EFFICIENT REGENERATION OF CARBONYL COMPOUNDS FROM HYDRAZONES:
REACTIONS OF SUBSTITUTED HYDRAZONES WITH THALLIUM (III) ACETATE:
COMPARISONS WITH MERCURY (II) AND LEAD (IV) ACETATES

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Summary: Thallium triacetate in acetic acid gave clean regeneration of both
           aldehydes and ketones from their toluene-p-sulphonylhydrazones.
           The reagent gave N-aroyl-N'-acetyl-N'-phenylhydrazines from aromatic
           aldehyde phenylhydrazones without prior dehydrogenation to
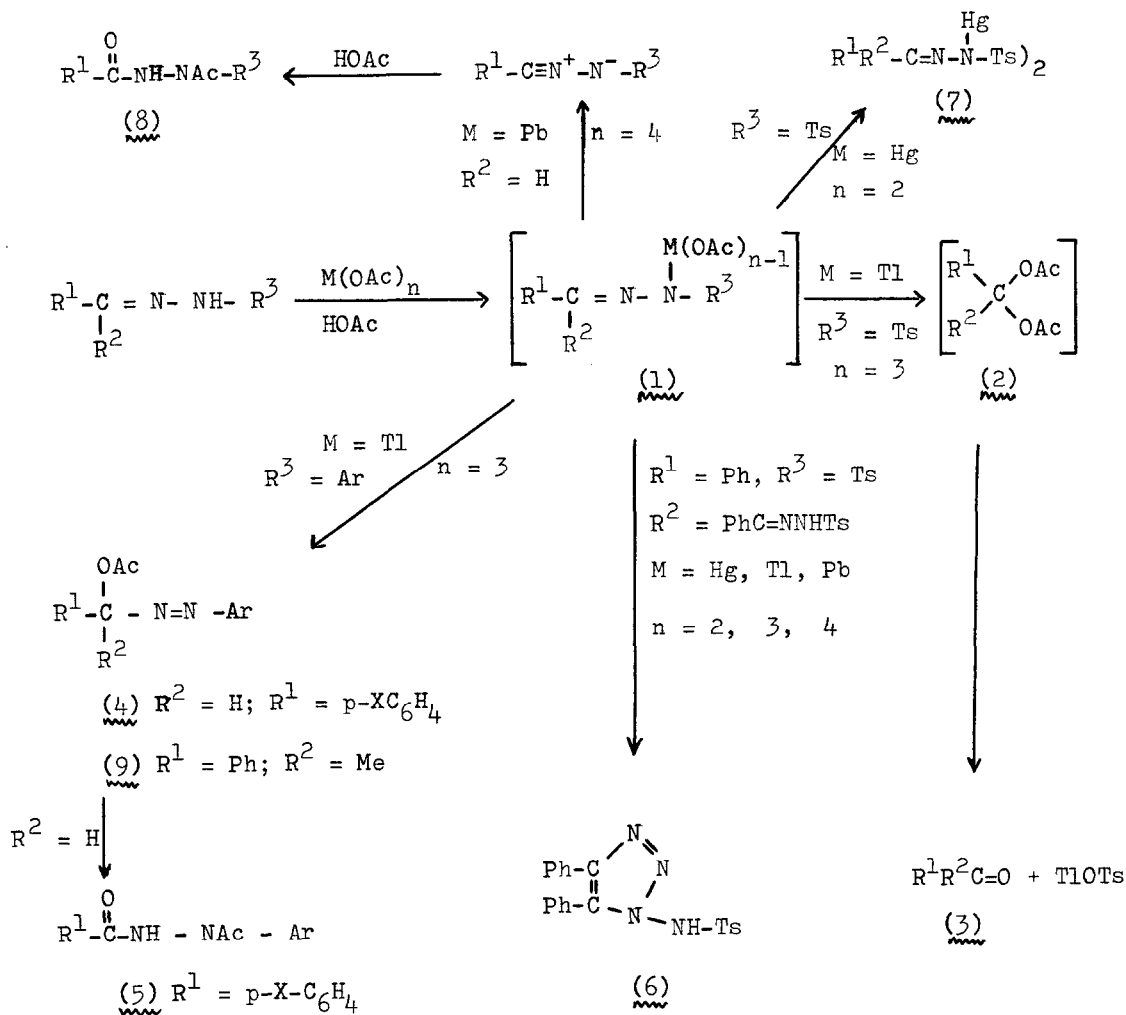   nitrilimine intermediates.

Considerable recent interest[1 - 4] has focussed on reagents which can
regenerate carbonyl compounds from crystalline hydrazone derivatives.
Thallium triacetate in acetic acid has now proved an effective reagent for
this purpose with toluene-p-sulphonylhydrazones.   While thallium trinitrate
in methanol has previously been used to regenerate carbonyl compounds from
oximes,[5] the reactions of thallium triacetate with hydrazone systems have not
been reported despite extensive studies of the reactions of hydrazones with the
isoelectronic oxidising agents lead tetraacetate[6] and, more recently, mercuric
acetate.[7 - 10]
     Treatment of a range of ketone and aldehyde toluene-p-sulphonyl-
hydrazones with Tl(OAc)$_3$ in acetic acid gave a clean high-yield regeneration
of the carbonyl compound at ambient temperatures for aldehydes and reflux
temperatures for ketones.[11]   For the corresponding toluene-p-sulphonylhydrazones
(Scheme) the results were, R^1, R^2, per cent yield of carbonyl compound (R^1R^2CO):
Ph, H, 80;   p-ClC$_6$H$_4$, H, 82;   p-MeC$_6$H$_4$, H, 90;   Ph, Me, 76(90 min. reflux);
Ph, Ph, 40(2 h. reflux);   cyclohexanone, 90(30 min. reflux);   camphor,
(2 h. reflux) 50 %.   In each case the remaining products were hydrazones
recovered and thallium (I) toluene-p-sulphonate and the reactions were generally
clean and without decomposition.   By analogy with lead tetraacetate[12 - 14]
and mercuric acetate[7] the reaction probably involved the intermediate (1).
Acetolysis of this to the unstable acetal (2) would regenerate the carbonyl
compound.   A similar acetolysis has been suggested recently[15] for cleavage
of N-bromotoluene-p-sulphonylhydrazones.   When benzophenone
toluene-p-sulphonylhydrazone was treated with Tl(OAc)$_3$ in dry methanol, the
products contained a 7 : 1 ratio of benzophenone and its dimethylketal,

$Ph_2C(OMe)_2$, confirming solvent involvement and supporting an unstable acetal intermediate (2) for the cleavage in acetic acid.

Comparison of the relative behaviour of the reagents $Hg(OAc)_2$, $Tl(OAc)_3$ and $Pb(OAc)_4$ with toluene-p-sulphonylhydrazones is now possible and suggests that the reactions are controlled by (i) the charge on the metal and accompanying relative lability of the N-metal bond (N-Pb > N-Tl ≫ N-Hg) and (ii) the relative solvolytic or oxidative lability of other activated bonds in the metallo-intermediates (1). For aldehyde toluene-p-sulphonyl-hydrazones when the metal was Tl(III), an external redox step involving solvolytic cleavage of the intermediate (1) dominated (Scheme). When the metal was Pb(IV), an internal redox in (1) gave rise to cleavage of the CH and N-Pb bonds giving compounds (8)[16] via nitrilimines (Scheme). When the metal was Hg(II), the intermediate (1) was stable and it reacted intermolecularly giving a bis-hydrazonomercurial product (7) without a change in the oxidation state of the metal.[6] Thallium triacetate oxidation of benzil bis(toluene-p-sulphonyl)hydrazone in hot acetic acid gave the 1,2,3-triazole derivative (6) (90 %) via a diazo intermediate as did $Pb(OAc)_4$ and $Hg(OAc)_2$ (cf. ref. 9) and to-date this is the only case where the three metallic acetates gave the same reaction with a hydrazone system.

The reaction of aromatic aldehyde-4-nitrophenylhydrazones with $Tl(OAc)_3$ in acetic acid required prolonged stirring and gave the products (5) (~ 90 %) (Scheme). The same products were obtained (but in lower yields accompanied by oils[16]) with lead tetraacetate as oxidant in a reaction involving an internal redox dehydrogenation to a nitrilimine,[13, 14] e. g. (8) (Scheme). The thallium triacetate reaction did not involve a nitrilimine intermediate. When it was carried out at 25°C, for periods of 1 - 7 days in the following solvents, the products (5) were again obtained along with hydrazone recovered; solvent, yield of (5): acrylonitrile, 2 - 4 % (from HOAc generated); acrylonitrile-HOAc (90 : 10 v/v), 25 - 28 %; acrylonitrile-Et_3N, (to trap HOAc generated), 0 (compounds (5) were not detected). No trace of cyanopyrazoles or cyanopyrazolines (the expected trapping products of nitrilimines[14]) were encountered. These results suggest an intermolecular involvement of acetic acid solvent also with these N-phenylhydrazones, (comparable to the toluene-p-sulphonylhydrazones). The intermediate (1) may be converted solvolytically to the azoacetates (4) which could rearrange to the compounds (5) under the prolonged conditions. In agreement with this, treatment of a ketone derivative, acetophenone-4-nitrophenylhydrazone with $Tl(OAc)_3$ at ambient temperature in acetic acid gave a product mixture of which the azoacetate (9) was the main component (ca. 65 % yield).

$$R^1-\overset{\overset{\textstyle O}{\|}}{C}-NH-NAc-R^3 \xleftarrow{\text{HOAc}} R^1-C\equiv N^+-N^--R^3$$

(8)

$M = Pb \quad n = 4 \qquad R^3 = Ts$

$R^2 = H$

$$R^1R^2-C=\overset{\overset{\textstyle Hg}{|}}{N}-N-Ts)_2$$

(7)

$M = Hg$

$n = 2$

$$R^1-\overset{|}{\underset{\underset{\textstyle R^2}{|}}{C}}=N-NH-R^3 \xrightarrow[\text{HOAc}]{M(OAc)_n} \left[R^1-\overset{|}{\underset{\underset{\textstyle R^2}{|}}{C}}=N-\overset{\overset{\textstyle M(OAc)_{n-1}}{|}}{N}-R^3 \right] \xrightarrow[\substack{R^3 = Ts \\ n = 3}]{M = Tl} \left[\overset{R^1}{\underset{R^2}{}} \overset{}{C} \overset{OAc}{\underset{OAc}{}} \right]$$

(1) (2)

$R^1 = Ph, \quad R^3 = Ts$

$R^2 = PhC=NNHTs$

$M = Hg, \quad Tl, \quad Pb$

$n = 2, \quad 3, \quad 4$

$M = Tl$

$R^3 = Ar \qquad n = 3$

$$R^1-\overset{\overset{\textstyle OAc}{|}}{\underset{\underset{\textstyle R^2}{|}}{C}}-N=N-Ar$$

(4) $R^2 = H; \quad R^1 = p\text{-}XC_6H_4$

(9) $R^1 = Ph; \quad R^2 = Me$

$R^2 = H$

$$R^1-\overset{\overset{\textstyle O}{\|}}{C}-NH-NAc-Ar$$

(5) $R^1 = p\text{-}X\text{-}C_6H_4$

Ph-C≡N

Ph-C—N—NH-Ts

(6)

$R^1R^2C=O + TlOTs$

(3)

Scheme (Ts = toluene-p-sulphonyl ;
Ar = p-nitrophenyl; X = Cl, H, Me)

References

1. G. A. Olah, J. Welch, G. K. Surya Prakash and T. L. Ho, *Synthesis*, 1976, 808.

2. D. H. R. Barton, D. J. Lester and S. V. Ley, *J.C.S.Chem.Comm.*, 1978, 276.

3. J. E. McMurry and M. Silvestri, *J.Org.Chem.*, 1975, $\underline{40}$, 1502.

4. G. A. Olah and J. Welch, *J.Amer.Chem.Soc.*, 1978, $\underline{100}$, 5396.

5. A. McKillop, J. D. Hunt, R. D. Naylor and E. C. Taylor, *J.Amer.Chem.Soc.*, 1971, $\underline{93}$, 4918. (These workers treated benzophenone phenylhydrazone with $Tl(NO_3)_3$ in MeOH and obtained 1-phenylazo-1,1-diphenyl dimethylether, $Ph_2C(OMe)-N=NPh$).

6. For reviews see, R. N. Butler, "Synthetic Reagents", Ed. J. Pizey, Ellis Horwood Ltd., Chester, 1977, pp. 307 - 313; R. N. Butler, T. A. F. O'Mahony and F. L. Scott, *Chem.Rev.*, 1973, $\underline{73}$, 93.

7. R. N. Butler and A. B. Hanahoe, *J.C.S.Chem.Comm.*, 1977, 622.

8. R. N. Butler and A. M. O'Donohue, *Tetrahedron Letters*, 1978, 275.

9. R. N. Butler, A. B. Hanahoe and W. B. King, *J.C.S.Perkin I*, 1978, 881.

10. R. N. Butler and W. B. King, *J.C.S.Perkin I*, 1976, 986.

11. Hydrazones (500 mg.) were treated with $Tl(OAc)_3$ (one mol.) in acetic acid 40 ml. containing acetic anhydride (0.5 ml.) for 16 h. at room temperature or as indicated. The reaction mixture was, (a) added to water and the carbonyl compound was isolated as a 2,4 DNP hydrazone derivative or (b) treated with ether whereupon $Tl(OSO_2C_6H_4Me-p)$ separated and the carbonyl compound was obtained from the ethereal layer after addition of water.

12. A. Bhati, *Chem.Comm.*, 1965, 476.

13. R. N. Butler and W. B. King, *J.C.S.Perkin I*, 1977, 282.

14. W. A. F. Gladstone, J. B. Aylward and R. O. C. Norman, *J.Chem.Soc.(C)*, 1969 (2587).

15. P. K. Freeman and J. R. Balyeat, *J.Org.Chem.*, 1977, $\underline{42}$, 3205.

16. F. L. Scott and R. N. Butler, *J.Chem.Soc.(C)*, 1966, 1202.