APPLICATION OF ELEMENT ORGANIC COMPOUND-DERIVED ALLYLSULFINATES IN ORGANIC SYNTHESIS

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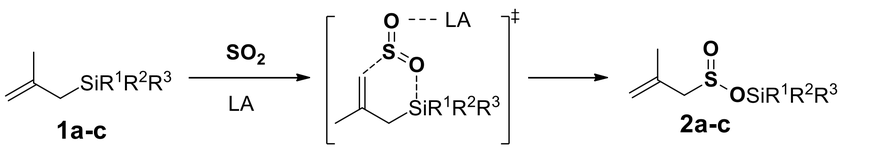
INTRODUCTION

Applications of SO_2 and its crystalline equivalents in organic synthesis are known [1, 2]. Here we report the application of *sila-* and *bora-ene* reactions of allylsilanes **1** and allyltrifluoroborates with SO_2. For example, Vogel's silyl sulfinate **2** and its use in quantitative GC–MS analysis has been reported [3, 4].
Silylsulfinates **2** were prepared from methallylsilanes **1** in the presence of strong Lewis acid. In order to optimize the reaction conditions for sulfoxide **3** synthesis we investigated influence of solvent, temperature, organometallic reagent and Lewis acid additive on sulfoxide **3** yield. We have also diversified silyl moiety in sulfinate **2** structure, examining trimethylsilyl- (**2a**), tert-butyldimethylsilyl- (**2b**) and triisopropylsilylsulfinate (**2c**) in order to increase the yields of sulfoxides **3**. The nucleophilic attack (**2**→**3**) of Grignard reagents was accelerated in toluene/THF and in the presence of LiCl or $ZnCl_2$ as Lewis acidic additives. The scope of the method has been demonstrated with the successful incorporation of aryl-, alkyl-, allyl-, and heterocyclic Grignard reagents. Under the given experimental conditions trialkylsilyloxy groups act as good leaving groups. Above described method gives opportunity to synthesize methallylsulfoxides **3** in up to 83% yield.
Next our attention was brought to *bora-ene* reactions. After some fruitless efforts in sulfoxide synthesis, we managed to obtain sulfones in good yield. Sulfones **4** were obtained from potassium allyltrifluoroborate **5** *via* bora-*ene* reaction through intermediate **6**. Optimization and scope of this method is shown below.
The reactivity of propargylsilanes **7** towards SO_2 is also being studied. Contrary to our expectations, so far only sulfolenes have been isolated. Silyldiene **8** is proposed as an intermediate.
Trialkylsilyl methallylsulfinates are good silylating reagents for polyols [4]. In this work we show good yields for glucose, galactose and xylose silylation with **2b** and **2d**. We also present nucleoside silylation with **2a** and **2d** in good to excellent yields.

ONE-POT SYNTHESIS OF SULFOXIDES FROM ALLYLSILANES

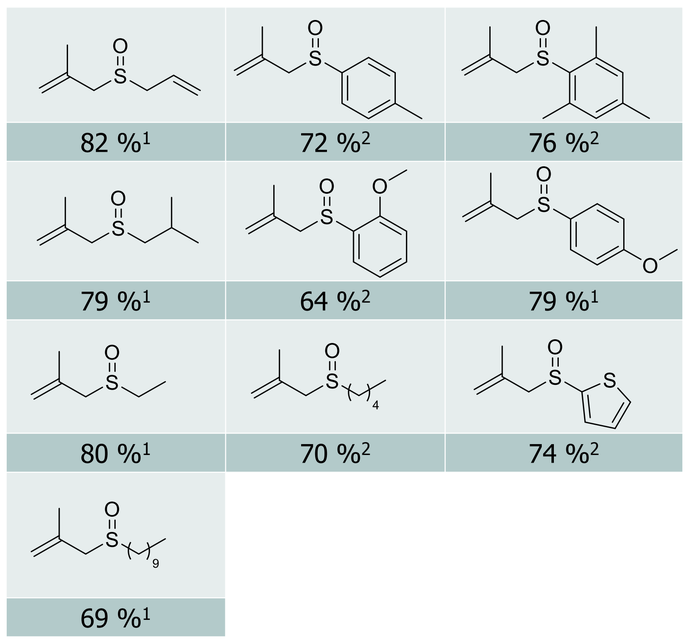


OPTIMIZATION OF REACTION 2→3 WITH R^4M = PhMgBr

Additive eq.	TMS	TBS	TIPS
	43[1]	65	59
TMSOTf (1)	57[1]	64	37
TBSOTf (1)	54	68	-
$AgNO_3$ (1)	54[1]	69	-
LiCl (0.1)	59[1]	-	-
LiCl (0.1)	70	-	-
LiCl (1)	72	69	48
LiCl (1)	79[2]	-	-
$BF_3{\cdot}OEt_2$ (1)	60	60	-
$ZnCl_2$ (1)	17	-	27
$ZnCl_2$ (1)	69[3]	78[3]	51[3]

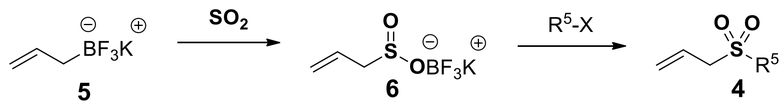
Reactions were carried out at -78 ˚C in toluene/THF 15:1-20:1 unless stated otherwise;
[1]the reaction was carried out in THF;
[2]the reaction was carried out at -100 ˚C;
[3]sulfinates **2** were added to a suspension of premixed solution of $ZnCl_2$ and PhMgBr.

SCOPE OF THE SULFOXIDE SYNTHESIS METHOD



[1] From 2b, $ZnCl_2$
[2] From 2a, LiCl

ONE-POT SYNTHESIS OF SULFONES FROM ALLYLBORANES

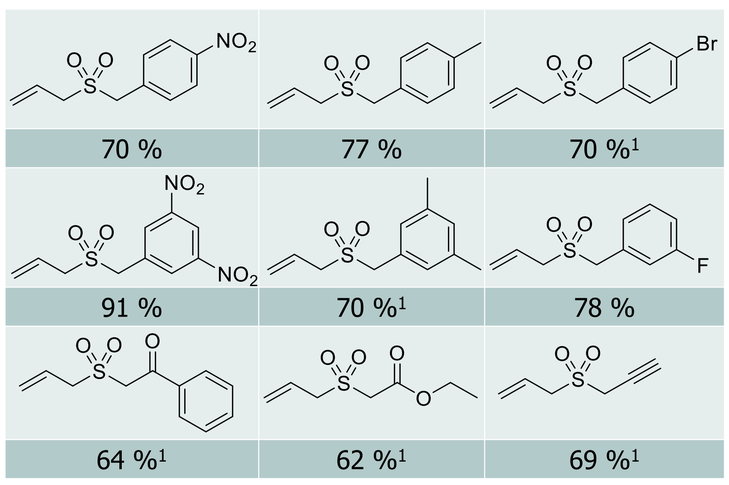


OPTIMIZATION OF REACTION 6→4 WITH R^5X = BnBr

Solvent[1]	Base (0,4 eq.)	T, °C	Time, h	Result, %[2]
H_2O/DCM	NaOH	rt	20	4
DMF	-	rt	18,5	(16)
DMF	-	40	23,5	(13)
H_2O/MeCN	-	rt	7,5	(7)
H_2O/DMF	-	rt	23	(23)
H_2O/DMF	-	40	22,5	(28)
H_2O/DMF	K_2CO_3	rt	27	62
H_2O/DMF	KF	rt	27	32
H_2O/DMF	**NaOH**	**rt**	**25,5**	**77**
H_2O/DMF	NaOAc	rt	24	64
DMSO	K_2CO_3	rt	22,5	(25)

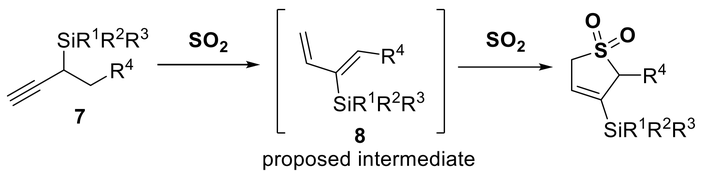
[1] When using solvent systems, ratio between solvents 1:1;
[2] Results in brackets determinated useing inner standart by ^{1}H-NMR

SCOPE OF THE SULFONE SYNTHESIS METHOD



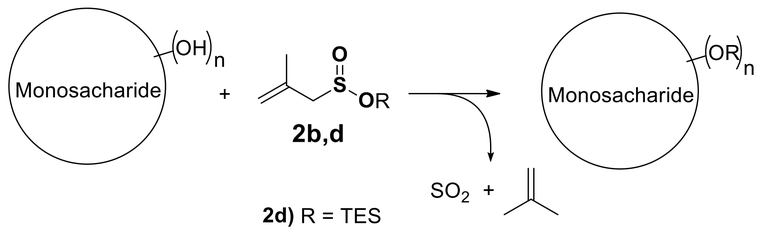
[1] Base K_2CO_3 (0.4 eq)

REACTIVITY OF PROPARGYL SILANE TOWARDS SULFUR DIOXIDE

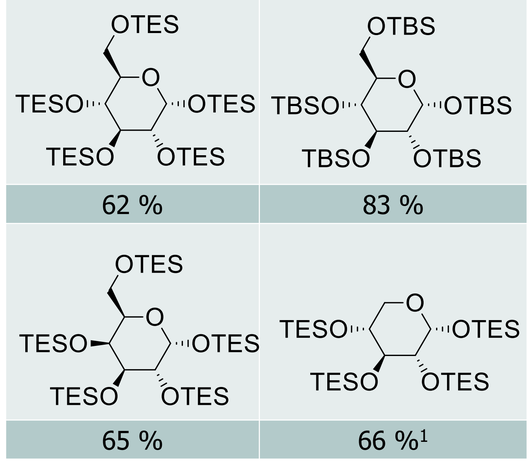


ALLYLSILYLSULFINATES AS SILYLATING AGENTS

MONOSACCHARIDES

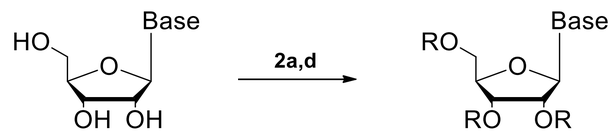


SCOPE

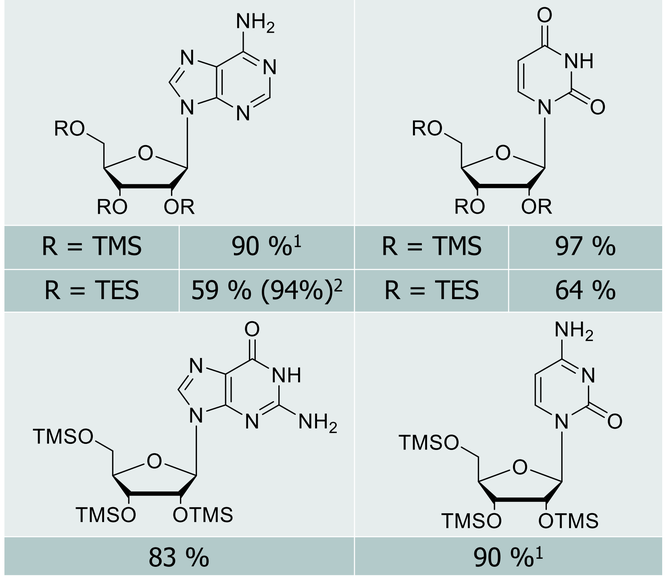


Reactions were carried out with 10 eq **2d** in rt or 20 eq **2b** in 80 ºC.
[1] Starting from xylofuranose

NUCLEOSIDES



SCOPE



Reactions were carried out with 10 eq **2a** in MeCN or with 10 eq **2d** in DMF unless stated otherwise.
[1] 3 eq **2a**
[2] C(5)-OH, 4 eq **2d**

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[4] Novosjolova, I.; Turks, M. *Phosphorus, Sulfur, Silicon Relat. Elem.* **2015**, *190*, 1251–1256.
[5] Stikute, A.; Peipiņš, V.; Turks, M. *Tetrahedron Lett.* **2015**, *56*, 4578–4581.

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SUMMARY

In conclusion, we have developed a novel approach to sulfoxide synthesis which is based on *sila-ene* reaction between allylsilanes and SO_2 followed by LiCl- or $ZnCl_2$-assisted Grignard reagent addition to the *S*-center of silyl sulfinate. The scope of the method has been demonstrated with the successful use of aryl-, alkyl, allyl- and heterocyclic Grignard reagents. We have also developed a novel approach to sulfone synthesis which is based on *bora-ene* reaction between allyltrifluoroborates and SO_2. The reaction is carried out in presence of TBAI and sodium hydroxide. The scope of the method has been demonstrated with the successful use of alIphatic and benzylbromides. Propargylsilanes react with SO_2, albeit not in the *ene* reaction. Silylsulfinates are good silylating reagents for polyols.