

METHODS FOR THE CONVERSION OF VINYL SULFIDES TO ALDEHYDES

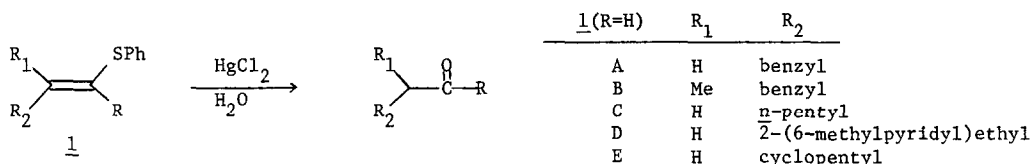
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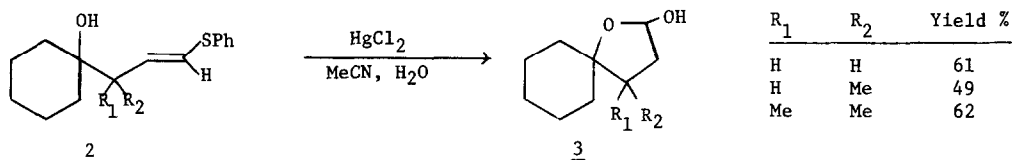
Since the introduction of the mild mercuric salt induced hydrolysis of vinyl sulfides to aldehydes and ketones,³ it has been generally assumed that the method is quite general and that any synthesis of a vinyl sulfide is equivalent to a synthesis of the corresponding aldehyde or ketone.⁴ Indeed, this assumption is a major reason for the extensive recent interest in the development of new methods for the preparation of vinyl sulfides.^{4,5} We now report, however, that the success of this hydrolytic method is highly dependent on structure

Enol phenyl thioether derivatives of ketones (1; R=alkyl or aryl) are reported to hydrolyze under the influence of mercuric chloride in aqueous acetonitrile.⁶ However, we have been unable to locate examples of the mercury(II) promoted hydrolysis of the corresponding derivatives of aldehydes (1, R=H) in which there are no free hydroxyl groups.⁷

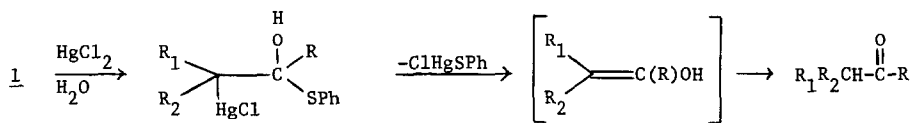


Furthermore, attempts in these laboratories to perform the mercuric chloride induced hydrolysis of a number of enol phenyl thioether derivatives of aldehydes (1, R=H) have proved futile. In our hands, sulfides 1 A-E⁸ (0.45 mmol) do not yield the expected aldehydes on heating for 3 days at reflux with HgCl₂ (0.90 mmol) in 15 ml of a 3:1 acetonitrile, water mixture, the presence of mercuric oxide¹¹ or calcium carbonate¹² has no effect on the course of the attempted reactions. Generally, unreacted starting material is recovered. When mercuric chloride was mixed with 1 D, an insoluble solid formed immediately and no starting material was recovered, the solid is undoubtedly an addition complex of Hg^{II} with the pyridine.¹³

On the other hand, when a homoallylic hydroxyl group is present as in 2,¹⁴ hydrolysis occurs under identical conditions to yield the lactols 3. It is of interest that, except for a class of compounds the members of which possess a γ -hydroxyl group and yield α,β -unsaturated aldehydes (apparently by a very special mechanism of hydrolysis¹⁵), the only case of hydrolysis of an enol phenyl thioether of an aldehyde which we have been able to locate in the literature is a derivative of a sugar which contains homoallylic as well as other hydroxyl groups.¹¹



These observations are readily rationalized if the likely assumption is made that the first step in the hydrolysis is the oxymercuration of the double bond in a Markovnikov fashion

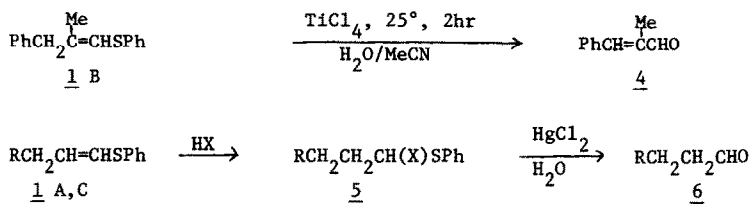


A recent kinetic study has revealed that oxymercuration is greatly accelerated by electron releasing groups (Taft's σ^* value is -3.3),¹⁶ this accounts for the success of the reaction in the case of 1 where R = alkyl or aryl but not hydrogen. Furthermore, there is evidence¹⁷ that the rate determining step is attack of solvent on a mercurinium ion,¹⁸ formed in a pre-equilibrium, it is thus reasonable to expect that the presence of an internal nucleophile, the δ -hydroxyl group, should greatly facilitate the reaction as in numerous examples of neighboring group participation.¹⁹ Such participation of an internal hydroxyl group has recently been invoked by Overman and Campbell²⁰ to account for a highly stereospecific oxymercuration of an olefin.²¹

The difficulty encountered in the one step hydrolysis of 1 (R=H) is not restricted to the mercuric chloride method. Attempted hydrolysis of 1 B, C and E in a mixture of water, tetrahydrofuran, and acetic acid containing 5 vol percent sulfuric acid also proved to be ineffective, the aldehyde was not formed in detectable quantities after 10 hours at reflux and starting material was again the major isolated compound. Very strong acid conditions²² yielded some aldehyde along with large quantities of a number of unidentified products, the aldehyde apparently does not survive the high acidity.

The titanium tetrachloride method,²³ in the cases which we have tried, has proved to be somewhat erratic. Whereas a 70% yield of aldehyde was obtained when 1 D was the substrate, a

mixture of products was formed in the case of 1 C and, surprisingly, the dehydrogenation product 4 was obtained (68% yield) in the case of 1 B.²⁴



A successful method²⁵ of hydrolysis of 1 A and C consists of addition of thiophenol to the double bond and mercuric chloride induced hydrolysis²⁶ of the resulting thioacetal 5(X=SPh). The addition is catalyzed by dry HCl²⁵ [90% yield of 5(R=Ph, X=SPh and Cl; see below); 95% yield of 5(R=n-butyl, X=SPh and Cl)] or, if protonic acids are undesirable, by Fe(CO)₅²⁸ [84% yield of 5(R=Ph, X=SPh); 85% yield of 5(R=n-butyl, X=SPh)]. The hydrolyses of these addition products to 6 (18 hr at 55°) are essentially quantitative.

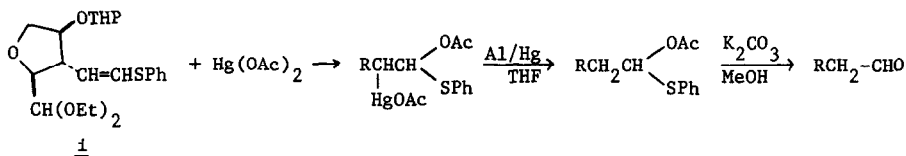
Since the HCl - catalyzed addition of PhSH resulted in 10-17% of the HCl adduct (5, X=Cl), a particularly facile and mild hydrolytic method becomes evident. The addition of dry HCl to 1 C (4.8 mmol) in benzene (20 ml) occurs rapidly and quantitatively. Treatment of 5 (R=n-butyl, X=Cl 1 mmol) obtained by benzene evaporation, with HgCl₂ (2 mmol) in water (1 ml) and THF (4 ml) at 25° (24 hr, appeared to be completed in 2 hr) provides a quantitative yield (NMR) of n-heptanal. The α-chlorosulfides hydrolyze in water alone; however, HgCl₂ is found necessary to remove the PhSH from solution, thus preventing thioacetal formation²⁹. This preliminary experiment indicates that the latter procedure may very well be the method of choice.

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