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A convenient synthesis of thiirene 1-oxides

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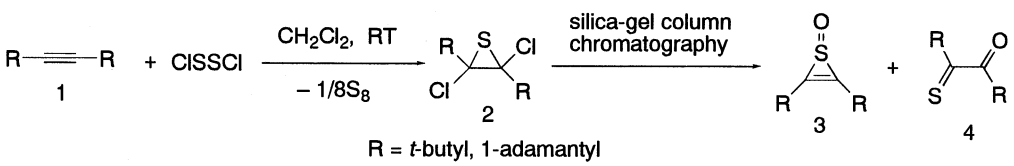
Abstract—Acetylenes (**1**), carrying two bulky alkyl substituents, reacted with sulfur dichloride (ClSCl) to give 2,3-dialkyl-2,3-dichlorothiiranes (**2**) nearly quantitatively. The alkaline hydrolysis of crude **2** resulted in the formation of thiirene 1-oxides (**3**) in 68–90% yields based on **1**, thus providing a convenient synthesis of **3**. © 2001 Elsevier Science Ltd. All rights reserved.

Thiirene 1-oxides are compounds of much interest not only as three-membered unsaturated and, thus, angle-strained heterocycles but also as α,β-unsaturated sulfoxides. 2,3-Diarylthiirene 1-oxides were synthesized by a modified Ramberg–Bäcklund reaction of ArCHBr-SOCHBrAr,[1] while 2,3-dialkylthiirene 1-oxides were prepared by [4+2] cycloaddition of a thiiranoradialene 1-oxide with dienophiles such as $^1O_2$ and *N*-substituted 1,2,4-triazoline-3,5-diones.[2] Quite recently, we have reported that acetylenes (**1**), carrying two bulky alkyl substituents, reacted with sulfur monochloride (ClSSCl) to give 2,3-dichlorothiiranes (**2**) and that **2** were hydrolyzed upon attempted purification by silica-gel column chromatography to provide thiirene 1-oxides (**3**) and α-oxothioketones (**4**), both in modest yields.[3] We have now found that the use of sulfur dichloride (ClSCl) in place of ClSSCl results in much cleaner reactions to provide the thiiranes **2** nearly quantitatively and that the alkaline hydrolysis of crude **2** furnishes the thiirene 1-oxides **3** as the sole product, thus providing a most convenient synthesis of **3**.

Thus, treatment of di-*t*-butylacetylene (**1a**) with an equimolar amount of ClSCl in CH_2Cl_2 at room temperature provided 2,3-di-*t*-butyl-2,3-dichlorothiirane (**2a**)[3,4] nearly quantitatively as a pale yellow oil upon evaporation of the solvent. Alkaline hydrolysis (NaOH) of crude **2a** in aqueous MeOH for 5.5 h at room temperature provided 2,3-di-*t*-butylthiirrene 1-oxide (**3a**)[3] in 68% yield based on **1a**. Meanwhile, acid hydrolysis (HCl) of **2a** in aqueous MeOH afforded **3a** and 2,2,5,5-tetramethyl-4-thioxo-3-hexanone (**4a**) in 10 and 36% yields, respectively, in accordance with the results obtained by silica-gel column chromatography.[3]

The reaction of di-1-adamantylacetylene (**1b**) with ClSCl also provided the corresponding dichlorothiirane (**2b**) quantitatively. Analytically pure **2b**[5,6] was obtained by washing the crude product with a small amount of pentane. Also, in this case, alkaline hydrolysis of crude **2b** in aqueous THF at room temperature furnished 2,3-di-1-adamantylthiirene 1-oxide (**3b**)[3] in 81% overall yield. Unsymmetrically substituted 2-(1-adamantyl)-3-*t*-butylthiirene 1-oxide (**3c**)[7] was also synthesized in 90% overall yield starting from the acetylene (**1c**) through the alkaline hydrolysis of the dichlorothiirane (**2c**)[6] in aqueous EtOH. The 1-oxide **3c** isomerized to give a 1:1 mixture of **4c** and **4c′** quantitatively, when heated in refluxing toluene for 15 h.[8]

The two chlorine atoms in **2** are presumed to be *trans* to each other based on mechanistic grounds. The initial addition of ClSCl to **1** would proceed by a *trans*-addition to give **5** (or **5′**). The intramolecular *trans*-addition of **5** (**5′**) would then produce the *trans*-products **2**. The formation of the *trans*-products, in which repulsion



Keywords: sulfur dichloride; thiirenes; dichlorothiiranes; alkaline hydrolysis; bulky substituents.

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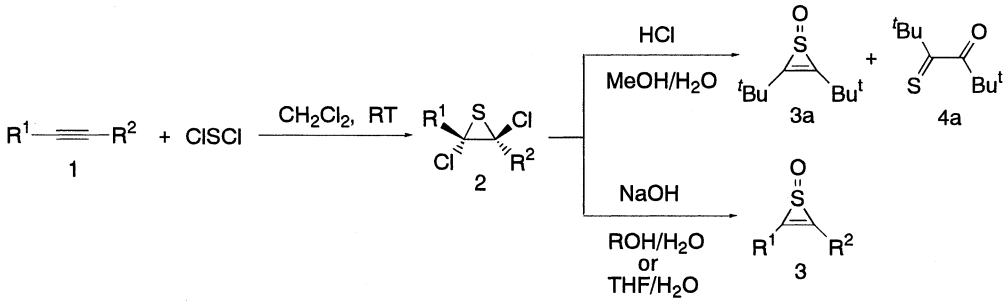
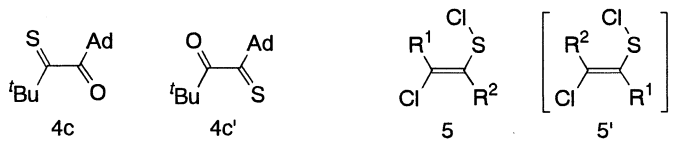


a: R^1, R^2 = *t*-butyl; b: R^1 = R^2 = 1-adamantyl; c: R^1 = 1-adamantyl, R^2 = *t*-butyl



between the bulky alkyl substituents diminishes considerably, would also be strongly favored due to steric reasons.

The formation of **3** and **4** by acid hydrolysis of **2** and the exclusive formation of **3** by alkaline hydrolysis would best be explained as follows. Under acidic conditions, protonation of **2** would produce carbocations (**6**), which are converted to **4** by addition of water and then by elimination of HCl (path A). In competition with this pathway, **2** would also come to an equilibrium with the sulfonium ion or dichlorosulfurane[9] intermediates (**9**) through **8**; the hydrolysis of the former provides **3** as the final products (path B). Under basic conditions, the path A is completely suppressed only to operate the path B, thus explaining the exclusive formation of **3** by alkaline hydrolysis.[10] The fact that the presence of NaCl as the additive retards the hydrolysis supports the intermediary formation of **8** in the rate-determining step; the alkaline hydrolysis of **2b** required 5 days for completion when NaCl was added, whereas the hydrolysis was completed within 17 h in the absence of NaCl.

In conclusion, we have developed a most convenient synthesis of thiirene 1-oxides **3**, which would contribute to bring on rapid growth of the chemistry of **3** and the related compounds.

References

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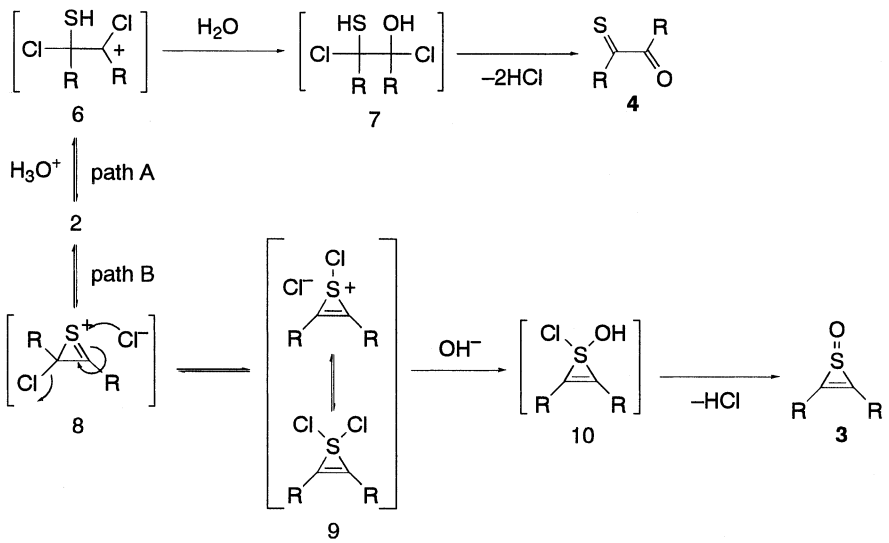
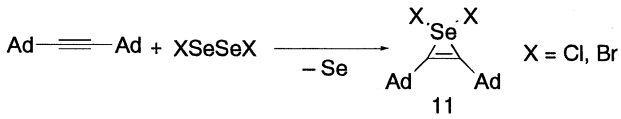
3. Nakayama, J.; Takahashi, K.; Watanabe, T.; Sugihara, Y.; Ishii, A. *Tetrahedron Lett.* **2000**, *41*, 8349.
4. Purification of the crude product by pot-to-pot distillation caused decomposition of **2a**, giving it in a decreased yield (50–60%) and, thus, leaving a considerable amount of a viscous oily pot residue.



5. Compound **2b** could not be isolated in analytically pure form by reaction of **1b** with ClSSCl.[3] Compound **2b**: mp 181–186°C; ^{1}H NMR ($CDCl_3$, 400 MHz) δ 1.66–1.68 (12H, m), 2.06–2.08 (6H, m), 2.14–2.17 (12H, m); ^{13}C NMR ($CDCl_3$, 100.6 MHz) δ 29.4, 36.7, 39.8, 46.2, 85.2.
6. Satisfactory elemental analysis results were obtained for all of the new compounds.
7. Compound **2c**: mp 118–119°C; ^{1}H NMR ($CDCl_3$, 400 MHz) δ 1.39 (9H, s), 1.65–1.67 (6H, m), 2.04–2.09 (3H, m), 2.10–2.18 (6H, m); ^{13}C NMR ($CDCl_3$, 100.6 MHz) δ 29.3, 30.0, 36.6, 39.5, 45.0, 45.8, 85.2, 85.6. Compound **3c**: mp 34–36°C; ^{1}H NMR ($CDCl_3$, 400 MHz) δ 1.39 (9H, s), 1.75–1.82 (6H, m), 1.95–1.98 (3H, m), 2.04–2.11 (6H, m); ^{13}C NMR ($CDCl_3$, 100.6 MHz) δ 27.9, 29.0, 32.8, 34.8, 36.2, 41.0, 144.2, 144.9.
8. A 1:1 mixture of **4c** and **4c′**: violet crystals; ^{1}H NMR ($CDCl_3$, 400 MHz) δ 1.26, 1.39 (^{t}Bu, 18H, s), 1.72–1.74, 1.94–1.96, 2.01–2.12 (Ad, 30H, m); ^{13}C NMR ($CDCl_3$, 100.6 MHz) δ 28.0, 28.4, 28.7, 30.4, 36.2, 36.4, 39.8, 41.9, 42.8, 44.4, 51.0, 53.8, 211.9, 212.8, 269.7, 269.9.
9. The quantitative formation of the selenurane **11** by reaction of di-1-adamantylacetylene (**1b**) with XSeSeX (X = Cl, Br) provides support for the existence of **9**, though indirectly; Watanabe, T.; Nakayama, J., unpublished results.



10. We cannot rule out a possibility that **10** is directly formed by reaction of **8** with OH^-.