Pergamon

Tetrahedron Letters 40 (1999) 277–280

TETRAHEDRON
LETTERS

A New Practical Synthesis of Tertiary S-Alkyl Dithiocarbonates and Related Derivatives

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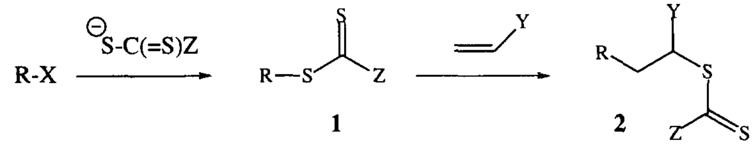
Received 13 October 1998; accepted 5 November 1998

Abstract : Decomposing a tertiary diazo derivative in the presence of a dithionodisulfide gives the corresponding tertiary thionosulfide (xanthate, dithiocarbamate, or dithioester) in good yield.

Dithiocarbonates (xanthates) and related derivatives of general structure **1** undergo inter- or intramolecular radical addition to olefins to give adducts of type **2** where a new carbon-carbon and carbon-sulfur bonds have been created (Scheme 1). This reaction is of some generality since a variety of radicals can be generated and captured in a synthetically useful manner.[1]

One practical advantage of this method is that the precursors are simply obtained by displacement of a leaving group such as a halide or a tosylate with a xanthate salt. Like S_N2-type reactions, however, such an approach becomes inefficient with hindered (e.g. tertiary) substrates. This limitation can sometimes be lifted by using O-neopentyl-S-triphenyltin xanthate, a reagent we introduced a few years ago[2] which allows the exchange of a halide with a xanthate through a radical chain process, and which combines the advantages of both organotin and xanthate chemistry. Alternatively, it is possible to exploit the radical decarboxylation or decarbonylation of alkoxycarbonyl[3] or acyl radicals respectively.[4] These processes could in principle be modified to provide related substances such as trithiocarbonates, dithiocarbamates, or dithioesters. We now report yet another radical procedure which allows the expedient synthesis of various tertiary S-alkyl dithiocarbonyl derivatives. This new method hinges on directing the reaction manifold in the desired direction by making the potential side reactions redundant or degenerate.



Scheme 1

The mechanistic basis of our approach is outlined in scheme 2. Thermal decomposition of a symmetrical diazo precursor **3** [5] provides two tertiary carbon centered radicals **4** which are rapidly captured by a bis(dithiocarbonate) type reagent **5** included in the medium. This reaction gives the desired dithiocarbonate derivative **7** and a sulfur centered radical **6** which can either dimerise to give back reagent **5** or recombine with carbon radical **4** to give another molecule of product **7**. Thus both parts of the

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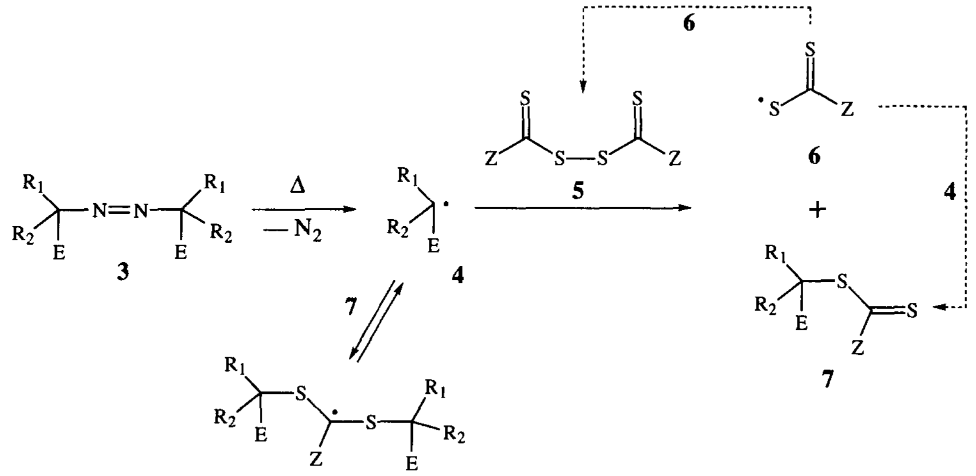
PII: S0040-4039(98)02380-6

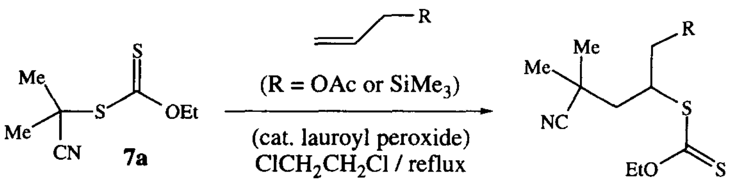
bis(dithiocarbonate) are eventually used constructively. Moreover, the reaction of radical **4** with the product **7** is reversible and degenerate and does not alter the system macroscopically. In fact, the main loss occurs through cage recombination of radicals **4**; for diazo derivatives, this has been estimated to be of the order of 15% in a non-viscous solvent.[6] Some excess of the diazo partner has therefore to be used.



Scheme 2

These considerations were easily reduced to practice. Mere heating of a mixture of AIBN **3a** and bis-O-ethyl xanthate **5a** in refluxing cyclohexane gave a good yield (87%) of the desired tertiary xanthate **7a**. A number of such hindered xanthates, dithiocarbamates, dithioesters were thus prepared easily and efficiently by modifying either the diazo precursor or the thiocarbonyl trap, as shown by the results collected in the Table. A typical experimental procedure is as follows: a mixture of the diazo derivative **3a-d** (1.2 mmole) and disulfide **5a-d** (1 mmole) in cyclohexane was heated to reflux under an inert atmosphere for 3-4 hours. If necessary, additional diazo derivative was added in portions (0.2 mmole) with further heating until the reaction was complete. The solvent was then evaporated and the residue purified by chromatography. A small amount of chlorobenzene was added in the case of tetramethythiuramdisulfide **5c**, whereas toluene and dioxane were used with diazo derivatives **3b** and **3c** respectively, and neat chlorobenzene with **3d** instead of cyclohexane. The synthesis of **7f** is interesting in that there is no need to protect the carboxylic acid function, demonstrating another advantage in using a radical process.[7]

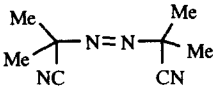
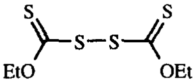
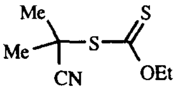
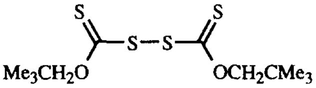
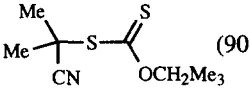
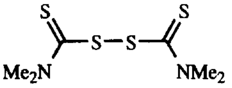
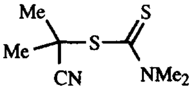
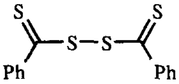
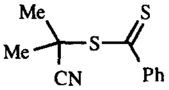
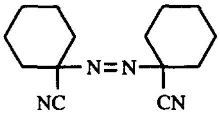
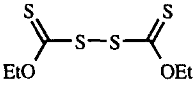
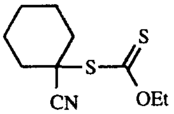
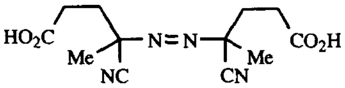
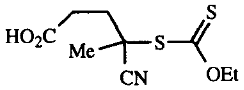
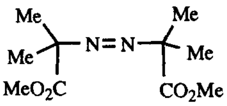
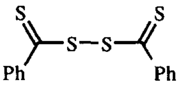
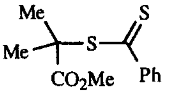
The utility of such derivatives may be illustrated by the radical addition of xanthate **7a** to olefins such as allyl acetate and allyl trimethylsilane, leading to the corresponding adducts **8a** and **8b** in 56% and 78% respectively. In both cases, a quaternary carbon is created by *intermolecular* addition to relatively unactivated olefins. Such reactions are difficult to perform by traditional tin based technology.[8]



8a, R = OAc (56%)

8b, R = $SiMe_3$ (78%)

Table. Reaction of various dithionodisulfides 5 with diazo derivatives 3.

Diazo derivative	Dithionodisulfide 5	Product	(Yield)
 **3a**	 **5a**	 **7a**	(87%)
3a	 **5b**	 **7b**	(90%)
3a	 **5c**	 **7c**	(95%)
3a	 **5d**	 **7d**	(56%)
 **3b**	 **5a**	 **7e**	(87%)
 **3c**	**5a**	 **7f**	(77%)
 **3d**	 **5d**	 **7g**	(65%)

In summary, we have developed an experimentally very simple entry to hindered dithiocarbonyl derivatives which employs cheap, readily accessible starting materials. Diazo compounds are easily made from ketone hydrazones, and many are used as initiators in the polymer industry and are thus commercially available.[5] Work aimed at exploring further the scope of this approach is in progress.

Acknowledgements: We wish to thank Rhône-Poulenc for generous financial support to one of us (GB) and Drs Dominique Charmot and Pascale Corpart for friendly discussions.

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7. **7a** (yellowish oil); ^{1}H NMR (200 MHz) δppm: 4.75 (q, J= 7 Hz, 2H) 1.82 (s, 6H), 1.54 (t, J= 7 Hz, 3H). ^{13}C NMR (50 MHz) δppm: 207.7, 121.1, 70.7, 40.9, 27.2, 13.5; IR (neat, ν_{max}) 2240, 1456, 1363, 1250, 1110, 1044 cm^{-1}. Anal. Calcd for $C_7H_{11}NOS_2$: %C 44.42; %H 5.86. Found: %C 44.61; %H 5.89. **7b:** Mp 39-40°C (ethanol); ^{1}H NMR (200 MHz) δppm: 4.37 (s, 2H) 1.76 (s, 6H), 1.1 (s, 9H). ^{13}C NMR (50 MHz) δppm: 209, 121, 84.6, 40.3, 31.9, 27.3, 26.9. IR (nujol, ν_{max}) 2235, 1370, 1236, 1060 cm^{-1}. Anal. Calcd for $C_{10}H_{17}NOS_2$: %C 51.91; %H 7.41. Found: %C 51.82; %H 7.42. **7c**: Mp 87-88°C (ether-heptane); ^{1}H NMR (200 MHz) δppm 3.5 (s, 3H), 3.3 (s, 3H), 1.93 (s, 6H). ^{13}C NMR (50 MHz) δppm: 191, 121.5, 44.3, 42.2, 41.7, 27.4; IR (nujol, ν_{max}) 2230, 1496, 1377, 1250, 1159, 1131, 990 cm^{-1}. Anal. Calcd for $C_7H_{12}N_2S_2$: %C 44.65; %H 6.42. Found: %C 44.58; %H 6.53. **7d**: NMR ^{1}H (300MHz) δppm: 1.95 (s, 6H); 7.40 (t, J= 7.4Hz, 2H); 7.57 (t, J= 7.4Hz, 1H); 7.92 (d, J= 7.4Hz, 2H); NMR ^{13}C (62.5MHz) δppm: 26.3; 41.6; 119.8; 126.5; 128.4; 132.9; 144.3; 223.0. Anal.: calcd for $C_{11}H_{11}NS_2$: %C 59.69; %H 5.01. Found %C 59.45; %H 5.07. **7e**: Mp: 41°C; NMR ^{1}H (250 MHz) δppm: 4.74 (q, J=7.1 Hz, 2H), 2.40-2.30 (m, 2H), 1.90-1.60 (m, 7H), 1.52 (t, J= 7.1 Hz, 3H), 1.40-1.20 (m, 1H); NMR ^{13}C (62 MHz): 207.9, 119.7, 70.6, 47.3, 35.5, 24.7, 22.9, 13.5. Anal.: calcd for $C_{10}H_{15}NOS_2$: %C 52.37; %H 6.69. Found %C 52.51; %H 6.51. **7f**: NMR ^{1}H (250 MHz) δppm: 4.75 (q, J=7.11 Hz, 2H), 2.67 (t, J= 7,92 Hz, 2H), 2.4-2.2 (m, 2H), 1.78 (s, 3H),1.53 (t, J=7.11 Hz, 3H); NMR ^{13}C (62 MHz): 206.7, 177.6, 119.6, 71.0, 44.7, 33.6, 29.7, 25.1, 13.4. Anal.: calcd for $C_9H_{13}NO_3S_2$: %C 43.71; %H 5.30. Found %C 43.72; %H 5.47. **7g**: RMN ^{1}H (200MHz) δppm: 1.78 (s, 6H); 3.72 (s, 3H); 7.37 (t, J= 7.4Hz, 2H); 7.54 (t, J= 7.4Hz, 1H); 7.97 (d, J= 7.4Hz, 2H); RMN ^{13}C (50MHz) δppm: 24.7; 52.9; 54.9; 126.5; 128.1; 132.4; 144.2; 173.1; 226.0. Anal.: calcd for $C_{12}H_{14}O_2S_2$: %C 56.66; %H 5.55. Found %C 57.14; %H 5.57. **8a**: (oil); ^{1}H NMR (250 MHz) δppm: 4.66 (q, J= 7 Hz, 2H), 4.38 (dd, J= 5 Hz, J= 11 Hz, 1H), 4.28 (dd, J= 6 Hz, J= 11 Hz, 1H), 4.16 (m, 1H), 2.1 (s, 3H), 2.07 (dd, J= 5 Hz, 1H), 1.9 (dd, J= 15 Hz, J= 7.5 Hz, 1H), 1.4 (t+2s, 9H). ^{13}C NMR (50 MHz) δppm: 212, 170.6, 124.3, 70.6, 65.7, 45.8, 40.9, 31.6, 27.6, 26.6, 20.8, 13.8. Anal. Calcd for $C_{12}H_{19}NO_3S_2$: %C 49.80; %H 6.62. Found: % C 49.87; H 6.72. **8b**: (oil); ^{1}H NMR (200 MHz) δppm: 4.84 (q, J= 7.2 Hz, 2H), 4.15 (m, 1H), 2.18 (dd, J= 15 Hz, J= 6 Hz, 1H), 2.08 (dd, J= 15 Hz, J= 6 Hz, 1H), 1.65-1.5 (t+2s+d, J= 6.2 Hz, 10H), 1.33 (dd, J= 15z, = 8.8 Hz, 1H), .3 (s, 9H); ^{13}C NMR (50 MHz) δppm: 211, 125, 69.8, 47.6, 45.1, 31.2, 28.6, 26.3, 23.4, 13.9, -0.6.
8. See for example: Curran, D. P.; Xu, J.; Lazzarini, E. *J. Am. Chem. Soc.* **1995**, *117*, 6603-6604.