An Unexpected Rearrangement in SO-substituted Acetal-allenes

Marta Marin-Luna, Mateo Alajarin and Angel Vidal

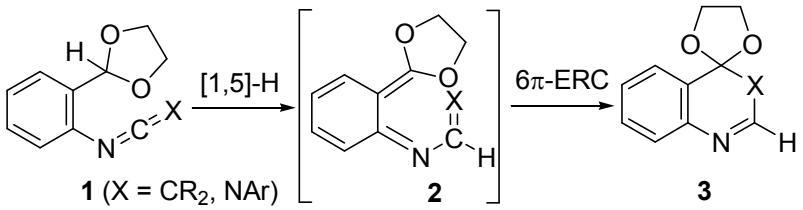
Departamento de Quimica Organica, Universidad de Murcia, Campus Universitario de Espinardo, 30100, Murcia
E-mail: martamarin@um.es

Abstract: An unexpected rearrangement in acetal-allenes substituted at the terminal carbon atom by a sulphoxide group is described. A mechanistic rationale for explaining these results is also disclosed.

Keywords: rearrangement, sulphoxide, allene

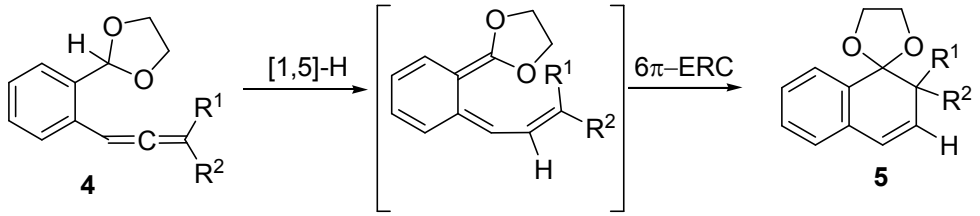
1. Introduction

During the last few years our research group has been involved in the investigation of the hydride donor ability of acetalic functions in a series of intramolecular processes. In these reactions the released hydride is transferred to the electrophilic central carbon atom of some heterocumulenic fragments (ketenimines, carbodiimides) and other electrophilic functions. Gratifyingly, we have shown that several of such hydride-like [1,4] [1] and [1,5]-H [2] shifts occur under mild reaction conditions, this migration step being habitually followed by a subsequent pericyclic transformation, most usually a 6π electrocyclic ring-closure (6π-ERC). Thus, for example, the [1,5]-H shift step in acetal-ketenimines (X= CR_2) and acetal-carbodiimides (X= NAr) **1** leads to the *o*-azaxylylene intermediates **2**, which quickly undergo a 6π-ERC to give quinolines and quinazolines **3**, respectively. (Scheme 1)



Scheme 1.

Following with our efforts in this area we reasoned that related tandem processes are conceivable by changing the hydride-acceptor unit from heterocumulenes to other electrophilic functional groups, while keeping the acetalic function as the hydride-releasing fragment. In this line, we assumed that the electrophilic sp-hybridized central carbon atom of an allene moiety may also act as the terminus of a similar 1,5-hydride shift from an acetal function, thus promoting a sequential transformation, from acetal-allene **4** to spirodioxolane **5**, closely related with those cited above. (Scheme 2)



Scheme 2

In order to secure the electrophilic character of the central carbon atom of the cumulenic function in **4** we decided to synthesize acetal-allenes bearing an electron-withdrawing group, such as the sulphoxide group, at the terminal carbon atom of the allene fragment.

Surprisingly, when we carried out the thermal activation of a particular class of sulphoxide-substituted acetal-allenes (generated in situ from the respective propargylic sulphoxides) built on an *ortho*-phenylene scaffold, an unexpected rearrangement involving an isomeric *O*-allenyl sulphenate took place instead of the presumed [1,5]-H/6π-ERC tandem process.

2. Methods/Experimental

Preparation of compounds **10** and **11**

Triethylamine (0,1 mmol) was added to a solution of the propargyl sulphoxide **9** (1 mmol) in anhydrous toluene (15 mL) at room temperature. The reaction mixture was stirred at reflux temperature for 5 h. Then, the solvent was removed under reduced pressure and the residue purified by silica gel column chromatography.

Compound 10a: yield 41%; yellow oil; eluent for column chromatography: hexanes/ethyl acetate (7:3 v/v); ^{1}H NMR (400 MHz, $CDCl_3$): δ= 8.03 (ddd, *J* = 0.8, 2.4, 8.8 Hz, 1 H), 7.68 (dd, *J* = 1.2, 7.6 Hz, 1 H), 7.53 (td, *J* = 1.6, 7.6 Hz, 1 H), 7.45 (td, *J* = 1.6, 7.6 Hz, 1 H), 7.37 (dd, *J* = 1,2, 7.6 Hz, 1 H), 7.29 (d, *J* = 8.4 Hz, 1 H), 6.17 (s, 1 H), 5.05 (dd, *J* = 8.8, 6 Hz, 1 H), 3.98-3.88 (m, 4 H), 3.84 (dd, *J* = 5.6, 7.6 Hz, 1 H), 3.74 (dd, *J* = 8.8, 11.2 Hz, 1 H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): δ= 201.4 (s), 152.4 (s), 145.1 (s), 138.7 (s), 137.5 (s), 137.2 (s), 131.2, 128.9, 127.4, 126.9, 124.2, 121.9, 121.4, 101.3, 65.2, 65.0, 58.1, 35.7 ppm; IR (Neat): ν= 1698 (s), 1578 (s), 1513 (vs), 1336 (vs), 1086 (s), 909 (m) cm $^{-1}$; HRMS (ESI): *m/z* calcd for $C_{18}H_{16}NO_5S$ $[M+H]^+$ 358.0744; found 358.0743.

Compound 11a: yield 13%; yellow oil; eluent for column chromatography: hexanes/ethyl acetate (7:3 v/v); ^{1}H NMR (300 MHz, $CDCl_3$): δ= 9.67 (d, *J* = 2.1 Hz, 1 H), 8.32 (dd, *J* = 2.1, 8.7 Hz, 1 H), 8.02-7.99 (m, 2 H), 7.74 (d, *J* = 8.1 Hz, 1 H), 7.58 (td, *J* = 6.9, 2.1 Hz, 1 H), 7.51-7.43 (m, 3 H), 6.06 (s, 1 H), 3.93-3.89 (m, 4 H) ppm; ^{13}C NMR (75 MHz, $CDCl_3$): δ= 191.2 (s), 146.8 (s), 144.5 (s), 142.8, 138.7 (s), 136.9 (s), 136.8 (s), 136.5 (s), 130.6, 128.7, 128.0, 127.4, 122.9, 121.6, 120.1, 101.4, 65.3 ppm; IR (Neat): ν= 1653 (m), 1517 (vs), 1342 (vs), 1234 (m), 1101 (m), 1072 (m) cm $^{-1}$; HRMS (ESI): *m/z* calcd for $C_{18}H_{14}NO_5S$ $[M+H]^+$ 356.0587; found 356.0592.

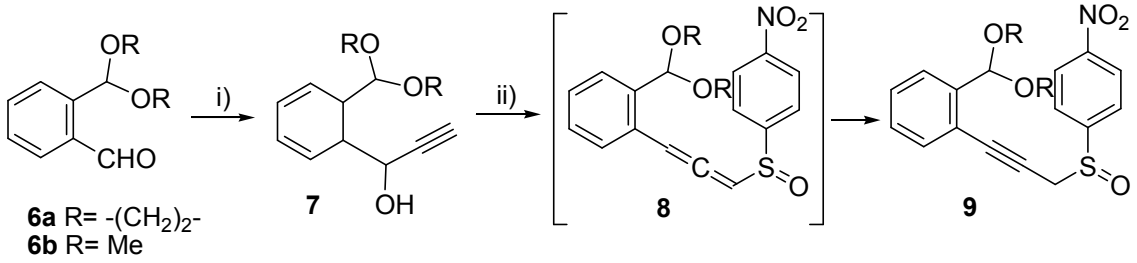
Compound 10b: yield 43%; yellow oil; eluent for column chromatography: hexanes/ethyl acetate (7:3 v/v); ^{1}H NMR (400 MHz, $CDCl_3$): δ= 8.02 (dd, *J* = 2.4, 8.4 Hz, 1 H),

7.77 (d, J = 2.4 Hz, 1 H), 7.59 (dd, J = 0.4, 7.6 Hz, 1 H), 7.51 (td, J = 0.8, 7.2 Hz, 1 H), 7.42 (td, J = 0.9, 7.2 Hz, 1 H), 7.30 (d, J = 6.4 Hz, 1 H), 7.28 (d, J = 8.4 Hz, 1 H), 5.56 (s, 1 H), 5.14 (dd, J = 5.2, 8.8 Hz, 1 H), 3.92 (dd, J = 5.2, 11.6 Hz, 1 H), 3.73 (dd, J = 8.8, 11.2 Hz, 1 H), 3.33 (s, 3 H), 3.26 (s, 3 H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): δ= 201.7 (s), 152.4 (s), 145.0 (s), 138.7 (s), 137.5 (s), 136.7 (s), 130.8, 128.6, 127.8, 127.2, 124.1, 121.8, 121.4, 102.4, 58.2, 54.3, 54.0, 35.4 ppm; IR (Neat): ν= 1697 (s), 1597 (m), 1577 (m), 1514 (vs), 1336 (vs), 1265 (m) cm $^{-1}$; HRMS (ESI): *m/z* calcd for $C_{18}H_{17}NaNO_5S$ $[M+Na]^+$ 382.072; found 382.072.

Compound 11b: yield 13%; yellow oil; eluent for column chromatography: hexanes/ ethyl acetate (7:3 v/v); ^{1}H NMR (400 MHz, $CDCl_3$): δ= 9.67 (d, J = 2.4 Hz, 1 H), 8.32 (dd, J = 2.4, 8.8 Hz, 1 H), 8.01 (d, J = 8.8 Hz, 1 H), 7.97 (s, 1 H), 7.73 (d, J = 7.6 Hz, 1 H), 7.55 (td, J = 1.6, 7.2 Hz, 1 H), 7.47-7.41 (m, 2 H), 5.63 (s, 1 H), 3.23 (s, 6 H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): δ= 191.6 (s), 146.9 (s), 145.6 (s), 142.1, 138.7 (s), 137.1 (s), 136.9 (s), 136.5 (s), 130.3, 128.2, 127.8, 127.3, 123.0, 121.6, 120.2, 101.1, 53.6 ppm; IR (Neat): ν= 1740 (vs), 1521 (w), 1373 (m), 1242 (vs), 1047 (s) cm $^{-1}$; HRMS (ESI): *m/z* calcd for $C_{18}H_{15}NaNO_5S$ $[M+Na]^+$ 380.0563; found 380.0564.

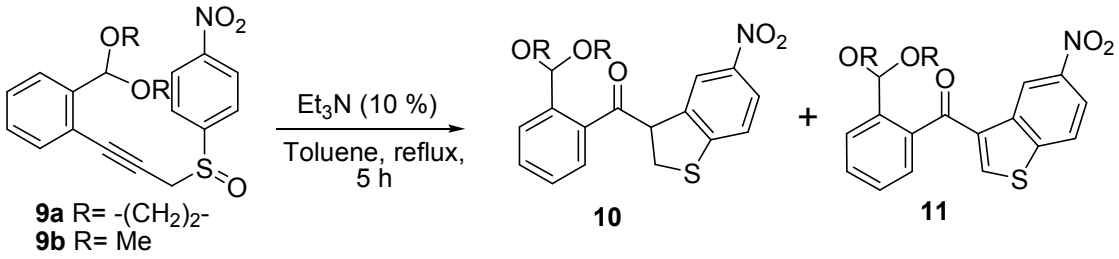
3. Results and Discussion

The reaction of 2-(1,3-dioxolan-2-yl)benzaldehyde **6a** and its dimethoxy analogous **6b** with ethynylmagnesium bromide yielded the corresponding propargylic alcohols **7**, which were converted into propargyl sulphoxides **9** by treatment with *para*-nitrobenzenesulfenyl chloride in the presence of triethylamine, instead of giving rise to the desired acetal-allenes **8**. (Scheme 3)



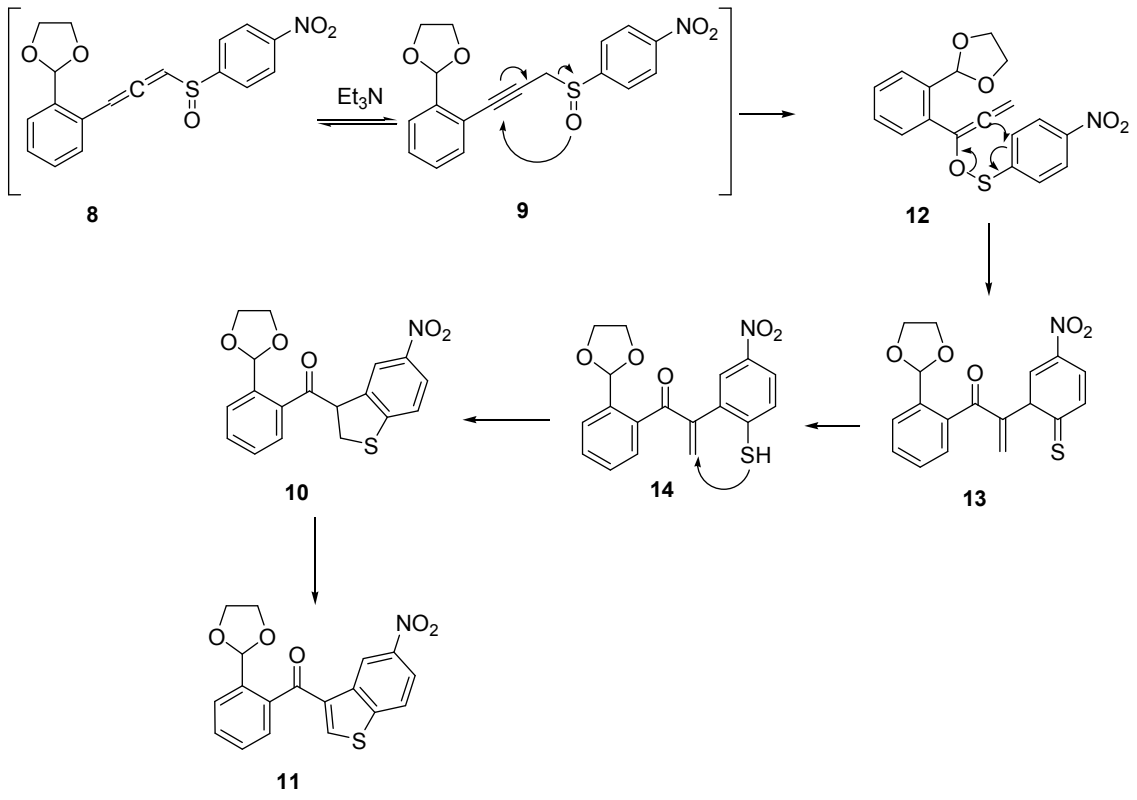
Scheme 3. *Reagents and conditions:* i) HC≡CMgBr, THF, 0 ºC, 40 min; ii) 4-NO_2-C_6H_4-SCl, Et_3N, DCM, 0 ºC → r.t, 3 h.

With the aim of promoting the designed hydride shift in an equilibrium fraction of acetal-allenes **8** we submitted the propargylic sulphoxides **9** to heating in toluene solution in the presence of a catalytic amount of Et_3N (10 %). To our surprise, the reaction products were mixtures of the benzothiophenes **10** and **11**, differing only in the degree of the hydrogenation at the five-membered ring. In these mixtures the dihydro derivatives **10** were always the major components. (Scheme 4)



Scheme 4

Clearly, the skeletal rearrangement summarized in the previous Scheme only involves the propargyl sulphoxide moiety. This rearrangement may be rationalized by a mechanism involving as a first step a [2,3] sigmatropic rearrangement of the propargyl sulphoxide function to give the allenyl-sulphenate **12** followed by a [3,3] sigmatropic rearrangement and further tautomerization of the initially formed thione **13** leading to the thiol-enone intermediate **14**. Finally, an internal nucleophilic addition of the thiol group to the enone fragment would account for the formation of the 2,3-dihydrobenzo[*b*]thiophenes **10**. Obviously, a fraction of **10** seems to become air-oxidized to the fully aromatic benzo[*b*]thiophenes **11**. (Scheme 5)



Scheme 5

From the results of these experiments, it seems that this type of propargylic rearrangement in **9** is faster than the expected hydride migration in acetal-allene **8**, thus precluding the occurrence of this latter chemical transformation.

Following the experimental study showing the conversion of propargyl sulphoxides **9** into benzothiophenes **10** and **11** we carried out an extensive bibliographic search, finding out a similar transformation previously reported by Majumdar and co-workers, who explained this type of propargylic sulphoxide rearrangement by a mechanism identical to that in Scheme 5. [3]

4. Conclusions

In this communication we have summarized our results on what to our mind was an unexpected propargyl sulphoxide rearrangement, which in fact was a known reaction although scarcely reported.

5. Acknowledgements

This work was supported by the MCYT (Project CTQ2008-05827/BQU) and Fundación Séneca-CARM (Project 08661/PI/08)

5. References

[1] Alajarin, M.; Marin-Luna, M.; Vidal, A. *Adv. Synth. Catal*. **2011**, *353*, 557.

[2] a) Alajarin, M.; Bonillo, B.; Ortin, M-M.; Sanchez-Andrada, P.; Vidal, A. *Org. Lett*. **2006**, *8*, 5645; b) Alajarin, M.; Bonillo, B.; Ortin, M-M.; Sanchez-Andrada, P.; Vidal, A.; Bautista, D. *Org. Lett*. **2009**, *11*, 1365; c) Alajarin, M.; Bonillo, B., Sanchez-Andrada, P.; Vidal, A. *J. Org. Chem*. **2010**, *75*, 3737; d) Alajarin, M.; Bonillo, B.; Ortin, M-M.; Sanchez-Andrada, P.; Vidal, A. *Eur. J. Org. Chem*. **2011**, *10*, 1896.

[3] a) Majumdar, K. C.; Biswas, P. *Tetrahedron*, **1998**, *54*, 11603; b) Majumdar, K. C.; Biswas, P. *Tetrahedron*, **1999**, *55*, 1449; c) Majumdar, K. C., Maji, P. K., Pal, A.K. *Lett. Org. Chem.* **2007,** *4,* 134.