

Synthesis of Sugar Episulfides and Olefins from *vic*-Diols via Cyclic Sulfates

Francisco Santoyo-González,* Francisco García-Calvo-Flores, Pilar García-Mendoza, Fernando Hernández-Mateo, Joaquín Isac-García and M^a Dolores Pérez-Alvarez

Departamento de Química Orgánica, Facultad de Ciencias, Universidad de Granada, Granada, E-18071, Spain

Cyclic sulfates of *vic*-diols are transformed in one-pot into sugar episulfides by treatment with potassium thioacetate or thiourea followed by reaction with sodium methoxide; reaction of these cyclic sulfates with potassium selenocyanate followed by treatment with sodium borohydride allows the synthesis of sugar olefins.

vic-Diols have been used as precursors for the synthesis of episulfides and olefins. The synthesis of episulfides¹ generally involves prior transformation of the diol into the corresponding epoxide and then opening with a nucleophile. Thiocyanate salts or thiourea² are the most common reagents. These methods have been applied in the syntheses of hexose 5,6-episulfides and other epithiosugars.³ Sugar episulfides have also been obtained by the reaction of sugar oxiranes with mono- and di-thioacids of phosphorus.⁴ Olefins can be obtained directly from *vic*-diols by treatment with tungsten reagents,⁵ titanium metals,⁶ Me₃SiCl-NaI,⁷ Ph₃P-imidazole-I₂⁸ and PBr₃-CuBr-ether followed by zinc powder.⁹ *vic*-Diols can also be deoxygenated indirectly by prior conversion into sulfonate ester derivatives,¹⁰ bisdithiocarbonates,¹¹ cyclic thionocarbonates,¹² oxiranes,¹³ episulfides,¹⁴ or cyclic orthoformates.¹⁵ However, to the best of our knowledge cyclic sulfates of *vic*-diols have never been used for the synthesis of episulfides and olefins.

The synthesis and use of cyclic sulfates have been recently reviewed.¹⁶ Nucleophilic reactions of cyclic sulfates are perhaps the most commonly studied reactions and are well known for their high reactivity. Nucleophilic substitution reactions of cyclic sulfates are superior to their epoxide counterparts. The opening of a cyclic sulfate by a nucleophile gives an acyclic sulfate. The sulfate group thus generated is a

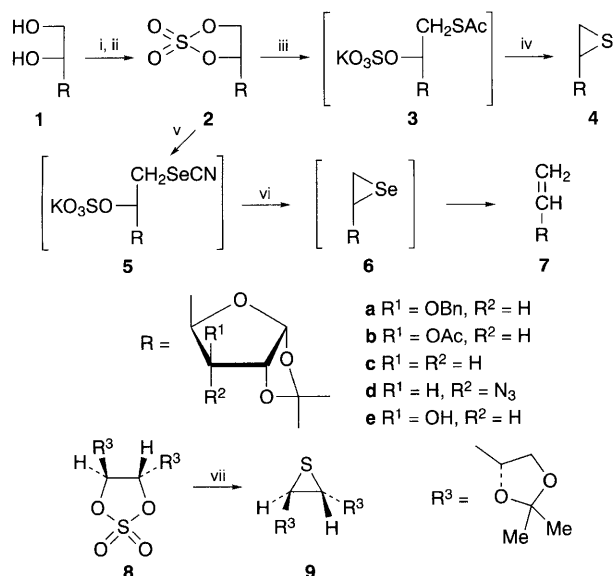
good leaving group and can undergo intramolecular displacement by the nucleophile incorporated into the molecule. We have applied this idea to the synthesis in one-pot of sugar episulfides and alkenes from cyclic sulfates.

The diols **1a-d**† were easily transformed *via* cyclic sulfates into the cyclic sulfates **2a-d** in high yields (66–88%) following the improvement procedure of Gao and Sharpless.¹⁹ Nucleophilic ring opening of the cyclic sulfates **2a-d**‡ with potassium thioacetate (1.1 equiv.) in dry acetone at room temp. followed by (without purification) treatment with sodium methoxide (3 equiv.) in methylene chloride-methanol leads to the thiirane derivatives **4a,e,c,d**,‡ respectively (55–91% yield) (see Table 1).§ Thiourea was also used as nucleophile with compound **2b** yielding the corresponding cyclic sulfide **4e**‡ in 52% yield. Inversion at C-5 should happen in these processes because the nucleophilic attack is regiospecific at C-6 leading to the β-acetylthiosulfate **3**. On treatment with sodium methoxide, **3** underwent deacetylation and cyclization giving the thiirane derivatives **4**. The reaction of the di-*O*-isopropylidene derivative **8** with sodium thioacetate did not yield the corresponding episulfide **9**. However, when sodium sulfide was used as nucleophile in boiling methanol, the desired cyclic sulfide **9**‡ was obtained in 42% yield.

Cyclic sulfates are also shown to be adequate precursors for the synthesis of olefins if potassium selenocyanate is used as nucleophile instead of potassium thioacetate. The β-selenocyanatosulfates that result in these reactions can be transformed in the corresponding seleniranes by treatment with sodium borohydride. However, seleniranes are unstable and expel the selenium atom giving alkenes.²⁰ When the cyclic sulfates **2a-d** were treated with potassium selenocyanate (1.1 equiv.) in dry acetone at room temp. the seleno derivatives **5a-d** were obtained. These products were used in the next step without further purification. Reaction with sodium borohydride (3 equiv.) in methanol at room temp. gave the olefins **7a-d**‡ in 50–94% yield (see Table 1).

Financial support from the Comisión Asesora de Investigación Científica y Técnica (Grant No PB92-0936) is gratefully acknowledged.

Received, 30th November 1994; Com. 4/07325H



Scheme 1 Reagents and conditions: i, SOCl₂, Et₃N, CH₂Cl₂; ii, RuCl₃·3H₂O, NaIO₄, MeCN, CCl₄, H₂O; iii, KSAc, acetone; iv, NaOMe, MeOH; v, KSeCN, acetone; vi, NaBH₄, MeOH; vii, Na₂S·10H₂O, MeOH

Table 1 Transformation of cyclic sulfates **2a-d** into episulfides **4a,c-e** and olefins **7a,c-e**

Starting material	Episulfides [yield (%)]	Olefins [yield (%)]
2a	4a (55)	7a (94)
2b	4e (90)	7e (50)
2c	4c (91)	7c (67)
2d	4d (83)	7d (55)

Footnotes

† Compounds **1c,d** have been obtained according to the procedures described in refs. 17 and 18, respectively.

‡ These compounds showed satisfactory spectral and analytical data. Yields refer to isolated compounds after purification by column chromatography or crystallization.

References

- U. Zoller, in *Small Ring Heterocycles, Part 1*, ed. A. Hassner, Wiley, New York, 1983, p. 333.
- C. C. J. Culvenor, W. Davies and K. H. Pausacker, *J. Chem. Soc.*, 1946, 1050; C. C. J. Culvenor, W. Davies and W. E. Savage, *J. Chem. Soc.*, 1952, 4480; F. G. Bordwell and H. M. Andersen, *J. Chem. Soc.*, 1953, 4959; L. Goodman and B. R. Baker, *J. Chem. Soc.*, 1959, 4924; M. G. Ettinger, *J. Chem. Soc.*, 1950, 4792; E. E. van Tamelen, *J. Chem. Soc.*, 1951, 3444; C. C. Price and P. F. Kirk, *J. Chem. Soc.*, 1953, 2396; R. D. Schuetz and R. L. Jacobs, *J. Org. Chem.*, 1961, **26**, 3467; D. C. Dittmer,

- in *Comprehensive Heterocyclic Chemistry*, ed. A. R. Katritzky, C. W. Rees and W. Lowski, Pergamon, New York, 1984, vol 7, p. 178.
- 3 A. Hasegawa, Y. Kawai, H. Kasugai and M. Kiso, *Carbohydr. Res.*, 1978, **63**, 131; R. Bognar, P. Herczegh, R. L. Whistler and E. B. Madumelu, *Carbohydr. Res.*, 1981, **90**, 138; E. Tanahashi, M. Kiso and A. Hasegawa, *Carbohydr. Res.*, 1983, **117**, 304; R. L. Whistler and W. C. Lake, in *Methods in Carbohydrate Chemistry*, 1972, vol 6, p. 286; M. V. Jesudason and L. N. Owen, *J. Chem. Soc., Perkin Trans. 1*, 1974, 2019; H. Hashimoto, T. Fujimori and H. Yuasa, *J. Carbohydr. Chem.*, 1990, **9**, 683; J. Branalt, I. Kvarnström, S. C. T. Svensson, B. Classon and B. Samuelsson, *J. Org. Chem.*, 1994, **59**, 4430.
 - 4 W. Kudelska and M. Michalska, *Carbohydr. Res.*, 1980, **83**, 43; W. Kudelska, M. Michalska and A. Swiatek, *Carbohydr. Res.*, 1981, **90**, 1; M. Michalska, W. Kudelska, J. Pluskowski, A. E. Kozior and T. Lis, *J. Chem. Soc., Perkin Trans. 1*, 1994, 979.
 - 5 K. B. Sharpless and T. C. Flood, *J. Chem. Soc., Chem. Commun.*, 1972, 370.
 - 6 J. E. McMurry and M. P. Fleming, *J. Org. Chem.*, 1976, **41**, 896; J. E. McMurry, *Acc. Chem. Res.*, 1983, **16**, 406.
 - 7 J. C. Sarma, N. C. Barua, R. P. Sharma and J. N. Barua, *Tetrahedron*, 1983, **39**, 2843.
 - 8 P. J. Garegg and B. Samuelsson, *Synthesis*, 1979, 469.
 - 9 S. Tamaka, A. Yasuda, H. Yamamoto and H. Nozaki, *J. Am. Chem. Soc.*, 1975, **97**, 3252.
 - 10 J. C. Carnahan, Jr and W. D. Closson, *Tetrahedron Lett.*, 1972, 3447; J. Defaye, *Bull. Soc. Chim. Fr.*, 1968, 2099; R. S. Tipson and A. Cohen, *Carbohydr. Res.*, 1965, **1**, 338; E. L. Albano, D. Horton and T. Tsuchiya, *Carbohydr. Res.*, 1966, **2**, 349.
 - 11 A. G. M. Barret, D. H. R. Barton and R. Bielski, *J. Chem. Soc., Perkin Trans. 1*, 1979, 2378.
 - 12 E. J. Corey and R. A. E. Winter, *J. Am. Chem. Soc.*, 1963, **85**, 2677; E. J. Corey, *Pure Appl. Chem.*, 1967, **14**, 19; D. Horton, J. K. Thomson and C. G. Tindall, Jr., *Methods Carbohydr. Chem.*, 1972, vol. 6, p. 297.
 - 13 G. Wittig and W. Haag, *Chem. Ber.*, 1955, **88**, 1654; C. B. Scott, *J. Org. Chem.*, 1957, **22**, 1118; E. Vedejs and P. L. Fuchs, *J. Am. Chem. Soc.*, 1971, **93**, 4070; E. Vedejs and P. L. Fuchs, *J. Am. Chem. Soc.*, 1973, **95**, 822; H. Suzuki, T. Fuchita, A. Iwasa and T. Mishina, *Synthesis*, 1978, 905.
 - 14 N. P. Neureiter and F. G. Bordwell, *J. Am. Chem. Soc.*, 1959, **81**, 578; P. E. Sonnet, *Tetrahedron*, 1980, **36**, 557.
 - 15 J. S. Josan and F. W. Eastwood, *Carbohydr. Res.*, 1968, **7**, 161.
 - 16 B. B. Lohray, *Synthesis*, 1992, 1035; R. A. Johnson and K. B. Sharpless, in *Comprehensive Organic Synthesis*, ed. B. M. Trost and I. Fleming, Pergamon, New York, 1991, vol. 7, p. 431.
 - 17 G. Just, G. Luthe and H. Oh, *Tetrahedron Lett.*, 1980, **21**, 1001.
 - 18 H. H. Baer and Y. Gan, *Carbohydr. Res.*, 1991, **210**, 233.
 - 19 Y. Gao and K. B. Sharpless, *J. Am. Chem. Soc.*, 1988, **110**, 7538.
 - 20 D. van Ende and A. Krief, *Tetrahedron Lett.*, 1975, **31**, 2709.