TABLE I

	Madhuca flavanonol	Dihydroquercetin from Douglas fir-wood
M.p.	241° dec.	240–242° dec.
Optical rotation	+36° (alc.)	+46° (acetone–water) +13 (absolute alc.)
Ultraviolet spectra:		
$\lambda_{max.}^{alc.}$ mμ	291 (log ε 4.18) and 330 (log ε 4.04)	290 and 330 (inflexion)
$\lambda_{max.}^{alc.}$ mμ (0.001 *N* alkali)	213 (log ε 4.40); 330 (log ε 4.38) and 410 (log ε 3.89)	
Infrared bands, μ (KBr)	2.98, 3.05, 6.17, 6.28, 6.61, 6.87, 7.33, 7.69, 7.93, 8.58, 8.81, 8.93, 9.24, 9.80, 10.28, 10.57, 11.65	2.96, 3.07, 6.10, 6.60, 6.80, 6.90, 7.37, 7.83, 7.95, 8.60, 8.81, 8.96, 9.25, 9.81, 10.04, 10.30, 10.62, 11.70
Mg or Zn and hydrochloric acid	Deep purple-red	Deep purple-red
Ferric chloride	Violet-brown-blueblack	Emerald green-black
Caustic alkali	Pink-yellow	Brown

Anal. Calcd. for $C_{25}H_{22}O_{12}$; C, 58.3; H, 4.3. Found: C, 57.92; H, 4.46.

Methyl Ethers.—Methylation was carried out by refluxing (36 hr.; steam bath) the flavanonol (1 g.) in acetone (100 ml.) with dimethyl sulfate (1.0 ml.) and anhydrous potassium carbonate (5 g.). After work-up and crystallization (alcohol), methylated products were obtained, one as a white crystalline product (50 mg.), m.p. 149–150°, and the other as pale-yellow needles, m.p. 159–160° (300 mg.). The former is identical with pentamethylquercetin (m.p. and mixed m.p. 149–150°) while the latter was found to be the tetramethyl ether of quercetin (*lit.*, m.p. 159–160° of 3,7,3′,4′-tetramethylquercetin). A ferric chloride test with both methyl ethers was negative but the tetramethyl ether showed the OH band (2.98 μ) in its infrared spectra.

Anal. Calcd. for $C_{15}H_5O_2\ (OCH_3)_5$: C, 64.6; H, 5.4. Found: C, 64.9; H, 6.0.

Anal. Calcd. for $C_{15}H_6O_3\ (OCH_3)_4$: C, 63.7; H, 5.3. Found: C, 63.67; H, 5.8.

Conversion of the Flavanonol to Quercetin.—(a) The flavanonol (300 mg.) was heated (24 hr.; steambath) with dilute sulfuric acid (7%) and the reaction mixture on fractional crystallization with dilute alcohol (30%) yielded quercetin (24 mg.), m.p. and mixed m.p. 310–312° dec., while the major fraction of the flavanonol (250 mg.) was recovered unchanged.

(b) The flavanonol (300 mg.) was heated (1 hr.; steam bath) with iodine (100 mg.) in glacial acetic acid (3 ml.) and fused sodium acetate (500 mg.). The yellow precipitate obtained on dilution and cooling was worked up and crystallized (glacial acetic acid) to give yellow needles of quercetin (270 mg.), m.p. and mixed m.p. 310–312° dec.

Reduction of the Flavanonol with Zinc and Hydrochloric Acid.—The flavanonol (200 mg.) was treated in methanolic solution (10 ml.) with zinc powder (2 g.) and concd. hydrochloric acid (4 ml. added dropwise) with vigorous shaking (1.5 hr.; room temperature). The reaction mixture was kept overnight and the clear filtrate after separation of the unchanged zinc was diluted with ice-cold water (20 ml.) and the resultant white precipitate collected and dried. On repeated crystallizations (water) it yielded crystalline needles (50 mg.), m.p. 268–270° (eriodictyol, lit.,[2] m.p. 272°). Its characteristic color reactions are same as those reported for eriodictyol.

Anal. Calcd. for $C_{15}H_{12}O_6$: C, 62.5; H, 4.2. Found: C, 62.3; H, 4.5.

Alkali Degradation.—(a) The flavanonol (300 mg.) was refluxed (1 hr.) with caustic potash (2.5 g. in 25 ml. water and 25 ml. alcohol) and worked up as usual to give a cream-white acidic product (30 mg.), m.p. 190° after purification through sublimation (150°/3 mm.). There was no depression in its melting point in admixture with authentic sample of protocatechuic acid.

(b) The total methylated product of the flavanonol (m.p. 150–155°; 1 g.) was boiled (3 hr.) with a potassium hydroxide solution (aqueous, 5%; 50 ml.) and the neutral precipitate obtained on cooling and dilution yielded after crystallization (alcohol) rhombic plates (250 mg.), m.p. 119°, $C_{17}H_{18}O_6$.

Anal. Calcd. for $C_{17}H_{18}O_6$: C, 64.1; H, 5.6. Found: C, 63.7; H, 5.76.

The filtrate on acidification (hydrochloric acid, 5 ml.) yielded a solid residue (100 mg.) which on sublimation (130°/3 mm.) gave veratric acid, m.p. and mixed m.p. with authentic sample, 179–180°.

Anal. Calcd. for $C_9H_{10}O_4$: C, 59.3; H, 5.49. Found: C, 59.5; H, 5.7.

Acknowledgment.—Authors' thanks are due to Professor K. N. Kaul, Director, National Botanic Gardens, Lucknow, for his keen interest in this investigation.

Crystalline Complexes of 1,3,5-Trinitrobenzene and Alkali Sulfites

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Muraour[1] reported that aqueous solutions of sodium sulfite (3–5%) would dissolve 1,3,5-trinitrobenzene (TNB) and lesser quantities of 2,4,6-trinitrotoluene (TNT) through the formation of red-colored addition compounds but would not dissolve 2,4,6-trinitro-*m*-xylene. From these aqueous solutions the TNB or TNT could be recovered by acidification or in the case of TNT by dilution with water. Although Muraour stated that this complex of TNB and sodium sulfite would be studied further, no other information has appeared.

Dark red crystalline compounds, in which the mole ratio of TNB to sulfite is 1:2, can be isolated if TNB is dissolved in warm aqueous solutions of sodium or potassium sulfite (20% by weight) and the resulting solutions quickly cooled to ambient temperature. If these solutions stand for twenty-four hours, the complex disappears completely and the TNB is destroyed (see below). When dry, these compounds are very stable; samples have

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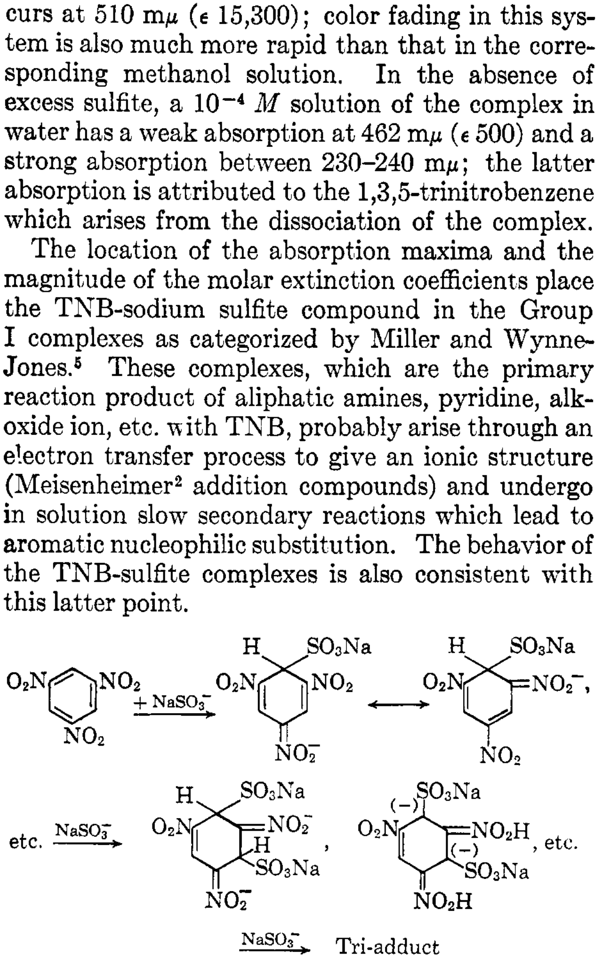
(1) H. Muraour, *Bull. soc. chim. France*, **35**, 367 (1924).

been stored at room temperature for six years without change. By way of contrast, the addition complexes obtained from TNB and sodium alkoxides or potassium cyanide[2-4] are both unstable and explosive.

These TNB-sulfite addition compounds show absorption maxima at 462 mμ (peak) and 525 mμ (shoulder) in either water or 40% methanol solutions which are 10^{-4} M in complex and 0.01 to 0.09 M in sodium sulfite. The extinction coefficients are 17,300 and 8700, respectively. In 40% acetone, 0.01 M sodium sulfite, an absorption maxima occurs at 510 mμ (ϵ 15,300); color fading in this system is also much more rapid than that in the corresponding methanol solution. In the absence of excess sulfite, a 10^{-4} M solution of the complex in water has a weak absorption at 462 mμ (ϵ 500) and a strong absorption between 230–240 mμ; the latter absorption is attributed to the 1,3,5-trinitrobenzene which arises from the dissociation of the complex.

The location of the absorption maxima and the magnitude of the molar extinction coefficients place the TNB-sodium sulfite compound in the Group I complexes as categorized by Miller and Wynne-Jones.[5] These complexes, which are the primary reaction product of aliphatic amines, pyridine, alkoxide ion, etc. with TNB, probably arise through an electron transfer process to give an ionic structure (Meisenheimer[2] addition compounds) and undergo in solution slow secondary reactions which lead to aromatic nucleophilic substitution. The behavior of the TNB-sulfite complexes is also consistent with this latter point.



Gitis[6] has proposed that the absorption maximum at 462 mμ corresponds to a diadduct since this is the form with the least conjugation. The monoadduct being more highly conjugated would absorb at longer wave lengths.

The solid complex showed no electron paramagnetic resonance. The relatively simple infrared spectrum of the symmetrical TNB has been replaced by a much more complicated one for the solid complex. This observation argues against a symmetrical, sandwich-type, π complex. The infrared spectrum is consistent with that required by the proposed addition complex; especially significant are the changes in the C—H stretching mode, the C—H in-plane and out-of-plane deformations, and the C—NO$_2$ asymmetric and symmetric stretching modes. The splitting and changes of intensity with the C—NO$_2$ absorptions are similar to those reported by Dyall,[7] who made a detailed interpretation of the infrared spectra of several Meisenheimer addition complexes derived from picryl ethers.

When dilute aqueous solutions (10^{-3}–10^{-4} M) of the complex are allowed to stand several days, the color fades. Both reversible and irreversible processes are involved since some of the color can be regenerated by adding more sulfite. When the solutions contain an excess of sulfite, only the irreversible process is observed; TNB cannot be recovered and the main products are water-soluble. Earlier, Muraour[1] suggested that the initial complex was transformed to a sulfonate. A 10–12% yield of picric acid is recovered when a solution of TNB in aqueous sodium sulfite, which has stood for 72 hr., is acidified. A somewhat larger yield of picric acid is realized if the solution also contains excess nitrite ion. This formation of picric acid is consistent with and offers support to the formulation of a Meisenheimer complex.

By heating TNB and sodium sulfite in aqueous methanol, sodium picrate, 3,5-dinitroaniline, 3,5-dinitroanisole, and 3,3′,5,5′-tetranitroazoxybenzene can be isolated in low yields. The latter two compounds have been previously isolated from reactions of TNB in alkaline solutions.[8] Gold and Rochester[9] also detected picric acid spectrophotometrically among the products from the reaction of TNB and aqueous alkali. Two different sulfonates of unknown structure have also been isolated; the analyses suggest that these sulfonates are nitroaniline derivatives which could arise in part through an intramolecular oxidation-reduction which simultaneously leads to aromatization of the initial complex.

Analogous to the method of Izzo,[10] who used a bicarbonate catalyst, one nitro group is rapidly replaced by methoxy when TNB is heated with an aqueous methanol solution of potassium cyanate. Some replacement of nitro by ethoxy can also be accomplished with the cyanate.

Experimental

1,3,5-Trinitrobenzene–Sodium Sulfite Complex.—Three grams of recrystallized 1,3,5-trinitrobenzene was added all at once with stirring to 20 ml. of an aqueous sodium sulfite solution (20% by weight) at 50°. Both the rate of solution and color development are rapid. After the TNB had dissolved, the dark red solution was cooled to room tempera-

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[2] J. Meisenheimer, *Ann.*, **323**, 205 (1902); **355**, 249 (1907).

[3] C. L. Jackson and F. H. Gazzolo, *Am. Chem. J.*, **23**, 376 (1900).

[4] C. L. Jackson and R. B. Earle, *ibid.*, **29**, 89 (1903).

[5] R. E. Miller and W. F. K. Wynne-Jones, *J. Chem. Soc.*, 2375 (1959); *Nature*, **186**, 149 (1960).

[6] S. S. Gitis, G. M. Oksengendler and A. Ya. Kaminskii, *J. Gen. Chem. U.S.S.R.* (Eng. Transl.), **29**, 2948 (1959).

[7] L. K. Dyall, *J. Chem. Soc.*, 5160 (1960).

[8] C. A. Lobry de Bruyn, *Rec. trav. chim.*, **9**, 208 (1890); C. A. Lobry de Bruyn and F. H. van Leent, *ibid.*, **13**, 148 (1894).

[9] V. Gold and C. H. Rochester, *Proc. Chem. Soc.*, 403 (1960).

[10] P. T. Izzo, *J. Org. Chem.*, **24**, 2026 (1959).

ture. The crystalline product was removed by filtration, aspirated as dry as possible, washed with two 30-ml. portions of 50% aqueous ethanol, two 20-ml. portions of 95% ethanol, and one 30-ml. portion of diethyl ether. Because of solubility losses the yield was only about 2 g. The purple-red crystals were very soluble in water but insoluble in 95% ethanol. By acidifying and cooling the original mother liquors there was recovered 0.72 g. of TNB.

Anal. Calcd. for $C_6H_3N_3O_6{\cdot}2Na_2SO_3{\cdot}4H_2O$: TNB, 39.67; C, 13.41; H, 2.06; N, 7.82; S, 11.93; Na, 17.13. Found: TNB, 39.33, 39.79, 39.44; C, 13.83, 14.15; H, 2.42, 2.03; N, 7.96, 7.93; S, 11.83; Na, 17.49.

The loss in weight after drying at 100° for 6 hr. was 10.1%; theory for the tetrahydrate requires 13.41% or 10.06% if only three of the four water molecules are lost under these drying conditions. Prolonged heating at 100° under vacuum causes a further loss in weight but is accompanied by the sublimation of some TNB.

The infrared spectra of TNB and its sodium sulfite complex were obtained in both Nujol and hexachlorobutadiene mulls and in potassium bromide pellets; the molar concentrations were kept approximately the same. Pertinent absorption frequencies (cm.$^{-1}$) follow: TNB: 3100 (wm); 1628 (m); 1543 (s); 1440 (w); 1340 (s); 1075 (m); 918 (m); 910 (w); 755 (w); 730 (ms); 713 (ms). TNB:$2Na_2SO_3$:$4H_2O$: 3100–3600 (m, broad peak); 1655 (w); 1580 (m); 1543 (ms); 1480 (ms); 1440 (s); 1330 (ms); 1297 (ms); 1223 (s, broad peak); 1120 (ms); 1035 (s, broad peak); 922 (m); 885 (m); 775 (wm).

1,3,5-Trinitrobenzene–potassium sulfite complex was made by the same procedure as outlined for the corresponding sodium compound. The crystals which separated initially were dark blue by reflected light, purple by transmitted. After standing several days at room temperature in the dry state, a polymorphic change occurred, and the product became microcrystalline and dark red in color.

Anal. Calcd. for $C_6H_3N_3O_6{\cdot}2K_2SO_3{\cdot}2H_2O$: TNB, 37.68; C, 12.73; H, 1.25; N, 7.43; S, 11.34; H_2O, 6.37. Found: TNB, 38.33; C, 12.59, 12.48; H, 1.93, 1.31; N, 7.48; S, 11.31, 11.32; H_2O, 6.09.

The water determination was only approximate since some TNB was lost simultaneously and a correction for this had to be applied.

Aqueous solutions (about 20 wt. %) of potassium bisulfite, sodium thiosulfate, sodium selenite, sodium chlorate, sodium metaphosphate, sodium orthophosphite, glycine, or sodium glycinate did not yield colored complexes or solid products with 1,3,5-trinitrobenzene. In general the latter material was recovered quantitatively. No solid complex resulted when 2,4,6-trinitrotoluene or 2,4,6-trinitroanisole was agitated with either aqueous sodium or potassium sulfite although red-colored solutions were formed.[11] 2,4,7-Trinitrofluorenone dissolved slowly with reaction in an aqueous solution (20%) of sodium sulfite; no starting nitrocompound could be recovered by acidifying the resulting dark brown solution even when the latter had only been made for 5 min. Benzotrifuroxane did not dissolve in aqueous sulfite solutions and no color developed in aqueous methanolic sulfite solutions. Diethyl sulfite and TNB did not give a colored complex; aqueous solutions of dimethyl sulfoxide (DMSO) did not dissolve TNB.

Picric Acid from 1,3,5-Trinitrobenzene and Aqueous Sodium Sulfite.—Trinitrobenzene (9 g.) was dissolved in 60 ml. of 20% aqueous sodium sulfite at 50–55°. The red crystalline complex separated when the solution was cooled to room temperature. The mixture was allowed to stand, however, for 72 hr. (90 hr. in a second experiment); after 24 hr. all of the complex had disappeared. The dark brown-colored solution was cooled and acidified with 17 ml. of concentrated hydrochloric acid; sulfur dioxide was evolved, the solution became red in color and a yellow solid separated. The latter was removed by filtration after chilling the solution at 5° for 24 hr.; the yield of dried product, which melted at 120–121°, was 1.0 g. (10.3%) in one experiment and 1.2 g. (12.4%) in a second. Upon admixture with picric acid the melting point was 121–122°; with TNB, 115–117°.

The mother liquors were evaporated to dryness and the residue extracted with one 75-ml. and two 25-ml. portions of hot 95% ethanol. The insoluble inorganic residue was discarded. The alcoholic extracts were cooled overnight at 5°, then decanted from some insoluble tar (water-soluble). The solvent was again evaporated and the residue fractionally crystallized from 95% ethanol. The less soluble fractions were generally tarry and were discarded; ultimately a fraction was obtained which, after several recrystallizations from ethanol, melted at 228–230° dec. It was readily soluble in water. Analyses of this latter material suggest sulfonation of the ring with some reduction of nitro groups. The structure of the compound was not determined.

Anal. Calcd. for $C_6H_7N_3O_6S{\cdot}H_2O$: C, 28.68; H, 3.61; N, 16.73; S, 12.76. Found: C, 29.17; H, 3.00; N, 16.37; S, 12.28; ash, none.

Reaction of Sodium Sulfite with 1,3,5-Trinitrobenzene in Aqueous Methanol.—To a solution of 10 g. of TNB in 190 ml. of methanol was added 9.5 g. of anhydrous sodium sulfite in 60 ml. of water. The dark red slurry was refluxed with stirring for 2.5 hr., then cooled overnight at 5°. The solid was removed by filtration (0.3 g. of TNB was recovered from the filtrate). When the solid cake was washed with five 25-ml. portions of water, 1.25 g. of insoluble material, m.p. 80–100°, was left; one recrystallization from 85 ml. of 50% aqueous ethanol gave 0.9 g. (9.7%) of 3,5-dinitroanisole, m.p. 105–106°, as pale yellow needles. The red water-washings were acidified (sulfur dioxide evolved) and cooled; 0.1 g. of TNB was recovered. The acid, aqueous solution was next evaporated to one-half volume in a current of air, heated to dissolve precipitated solid, and re-cooled. A small amount of water-soluble solid crystallized and was removed; after one recrystallization from 95% ethanol, the yellow prisms decomposed at 188–189°. The analyses are reasonably consistent with those required for a hydrated sodium salt of 3,5-dinitroaniline-2-sulfonic acid.

Anal. Calcd. for $C_6H_4N_3SO_7Na{\cdot}2H_2O$: C, 22.44; H, 2.50; N, 13.08; S, 9.98; Na, 7.16. Found: C, 22.31, 22.25; H, 2.34, 2.51; N, 13.58, 13.24; S, 10.27; Na, 8.0.

The aqueous mother liquors were evaporated to dryness; the residue was extracted with absolute ethanol, the extract cooled, filtered, and partially evaporated. The solid material, which was recovered and which decomposed about 180°, was first extracted with two 25-ml. portions of boiling water, then recrystallized from 70% aqueous ethanol. The yellow, crystallized product now melted at 187–188°; reported[8] for 3,3′,5,5′-tetranitroazoxybenzene, 185°. The analyses are also in agreement with those required for this compound.

Anal. Calcd. for $C_{12}H_6N_6O_9$: C, 38.10; H, 1.60; N, 22.22. Found: C, 38.00; H, 1.74; N, 22.64.

In another experiment with double the quantities there was recovered 2.7 g. (14.5%) of 3,5-dinitroanisole, 0.8 g. (4.5%) of impure 3,3′,5,5′-tetranitroazoxybenzene (m.p. 180–182°), and 2.7 g. (16%) of crude 3,5-dinitroaniline (m.p. 125–128°). After several recrystallizations from water the latter fraction was obtained as felted orange needles, m.p. 148–149°, somewhat lower than the reported 163°. However, upon admixture with an authentic sample of 3,5-dinitroaniline[12] the melting point was raised to 160–161°. The acetyl derivative melted at 191°, reported for 3,5-dinitroacetanilide, 191°.[12] In addition a small quantity of sodium picrate monohydrate, m.p. 277–278° dec., was separated from the final fractions and identified.

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[11] For a solution which is 10^{-4} *M* in TNT and 0.01 *M* in sodium sulfite (40% aqueous methanol as solvent) the extinction coefficients are 1600 and 1200 at 462 and 525 mμ, respectively; for a comparable TNB solution, they are 24,100 and 12,100.

[12] J. J. Blanksma and G. Verberg, *Rec. trav. chim.*, **53**, 988 (1934).

Anal. Calcd. for $C_6H_4N_3O_8Na$: C, 26.78; H, 1.50; N, 15.61; Na, 8.55. Found: C, 26.91; H, 1.52; N, 15.20, 16.22; Na, 8.38.

An unidentified, water-soluble sulfonate (3.9 g., m.p. > 300°) was also isolated. The salt was fractionally precipitated by dissolving in 75% ethanol and adding increments of absolute ethanol. The initial fractions, which were dark and amorphous, were discarded. Ultimately, a well crystallized, tan-colored solid was obtained; a sample was dried at 105° for 40 hr. before analysis.

Anal. Found: C, 21.87, 21.46; H, 1.60, 1.75; N, 15.75, 15.65; S, 9.17, 9.13; Na, 10.25, 10.81.

The *p*-toluidine salt of the above sulfonate was prepared in 5 *N* hydrochloric acid; after recrystallization from water it was obtained as rosettes of orange-red needles, m.p. 196–197° (vigorous decomposition).

Anal. Calcd. for $C_{14}H_{16}N_5O_{11}S$: C, 36.36; H, 3.49; H, 15.15; S, 6.93. Found: C, 36.44; H, 3.34; N, 15.19; S, 7.10.

Regeneration of the sodium salt from the recrystallized *p*-toluidine salt gave a compound which was analytically the same as the starting sodium salt.

Much dark orange, amorphous, water- and ethanol-soluble material was also formed.

1,3,5-Trinitrobenzene with Sodium Sulfite–Sodium Nitrite in Aqueous Methanol.—The reaction was performed as in the previous experiment except that 20 g. of TNB, 10 g. of sodium sulfite, 10 g. of sodium nitrite, 300 ml. of methanol, and 120 ml. of water were used. Much dark purple solid was present in the mixture throughout the 2.5-hr. heating period. After the solution had been cooled to room temperature, this precipitate was removed by filtration, washed once with 40 ml. of 75% aqueous methanol, then three times with 50-ml. portions of absolute methanol. There was left 9.4 g. of the TNB-sodium sulfite complex admixed with some sodium sulfate (based on X-ray powder pattern).

When the combined mother liquors and washings were cooled overnight at 0°, there was recovered 7.3 g. of material, m.p. 85–100°. Recrystallization from ethanol gave 3.2 g. of TNB, m.p. 121–123°. Probably some 3,5-dinitroanisole was present but no effort was made to isolate and characterize it in this experiment.

The mother liquor was next evaporated to 75 ml. under reduced pressure and cooled at 5° for 24 hr. The mixture of yellow plates and orange powder was removed by filtration. Extraction with warm water dissolved the orange powder and left 1.35 g. of insoluble material, m.p. 90–110° (probably TNB). Evaporation of the water extracts gave 1.8 g. (7.5% conversion; at least 20% yield) of sodium picrate monohydrate which was identified by comparison of its X-ray powder pattern with that of an authentic sample and by conversion to picric acid, m.p. 121–122°, mixed melting point undepressed.

3,5-Dinitroanisole.—A solution consisting of 10 g. of 1,3,5-trinitrobenzene, 12.5% of potassium cyanate, 190 ml. of methanol, and 40 ml. of water was refluxed and stirred for 2.5 hr. Ammonia was evolved from the orange-red solution. After the reaction mixture had been cooled to 5°, the long, orange-brown needles were removed by filtration and washed with 25 ml. of cold 50% ethanol. The yield of dried product, m.p. 107–108°, was 8 g. (86%).

By evaporating the mother liquors to dryness, dissolving the residue in water, and acidifying the resulting solution, there was recovered 0.6 g. of a mixture of TNB and dinitroanisole, melting at 75–80°.

When the above procedure was repeated using ethanol instead of methanol and keeping the temperature 60–61°, 7.0 g. of TNB, m.p. 120–121°, was recovered. By diluting the mother liquors with a large volume of water and cooling, there was precipitated 1.0 g. of solid melting 75–80°. Three recrystallizations, one from methanol and two from absolute ethanol, gave a small quantity of material melting sharply at 97–98°. Blanksma[13] reported a m.p. of 96° for 3,5-dinitrophenetole.

Acknowledgment.—The author wishes to thank Prof. Hans Jonassen, Tulane University, for numerous helpful discussions, Dr. Allen Olsen for the infrared spectra, and Fred Bien for the e.p.r. measurement.

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[13] J. J. Blanksma, *Rec. trav. chim.*, **24**, 40 (1905).

The Reductive Acylation of Schiff Bases Using Trimethylamine Borane. IV

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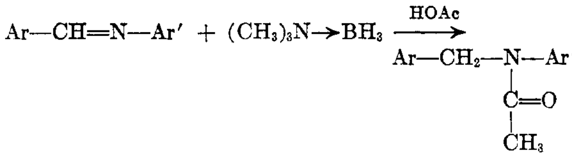
During the course of the investigation dealing with the use of dimethylamine borane for the reduction of Schiff bases[1] an attempt was made to utilize trimethylamine borane for the same purpose. It was found that this reagent would likewise reduce a Schiff base to the corresponding secondary amine. However, it was also discovered that, upon prolonged refluxing with an excess of the amine borane in glacial acetic acid, the acetamide corresponding to the acetyl derivative of the secondary amine was obtained.



$$\text{Ar—CH=N—Ar'} + (CH_3)_3N\rightarrow BH_3 \xrightarrow{\text{HOAc}} \text{Ar—CH}_2\text{—N(—C(=O)—CH}_3\text{)—Ar'}$$

This reaction is unique in that the acid itself is the acylating agent, whereas usually more reactive acid derivatives, such as the acyl halides or anhydrides, must be used for this purpose. This reagent thus is capable of reducing and acetylating the Schiff base in a single reaction process. There have been several examples of reductive acylation in the literature, all of which involve an integrated use of two reagents, one for reduction and one for acylation. For example, azo compounds or hydrazones containing an active methylene group were reduced with a metal reducing agent and an aliphatic acid anhydride to form the corresponding acylated amine.[2] Another case was the reductive acetylation of the actinomycins using hydrogenation over platinum in acetic anhydride followed by addition of pyridine to promote acetylation.[3] In light of these facts, it was decided to investigate this reaction

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[1] J. H. Billman and J. W. McDowell, *J. Org. Chem.*, **26**, 1437 (1961).

[2] K. Pfister and M. Tishler, U.S. Patent 2,489,927; *Chem. Abstr.*, **44**, 2552 (1950).

[3] H. Brockmann and B. Franch, *Angew. Chem.*, **68**, 68 (1956).