H 5-H), 4.43-4.50 (1H, m, 6-H), 4.81 (1H, dd, *J* 7.3, 4.3 Hz, 2-H), 5.26 (1H, dt, *J* 10.7, 2.0 Hz, CH=C<u>H</u>$_2$), 5.28 (1H, dt, *J* 17.6, 2.0 Hz, CH=C<u>H</u>$_2$), 6.02 (1H, ddd, *J* 17.6, 10.7, 4.3 Hz, C<u>H</u>=CH$_2$, irradiation at 4.47p.p.m. gave a n.O.e. enhancement), and 7.25-7.43 (5H, m, ArH); m/z 188 (M^+, 14%), 160, 105, 104, and 54; (Found: C,83.05; H,8.71. $C_{13}H_{16}O$ requires C,82.94; H,8.57%).

***trans*-Tetrahydro-2-methoxy-6-phenyl-2*H*-pyran (28).- Method a).** Reaction of *trans*-2-(benzenesulphonyl)tetrahydro-6-methoxy-2*H*-pyran (8) (2.05 g, 8.0 mmol) with the organozinc prepared from bromobenzene gave compoud **28** (1.23 g, 80%) as a colourless oil; ν_{max} (film) 2941, 1125, 1061, 1028, 951, 754, and 699 cm^{-1}; δ_H (250 MHz) 1.60-2.10 (6H, m, 3-H 4-H 5-H), 3.42 (3H, s, OCH_3), 4.76 (1H, dd, *J* 11.0, 2.5 Hz, 6-H), 4.88 (1H, dd, *J* 2.5, 2.0 Hz, 2-H), and 7.25-7.40 (5H, m, ArH); m/z 192 (M^+, 3%), 162, 161, 105, 104, and 58; (Found: C,74.96; H,8.41. $C_{12}H_{16}O_2$ requires C,74.97; H,8.39%).

Method b). Reaction of *cis*-2-(benzenesulphonyl)tetrahydro-6-methoxy-2*H*-pyran (9) (256 mg, 1.0 mmol) with the organozinc prepared from bromobenzene gave compoud **28** (148 mg, 77%) as a colourless oil; ν_{max} (film) 2942, 1124, 1061, 1029, 951, 754, and 699 cm^{-1}; δ_H (250 MHz) 1.60-2.10 (6H, m, 3-H 4-H 5-H), 3.42 (3H, s, OCH_3), 4.76 (1H, dd, *J* 11.0, 2.5 Hz, 6-H), 4.88 (1H, dd, *J* 2.5, 2.0 Hz, 2-H), and 7.25-7.40 (5H, m, ArH); m/z 192 (M^+, 27%), 162, 161, 105, 104, and 58.

(2*R*,6*S*)-2-Butyltetrahydro-6-phenyl-2*H*-pyran (29).- Reaction of (2*R*,6*R*)-2-(benzenesulphonyl)-6-butyl-2*H*-pyran (10)[15] (282 mg, 1.0 mmol) with the organozinc prepared from bromobenzene gave compound **29** (205 mg, 94%) as a colourless oil; ν_{max} (film) 3027, 2934, 1447, 1213, 1082, 1068, 1042, 751, 723, and 699 cm^{-1}; δ_H (250 MHz) 0.93 (3H, t, *J* 8.0 Hz, CH_3), 1.30-1.50 (6H, m, -$(CH_2)_3$Me), 1.65-2.00 (6H, m, 3-H 4-H 5-H), 3.68-3.78 (1H, m, 2-H), 4.85 (1H, t, *J* 5.5 Hz, 6-H), and 7.25-7.45 (5H, m, ArH, irradiation at 3.7 p.p.m. gave a n.O.e. enhancement); m/z 218 (M^+, 37%), 161, and 104; (Found: C,82.36; H,10.24. $C_{15}H_{22}O$ requires C,82.52; H,10.16%).

(2*R*,3*S*)-3-acetoxy-3,6-dihydro-6-phenyl-2*H*-pyran-2-methanol acetate (30).- Reaction of (2*R*,3*S*,6*R*)-3-acetoxy-6-(bezenesulphonyl)-3,6-dihydro-2*H*-pyran-2-methanol acetate (11) (354 mg, 1.0 mmol) with the organozinc prepared from bromobenzene (4.0 equiv.) gave recovered starting material (83 mg, 23%) and compound **30** (156 mg, 54%) (6*R*:6*S*, 17:83) as a colourless gum; ν_{max} (film) 3021, 2957, 1741, 1370, 1240, 1046, 755, 701, and 666 cm^{-1}; δ_H (250 MHz) 2.08 (2.5H, s, 6*S* CH_3), 2.09 (0.5H, s, 6*R* CH_3), 2.10 (2.5H, s, 6*S* CH_3), 2.12 (0.5H, s, 6*R* CH_3), 3.74 (0.83H, ddd, *J* 7.0, 5.8, 2.9 Hz, 6*S* 2-H), 3.80-3.88 (0.17H, m, 6*R* 2-H), 3.99 (0.83H, dd, *J* 11.8, 2.9 Hz, 6*S* α-H), 4.05-4.20 (0.34H, m, 6*R* α-H), 4.17 (0.83H, dd, *J* 11.8, 5.8 Hz, 6*S* α-H), 5.20-5.45 (2H, m, 6*R*/6*S* 3-H 6-H), 5.80-6.03 (1.17H, m, 6*R* 4-H 6*R*/6*S* 5-H), 6.16-6.23 (0.83H, m, 6*S* 4-H), and 7.33-7.45 (5H, m, 6*R*/6*S* ArH); m/z 231 (M^+-AcO, 1%), 230, 170, 105, and 43; (Observed M^+, 290.1149. Calc. for $C_{16}H_{18}O_5$ M, 290.1154).

General Method for 2-Substitution of Cyclic Ethers with Alkynylzinc Reagents.- A mixture of *iso*-propyl magnesium bromide (2.0 equiv., 1M solution in tetrahydrofuran) and the appropriate alkyne (2.0 equiv.) in dry tetrahydrofuran (2 ml/mmol) was stirred at room temperature for 1 hour to prepare the alkynyl Grignard Reagent. Treatment of this with anhydrous zinc bromide[8](1.2 equiv.) then the sulphone (1.0 equiv.) in dry tetrahydrofuran (4 ml/mmol) and work up as above after 18-24 hours gave the product.

Tetrahydro-2-(2-phenylethynyl)furan (31).- Reaction of 2-(benzenesulphonyl)tetrahydrofuran (1) (212 mg, 1.0 mmol) with the organozinc prepared from phenylacetylene gave compound **31** (151 mg, 88%) as a pale yellow oil; ν_{max} (film) 3056, 2953, 2871, 1488, 1442, 1334, 1053, 916, 757, and 690 cm^{-1}; δ_H (270 MHz) 1.80-2.20 (4H, m, 3-H 4-H), 3.75-3.83 (1H, m, 5-H), 3.90-4.00 (1H, m, 5-H), 4.75 (1H, dd, *J* 7.1, 5.1 Hz, 2-H), and 7.20-7.38 (5H, m, ArH); m/z 172 (M^+, 100%), 171, 157, 129, and 102; (Found: C,83.91; H,7.31. $C_{12}H_{12}O$ requires C,83.69; H,7.02%).

Tetrahydro-2-(2-phenylethynyl)-2*H*-pyran (32).- Reaction of 2-(benzenesulphonyl)tetrahydro-2*H*-pyran (6) (226 mg, 1.0 mmol) with the organozinc prepared from phenylacetylene gave compound **32** (181 mg, 97%) as a colourless oil; ν_{max} (film) 3056, 2939, 2854, 1489, 1441, 1363, 1334, 1083, 1038, 896, 757, and 690 cm^{-1}; δ_H (270 MHz) 1.50-2.00 (6H, m, 3-H 4-H 5-H), 3.55-3.63 (1H, m, 6-H_{ax}), 4.00-4.10 (1H, m, 6-H_{eq}), 4.51 (1H, dd, *J* 7.6, 2.9 Hz, 2-H), and 7.28-7.48 (5H, m,ArH); m/z 186 (M^+, 100%), 185, 157, 129, and 102; (Found: C,83.93; H,7.78. $C_{13}H_{14}O$ requires C,83.83; H,7.58%).

2-[4-(Tetrahydro-2*H*-pyran-2-yloxy)-1-butynyl]tetrahydro-2*H*-pyran (33).- Reaction of 2-(benzenesulphonyl)tetrahydro-2*H*-pyran (6) (226 mg, 1.0 mmol) with the organozinc prepared from 2-(3-butyn-1-yloxy)tetrahydro-2H-pyran gave compound **33** (197 mg, 83%) as a colourless oil; ν_{max} (film) 2953, 2840, 1440, 1353, 1201, 1121, 1090, 1030, 904, 868, and 814 cm^{-1}; δ_H (250 MHz) 1.45-1.90 (12H, m, 3-H 4-H 5-H 3'-H 4'-H 5'-H), 2.52 (2H, dt, *J* 7.3, 2.0 Hz, C≡CCH_2), 3.43-4.00 (6H, m, 6-H 6'-H CH_2O), 4.18-4.25 (1H, m, 2-H), and 4.62 (1H, t, *J* 3.3 Hz, 2'-H); m/z 238 (M^+, 1%), 193, 181, 179, 153, and 85; (Found: C,70.29; H,9.48. $C_{14}H_{22}O_3$ requires C,70.55; H,9.30%).

***trans*-2-Hex-1-ynyltetrahydro-6-phenyl-2*H*-pyran (34).-** Reaction of 2-(benzenesulphonyl)tetrahydro-6-phenyl-2*H*-pyran (7) (302 mg, 1.0 mmol) with the organozinc prepared from 1-hexyne (^iPrMgBr, THF, reflux, 2 hours) gave compound **34** (196 mg, 81%) as a colourless oil; ν_{max} (film) 3028, 2934, 2861, 1450, 1090, 1039, 752, and 699 cm^{-1}; δ_H (250 MHz) 0.94 (3H, t, *J* 7.1 Hz, CH_3), 1.40-2.33 (12H, m, 3-H 4-H 5-H $(CH_2)_3$), 4.87-4.90 (1H, br s, 2-H), 4.93 (1H, dd, *J* 11.2, 2.2 Hz, 6-H), and 7.20-7.40 (5H, m, ArH); m/z 242 (M^+, 4%), 199, 141, and 77; (Observed M^+, 242.1660. Calc. for $C_{17}H_{22}O$ M, 242.1671).

General Method for the Preperation of Dihydropyrans.- A mixture of the sulphone (1.0 equiv.), triethylamine (1.5 equiv.) and magnesium bromide etherate (2.0 equiv.) in dry tetrahydrofuran (6 ml/mmol) under argon was placed in an ultrasound bath for 18 hours. Aqueous $NaHCO_3$ work up and purification by alumina chromatography (Et_2O : 40-60 petrol) gave the product.

3,4-Dihydro-2-phenyl-2*H*-pyran (35).- Reaction of 2-(benzenesulphonyl)tetrahydro-6-phenyl-2*H*-pyran (7) (151 mg, 0.5 mmol) gave compound **35** (71 mg, 89%) as a colourless oil; ν_{max} (film) 3059, 3030, 2921, 2847, 1647, 1241, 1059, 1038, 757, 730, and 698 cm^{-1}; δ_H (270 MHz) 1.90-2.35 (4H, m, 3-H 4-H), 4.75-4.80 (1H, m, 5-H), 4.83 (1H, dd, *J* 10.1, 2.4 Hz, 2-H), 6.54 (1H, dt, *J* 5.9, 1.6 Hz, 6-H), and 7.23-7.40 (5H, m, ArH); m/z 160 (M^+, 23%), 131, and 104; (Found: C,82.29; H,7.56. $C_{11}H_{12}O$ requires C,82.46; H,7.55%).

3,4-Dihydro-2*H*-pyran-2-methanol acetate (36).- Reaction of *trans*-6-(benzenesulphonyl)tetrahydro-2*H*-pyran-2-methanol acetate (12) (149 mg, 0.5 mmol) gave compound **36** (59 mg, 76%) as a colourless oil; ν_{max} (film) 3061, 2927, 2851, 1738, 1647, 1368, 1226, 1072, 1045, and 730 cm^{-1}; δ_H (270 MHz) 1.60-2.20 (4H, m, 3-H 4-H), 2.11 (3H, s, CH_3), 4.00-4.08 (1H, m, 2-H), 4.10-4.25 (2H, m, α-H), 4.70-4.75 (1H, m, 5-H), and 6.38 (1H, dt, *J* 6.1, 1.7 Hz, 6-H); m/z 156 (M^+, 22%), 96, 83, and 43; (Found: C,61.21; H,7.90. $C_8H_{12}O_3$ requires C,61.52; H,7.74%).

General Method for 2-Substitution of Cyclic Ethers with Silyl Derivatives.- The silyl reagent (2.0 equiv.) was added

to a stirred suspension of anhydrous aluminium chloride (2.0 equiv.) in dry dichloromethane (2 ml/mmol) at -78°C under argon. The mixture was stirred at -78°C for 30 minutes then a solution of the sulphone (1.0 equiv.) in dry dichloromethane (3 ml/mmol) was added. The solution was allowed to warm to -35°C over one hour and stirred at this temperature for 1-5 hours. Acidic work up and purification gave the product.

Methyl tetrahydro-α,α-dimethyl-2-furanacetate (37).- Reaction of 2-(benzenesulphonyl)tetrahydrofuran (1) (212 mg, 1.0 mmol) with methyl trimethylsilyl dimethylketene acetal gave compound **37** (149 mg, 87%) as a colourless oil; ν_{max} (film) 2976, 2874, 1733, 1465, 1270, 1142, and 1072 cm^{-1}; δ_H (270 MHz) 1.13 (3H, s, CCH_3), 1.18 (3H, s, CCH_3), 1.60-1.93 (4H, m, 3-H 4-H), 3.68 (3H, s, OCH_3), 3.71-3.85 (2H, m, 5-H), and 4.05 (1H, dd, *J* 8.0, 6.6 Hz); m/z 172 (M^+, 1%), 141, and 71; (Observed M^+, 172.1100. Calc. for $C_9H_{16}O_3$ M, 172.1099).

1-Phenyl-2-(tetrahydro-2*H*-pyran-2-yl)-1-ethanone (38).- Reaction of 2-(benzenesulphonyl)tetrahydro-2H-pyran (6) (226 mg, 1.0 mmol) with 1-(*tert*-butyldimethylsilyloxy)-1-phenylethene gave compound **38** (183 mg, 90%) as a pale yellow oil; ν_{max} (film) 3060, 2933, 2851, 1681, 1086, 1045, 752, and 690 cm^{-1}; δ_H (270 MHz) 1.30-1.90 (6H, m, 3-H 4-H 5-H), 2.92 (1H, dd, *J* 16.1, 5.8 Hz, α-H), 3.29 (1H, dd, *J* 16.1, 6.6 Hz, α-H), 3.47 (1H, td, *J* 11.2, 3.1 Hz, 6-H_{ax}), 3.90-4.00 (2H, m, 2-H 6-H_{eq}), 7.43-7.50 (2H, m, *m*-H), 7.53-7.58 (1H, m, *p*-H), and 7.95-8.00 (2H, m, *o*-H); m/z 204 (M^+, 32%), 120, 105, and 77; (Found: C,76.62; H,8.18. $C_{13}H_{16}O_2$ requires C,76.44; H,7.90%).

***cis*-Methyl α-acetyltetrahydro-6-phenyl-2*H*-pyran-2-acetate (39).-** Reaction of 2-(benzenesulphonyl)tetrahydro-6-phenyl-2H-pyran (7) (302 mg, 1.0 mmol) with methyl 3-(trimethylsilyloxy)crotonate gave compound **39** (193 mg, 70%).(*minor:major*, 40:60) as a colourless gum; ν_{max} (film) 3029, 2942, 2860, 1746, 1715, 1198, 1148, 1084, 1047, 753, and 700 cm^{-1}; δ_H (270 MHz) 1.25-2.00 (6H, m, *minor/major* 3-H 4-H 5-H), 2.29 (3H, s, *minor/major* Ac), 3.68 (0.6H, d, *J* 9.3 Hz, *major* α-H), 3.71 (1.2H, s, *minor* OCH_3), 3.72 (1.8H, s, *major* OCH_3), 3.76 (0.4H, d, *J* 8.1 Hz, *minor* α-H), 4.13-4.25 (2H, m, *minor/major* 2-H, irradiation at 3.65-3.80 p.p.m. gave *major* 4.23, dd, *J* 11.0, 2.0 Hz and *minor* 4.19, ddd, *J* 10.8, 4.8, 2.2 Hz), 4.40 (0.6H, dd, *J* 11.3, 2.1 Hz, *major* 6-H), 4.43 (0.4H, dd, *J* 11.3, 2.1 Hz, *minor* 6-H), and 7.23-7.35 (5H, m, *minor/major* ArH); m/z 276 (M^+, 11%), 201, 104, and 43; (Found: C,69.69; H,7.44. $C_{16}H_{20}O_4$ requires C,69.55; H,7.30%).

***trans*-Ethyl α-acetyltetrahydro-α-methyl-6-phenyl-2*H*-pyran-2-acetate (40).-** Reaction of 2-(benzenesulphonyl)tetrahydro-6-phenyl-2H-pyram (7) (151 mg, 0.5 mmol) with ethyl 2-methyl-3-(trimethylsilyloxy)crotonate gave compound **40** (112 mg, 77%) (ratio 50:50) as a colourless gum; ν_{max} (film) 2940, 1735, 1715, 1449, 1248, 1111, 1039, 729, and 701 cm^{-1}; δ_H (270 MHz) 1.23 (1.5H, s, *J* 7.1 Hz, $OCH_2\underline{CH_3}$), 1.25 (1.5H, t, *J* 7.1 Hz, $OCH_2\underline{CH_3}$), 1.30-2.33 (6H, m, 3-H 4-H 5-H), 1.37 (1.5H, s, α-CH_3), 1.43 (1.5H, s, α-CH_3), 2.09 (1.5H, s, CH_3CO), 2.17 (1.5H, s, CH_3CO), 4.05 (0.5H, dd, *J* 11.5, 2.2 Hz, 2-H), 4.10-4.23 (1.5H, m, 2-H $O\underline{CH_2}CH_3$), 4.32 (0.5H, q, *J* 7.1 Hz, $O\underline{CH}H'CH_3$), 4.36 (0.5H, q, *J* 7.1 Hz, $OCH\underline{H}'CH_3$), 5.07 (1H, br s, 6-H), and 7.23-7.43 (5H, m, ArH); m/z 304 (M^+, 1%), 258, 160, 144, and 43; (Found: C,71.24; H,8.11. $C_{18}H_{24}O_4$ requires C,71.03; H,7.95%).

Methyl tetrahydro-6-(hydroxymethyl)-α,α-dimethyl-2*H*-pyran-2-acetate (41).- Reaction of *trans*-6-(benzenesulphonyl)tetrahydro-2H-pyran-2-methanol (13) (128 mg, 0.5 mmol) with methyl trimethylsilyl dimethylketene acetal (3.0 equiv.) and $AlCl_3$ (1.05 equiv.) gave some recovered starting material (13 mg, 10%) and compound **41** (85 mg, 79%) (*cis:trans* 50:50) as a colourless oil; ν_{max} (film) 3456, 2944, 2880, 1732, 1464, 1272, 1144, and 1048 cm^{-1}; δ_H (270 MHz) 1.09 (1.5H, s, CH_3), 1.11 (1.5H, s, CH_3), 1.17 (1.5H, s, CH_3), 1.18 (1.5H, s, CH_3), 1.10-2.00 (6H, m, 3-H 4-H 5-H), 2.78 (0.5H, br s, OH), 2.83 (0.5H, br s, OH), 3.25-4.05 (3.5H, m, α-H 6-H *trans* 2-H), 3.65 (1.5H, s, OCH_3), 3.68 (1.5H, s, OCH_3), and 4.15 (0.5H, td, *J* 11.5 1.5 Hz, *cis* 2-H); m/z 216 (M^+, 2%), and 185; (Observed M^+, 216.1355. Calc. for $C_{11}H_{20}O_4$ M, 216.1362).

***cis*-Methyl 6-(acetoxymethyl)tetrahydro-α,α-dimethyl-2*H*-pyran-2-acetate (42).-** Reaction of *trans*-6-(benzenesulphonyl)tetrahydro-2H-pyran-2-methanol acetate (12) (298 mg, 1.0 mmol) with 1-methoxy-2-methyl-1-(trimethylsilyloxy)propene gave compound **42** (85 mg, 33%) as a colourless oil; ν_{max} (film) 2947, 2862, 1738, 1368, 1236, 1196, 1146, 1088, and 1051 cm^{-1}; δ_H (270 MHz) 1.10 (3H, s, CCH_3), 1.17 (3H, s, CCH_3), 1.13-1.95 (6H, m, 3-H 4-H 5-H), 2.03 (3H, s, CH_3CO_2), 3.51 (1H, dd, *J* 11.1, 1.8 Hz, 2-H), 3.48-3.60 (1H, m, 6-H, irradiation at 3.98 p.p.m. gave dd, *J* 9.6, 1.8 Hz), 3.65 (3H, s,

OCH_3), and 3.92-4.05 (2H, m, $AcOCH_2$); m/z 258 (M^+, 2%), 198, 157, 102, 97, and 43; (Found: C,60.72, H,8.81. $C_{13}H_{22}O_5$ requires C,60.45; H,8.58%). Further elution of the column gave ***trans*-methyl 6-(acetoxymethyl)tetrahydro-α,α-dimethyl-2*H*-pyran-2-acetate (43)** (165 mg, 64%) as a colourless oil; ν_{max} (film) 2946, 2873, 1737, 1368, 1237, 1203, 1144, and 1036 cm^{-1}; δ_H (270 MHz) 1.10 (3H, s, CCH_3), 1.15 (3H, s, CCH_3), 1.25-1.75 (6H, m, 3-H 4-H 5-H), 2.06 (3H, s, CH_3CO_2), 3.66 (3H, s, OCH_3), 3.75 (1H, dd, *J* 11.3, 2.3 Hz, 2-H), 4.06 (1H, dd, *J* 10.5, 5.4 Hz, $AcOCH_2$); 4.07-4.17 (1H, m, 6-H), and 4.43 (1H, dd, *J* 10.5, 7.7 Hz, $AcOCH_2$); m/z 258 (M^+, 2%), 198, 185, 157, 97, and 43; (Found: C,60.35, H,8.76. $C_{13}H_{22}O_5$ requires C,60.45; H,8.58%).

***cis*-Methyl 6-[(*tert*-butyldiphenylsilyloxy)methyl]tetrahydro-α,α-dimethyl-2*H*-pyran-2-acetate (44).-** Reaction of *trans*-2-(benzenesulphonyl)-6-[(*tert*-butyldiphenylsilyloxy)methyl]tetrahydro-2H-pyran (14) (198 mg, 0.4 mmol) with methyl trimethylsilyl dimethylketene acetal gave compound **44** (64 mg, 35%) as a colourless gum; ν_{max} (film) 3070, 3048, 2933, 2857, 1734, 1427, 1266, 1113, 741, and 703 cm^{-1}; δ_H (270 MHz) 1.03 (9H, s, $C(CH_3)_3$), 1.13 (3H, s, CCH_3), 1.22 (3H, s, CCH_3), 1.18-1.95 (6H, m, 3-H 4-H 5-H), 3.47-3.67 (4H, m, 2-H 6-H $SiOCH_2$), 3.61 (3H, s, OCH_3), 7.30-7.48 (6H, m, *m*-H *p*-H), and 7.65-7.73 (4H, m, σ-H); m/z 423 (M^+-MeO, 5%), 397, 199, and 121; (Found: C,71.16; H,8.57. $C_{27}H_{38}O_4Si$ requires C,71.32; H,8.42%). Further elution of the column gave ***trans*-methyl 6-[(*tert*-butyldiphenylsilyloxy)methyl]tetrahydro-α,α-dimethyl-2*H*-pyran-2-acetate (45)** (113 mg, 62%) as a colourless oil; ν_{max} (film) 3070, 3048, 2933, 2857, 1734, 1268, 1113, 741, and 704 cm^{-1}; δ_H (270 MHz) 1.04 (9H, s, $C(CH_3)_3$), 1.06 (3H, s, CCH_3), 1.13 (3H, s, CCH_3), 1.22-1.78 (6H, m, 3-H 4-H 5-H), 3.55 (3H, s, OCH_3), 3.64 (1H, dd, *J* 11.2, 2.5 Hz, 2-H), 3.72 (1H, dd, *J* 10.0, 5.4 Hz, $SiOCH_2$), 3.85 (1H, dd, *J* 10.0, 8.0 Hz, $SiOCH_2$), 3.97-4.03 (1H, m, 6-H), 7.35-7.48 (6H, m, *m*-H *p*-H), and 7.65-7.73 (4H, m, σ-H); m/z 423 (M^+-MeO, 1%), 397, 199, and 121; (Found: C,71.29; H,8.53. $C_{27}H_{38}O_4Si$ requires C,71.32; H,8.42%).

[2*R(*S**),6*R**]-*S*-*tert*-Butyl tetrahydro-α-methyl-6-phenyl-2*H*-pyran-2-ethanethioate (46).-** Reaction of 2-(benzenesulphonyl)tetrahydro-6-phenyl-2H-pyran (7) (151 mg, 0.5 mmol) with *cis*-1-(*tert*-butyldimethylsilyloxy)-1-*tert*-butylthio-1-propene gave compound **46** (94 mg, 61%) as a white solid, m.p. 53.5-55°C; ν_{max} ($CHCl_3$) 3020, 2940, 2867, 1671, 1451, 1363, 1216, 1041, 958, 755, and 699 cm^{-1}; δ_H (270 MHz) 1.25 (3H, d, *J* 6.8 Hz, CH_3), 1.43-1.95 (6H, m, 3-H 4-H 5-H), 1.46 (9H, s, $C(CH_3)_3$), 3.03 (1H, dq, *J* 9.4, 6.8 Hz, α-H), 3.86 (1H, ddd, *J* 9.5, 5.5, 4.0 Hz, 2-H), 4.69 (1H, t, *J* 5.4 Hz, 6-H), and 7.23-7.38 (5H, m, ArH); m/z 306 (M^+, 1%), 249, 217, 188, 161, 117, and 104; (Found: C,70.47; H,8.67. $C_{18}H_{26}O_2S$ requires C,70.55; H,8.55%). Further elution of the column gave **[2*R**(*R**),6*R**]-*S*-*tert*-butyl tetrahydro-α-methyl-6-phenyl-2*H*-pyran-2-ethanethioate (47)** (57 mg, 37%) as a colourless gum; ν_{max} ($CHCl_3$) 3060, 3027, 2942, 2863, 1676, 1452, 1363, 1043, 957, 748, 728, and 699 cm^{-1}; δ_H (270 MHz) 1.03 (3H, d, *J* 6.8 Hz, CH_3), 1.40-2.10 (6H, m, 3-H 4-H 5-H), 1.47 (9H, s, $C(CH_3)_3$), 2.88 (1H, dq, *J* 9.5, 6.8 Hz, α-H), 3.81 (1H, ddd, *J* 9.5, 7.8, 2.9 Hz, 2-H), 5.01 (1H, t, *J* 4.8 Hz, 6-H), and 7.23-7.40 (5H, m, ArH); m/z 306 (M^+, 22%), 249, 217, 188, 161, and 117; (Observed M^+, 306.1660. Calc. for $C_{18}H_{26}O_2S$ M, 306.1654).

***cis*-Tetrahydro-2-phenyl-6-prop-2-enyl-2*H*-pyran (49).-** Reaction of 2-(benzenesulphonyl)tetrahydro-6-phenyl-2H-pyran (7) (151 mg, 0.5 mmol) with allyltrimethylsilane gave compound **49** (11 mg, 11%) as a colourless oil; ν_{max} (film) 3423, 3071, 2934, 2855, 1639, 1490, 1447, 1210, 1082, 1044, 911, 749, and 697 cm^{-1}; δ_H (270 MHz) 1.25-1.98 (6H, m, 3-H 4-H 5-H), 2.23-2.48 (2H, m, $CH_2CH=CH_2$), 3.50-3.60 (1H, m, 6-H, irradiation at 2.35 p.p.m. gave dd, *J* 10.7, 1.0 Hz), 4.38 (1H, dd, *J* 11.0, 2.2 Hz, 2-H), 5.03-5.15 (2H, m, $CH=CH_2$), 5.85-6.00 (1H, m, $CH=CH_2$), and 7.23-7.43 (5H, m, ArH); m/z 202 (M^+, 5%), 161, 117, and 104; (Observed M^+, 202.1355. Calc. for $C_{14}H_{18}O$ M, 202.1358). Further elution of the column gave ***trans*-tetrahydro-2-phenyl-6-prop-2-enyl-2*H*-pyran (50)** (81 mg, 80%) as a colourless oil; ν_{max} (film) 3064, 3027, 2935, 2863, 1639, 1491, 1446, 1213, 1099, 1069, 1042, 997, 912, 752, 726, and 699 cm^{-1}; δ_H (270 MHz) 1.45-1.97 (6H, m, 3-H 4-H 5-H), 2.23-2.35 (1H, m, $CH_2CH=CH_2$), 2.45-2.57 (1H, m, $CH_2CH=CH_2$), 3.77-3.85 (1H, m, 6-H, irradiation at 2.4 p.p.m. gave 3.83, dd, *J* 5.9, 3.2 Hz), 4.85 (1H, t, *J* 5.4 Hz, 2-H), 5.03-5.15 (2H, m, $CH=CH_2$), 5.78-5.95 (1H, m, $CH=CH_2$), and 7.23-7.43 (5H, m, ArH); m/z 202 (M^+, 9%), 161, and 104; (Found: C,83.21; H,9.28. $C_{14}H_{18}O$ requires C,83.12; H,8.97%).

***trans*-2-Cyanotetrahydro-6-phenyl-2*H*-pyran (52).-** Reaction of 2-(benzenesulphonyl)tetrahydro-6-phenyl-2H-pyran (7) (151 mg, 0.5 mmol) with trimethylsilyl cyanide gave compound **52** (56 mg, 60%) as a colourless gum; ν_{max} (film) 3031, 2945, 2863,

2240, 1451, 1215, 1103, 1085, 1030, 757, and 700 cm^{-1}; δ_H (270 MHz) 1.60-2.07 (6H, m, 3-H 4-H 5-H), 4.81 (1H, dd, *J* 11.3, 2.1 Hz, 6-H), 5.02 (1H, br s, 2-H), and 7.27-7.37 (5H, m, ArH); m/z 187 (M^+, 99%), and 105; (Observed M^+, 187.1001. Calc. for $C_{12}H_{13}NO$ M, 187.0997). Further elution of the column gave ***cis*-2-cyanotetrahydro-6-phenyl-2*H*-pyran (51)** (34 mg, 36%) as a colourless gum; ν_{max} (film) 3031, 2947, 2861, 2251, 1451, 1088, 1048, 757, and 700 cm^{-1}; δ_H (270 MHz) 1.57-2.10 (6H, m, 3-H 4-H 5-H), 4.39 (1H, dd, *J* 12.0, 2.2 Hz, 6-H), 4.44 (1H, dd, *J* 10.7, 2.9 Hz, 2-H), and 7.25-7.37 (5H, m, ArH); m/z 187 (M^+, 91%), and 105; (Found: C,76.78; H,7.12; N,7.33. $C_{12}H_{13}NO$ requires C,76.98; H,7.00; N,7.48%).

***trans*-Tetrahydro-2-methyl-6-phenyl-2*H*-pyran (53).-** A solution of 2-(benzenesulphonyl)tetrahydro-6-phenyl-2H-pyran (7) (151 mg, 0.5 mmol) and trimethylaluminium (0.5 ml, 1.0 mmol, 2M solution in hexanes) was stirred at 0°C under argon for 2 hours. Aqueous NaOH work up and purification gave compound **53** (86 mg, 98%) as a colourless oil; ν_{max} (film) 3059, 3027, 2934, 2863, 1448, 1379, 1216, 1133, 1119, 1076, 1066, 1043, 751, 725, and 700 cm^{-1}; δ_H (250 MHz) 1.27 (3H, d, *J* 6.4 Hz, CH_3), 1.35-1.95 (6H, m, 3-H 4-H 5-H), 3.90-4.05 (1H, m, 2-H), 4.87 (1H, t, *J* 5.4 Hz, 6-H, irradiation at 1.27 p.p.m. gave a n.O.e. enhancement), and 7.20-7.45 (5H, m, ArH); m/z 176 (M^+, 66%), 107, 105, 104, and 77; (Found: C,81.64; H,9.25. $C_{12}H_{16}O$ requires C,81.77; H,9.15%).

[2*R(*R**),6*R**]-[2-(Tetrahydro-6-phenyl-2*H*-pyran-2-yl)propyl] 3,5-dinitrobenzoate (48)[12].-** A solution of [2*R**(*S**),6*R**]-*S*-*tert*-butyl tetrahydro-α-methyl-6-phenyl-2*H*-pyran-2-ethanethioate (46) (10.0 mg, 33 μmol) in dry diethyl ether (1 ml) was added to a stirred suspension of lithium aluminium hydride (10 mg) in dry diethyl ether (0.5 ml) at 0°C under argon. The mixture was stirred at room temperature for 1 hour, quenched with ethyl acetate and then saturated aqueous Na_2SO_4 work up gave the crude alcohol. A mixture of the alcohol, 3,5-dinitrobenzoyl chloride (76 mg, 0.33 mmol), triethylamine (61 μl, 45 mg, 0.44 mmol) and a crystal of 4-(dimethylamino)pyridine in dry dichloromethane (2 ml) was stirred for 20 hours at room temperature under argon. Aqueous Na_2CO_3 work up and purification gave compound **48** (11.4 mg, 84%) as a white crystalline solid, m.p. 101-101.5°C; ν_{max} (film) 3101, 3020, 2943, 1729, 1546, 1344, 1216, 757, 702, and 667 cm^{-1}; δ_H (250 MHz) 1.85-2.25 (7H, m, 3-H 4-H 5-H CHMe), 1.12 (3H, d, *J* 6.8 Hz, CH_3), 3.54-3.62 (1H, m, 2-H), 4.34 (1H, dd, *J* 10.6, 6.4 Hz, CO_2CH_2), 4.52 (1H, dd, *J* 10.6, 6.8 Hz, CO_2CH_2), 4.99 (1H, t, *J* 4.0 Hz, 6-H), 7.10-7.43 (5H, m, ArH), 8.03 (2H, d, *J* 2.1 Hz, *o*-H), and 8.21 (1H, t, *J* 2.1 Hz, *p*-H); m/z 414 (M^+, 10%), 202, and 161; (Found: C,60.85; H,5.30; N,6.70. $C_{21}H_{22}N_2O_7$ requires C,60.86; H,5.35; N,6.76%).

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