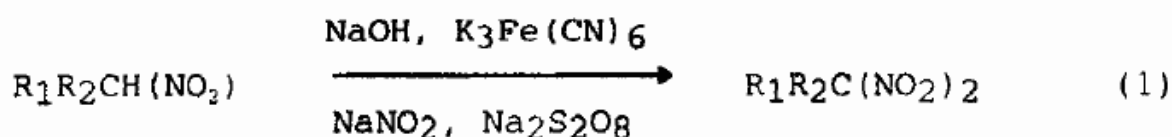
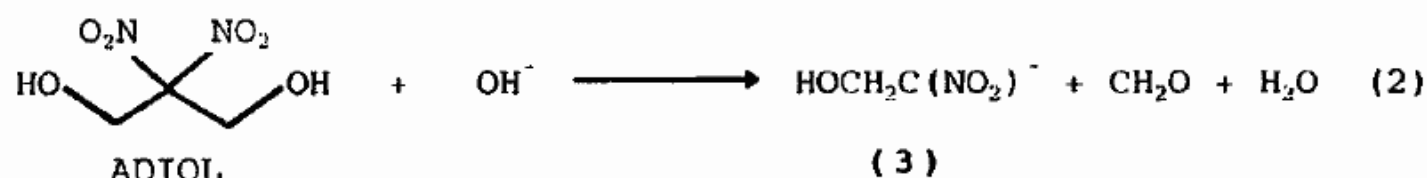


IMPROVED SYNTHETIC ROUTES TO POLYNITROHETEROCYCLES

The oxidative nitration of nitronate salts to gem-dinitro compounds using potassium ferricyanide (Eq.1) has been thoroughly explored<sup>1,2</sup>. This method has also proved useful in the large-scale production of the explosive 1,3,3-trinitroazetidine (TNAZ) largely because the yield is high, the reagents are inexpensive, and the waste is easily disposable<sup>3-5</sup>. It is for these reasons that the authors have adopted this method in the preparation of other gem-dinitro compounds.

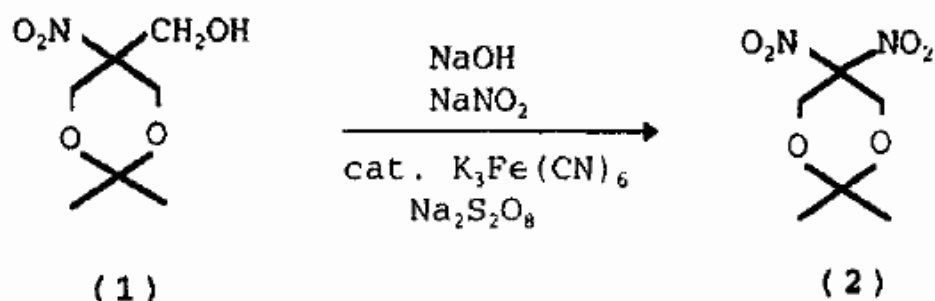


However, oxidative nitration is not nearly so successful for the preparation of some gem-dinitro compounds. One example is the direct synthesis of 2,2-dinitro-1,3-propanediol (ADIOL) by the oxidative nitration of nitromethane/formaldehyde mixture or tris(hydroxymethyl)nitromethane<sup>1</sup>. In these preparations, the ADIOL is extracted by organic solvent after oxidative nitration with only 30-35% recovery. This is attributed to the solubility of ADIOL in water and its ability to undergo deformylation by a retro-Henry reaction under basic conditions (Eq.2). The oxidative nitration reaction is normally performed under basic conditions, with pH values between 8 and 11. Any attempt to shift the deformylation equilibrium by lowering the pH of the reaction solution prior to extraction will only complicate the procedure.



The oxidative nitration medium contains an excess of nitrite ion which, at low pH, converts to nitrous acid. The acid decomposes into voluminous amounts of nitric oxide and nitrosates the ADIOL to an unstable nitrite ester.

The difficult extraction step was circumvented by isolating the ADIOL as a water insoluble cyclic ketal. This was achieved by treating tris(hydroxymethyl)nitromethane with acetone and boron trifluoride etherate to generate 5-hydroxymethyl-2,2-dimethyl-5-nitro-1,3-dioxane<sup>6</sup> (1), which was converted in excellent yield to 2,2-dimethyl-5,5-dinitro-1,3-dioxane (2) by oxidative nitration. ADIOL was nearly quantitatively recovered by treating the cyclic ketal with excess methanol and trace acid. Potassium aci-2,2-dinitroethanol (3) was obtained by treating the said methanolic solution with potassium hydroxide.



### 2,2-Dimethyl-5,5-dinitro-1,3-dioxane (2)

To 200 mL of water containing sodium hydroxide (4.2 g, 105 mmol) was added compound (1) (10.0 g, 52.4 mmol) and the suspension was stirred until solution was complete. To this solution was added a solution of sodium nitrite (14.4 g, 209 mmol) and potassium ferricyanide (1.7 g, 5.2 mmol) in 30 mL of water. Solid sodium persulfate (13.1 g, 55.0 mmol) was added in portions while the temperature was kept below 30°C by the addition of ice. The cloudy solution was stirred for an additional two hours. The solid was filtered, washed with water and air dried to give 9.25 g (86%) of white product, mp 55.3-56°C (lit. mp 55.5-56°C)<sup>6</sup>. <sup>1</sup>H nmr (CDCl<sub>3</sub>) δ 1.45 (s, 6H), 4.65 (s, 4H); <sup>13</sup>C nmr (CDCl<sub>3</sub>) δ 22.93, 62.19, 101.01, 111.75.

### 2,2-Dinitro-1,3-propanediol (ADIOL)

To a solution of (2) (10.0 g, 48.5 mmol) in 100 mL of anhydrous methanol was bubbled a catalytic amount of dry HCl gas. The solution was allowed to react for 24 hours at room temperature and tested for completion by TLC. One gram of activated charcoal was added and the mixture warmed, filtered, and stripped of solvent. Several grams of anhydrous magnesium sulfate was mixed into the crude syrupy residue to initiate solidification. Soxhlet extraction of the solid matrix with methylene chloride (60 mL) yielded 6.49 g of product. Evaporation of the methylene chloride solvent afforded an additional 1.37 grams, mp 134.2-134.5°C (combined yield, 98%). Recrystallization from chloroform/heptane mixture gave white needles, mp 137.6-140.0°C (lit. mp 140-2°C).<sup>1</sup>

<sup>1</sup>Lee C. Garver, V. Grakauskas and K. Baum, *J. Org. Chem.*, **50**, 1699 (1985).

<sup>2</sup>N. Kornblum, H. K. Singh and W. J. Kelly, *J. Org. Chem.*, **48**, 332 (1983).

<sup>3</sup>M. A. Hiskey and M. D. Coburn, Synthesis of 1,3,3-Trinitroazetidine, U.S. Patent 5,336,784 (9 August 1994).

<sup>4</sup>T. G. Archibald, R. Gilardi, K. Baum and C. George, *J. Org. Chem.*, **55**, 2920 (1990).

<sup>5</sup>M. D. Coburn, M. A. Hiskey and T. G. Archibald, *Waste Management*, **17**, No. 2/3, 143 (1997).

<sup>6</sup>G. B. Linden and M. H. Gold, *J. Org. Chem.*, **21**, 1175 (1956); "Method B. Using a molecular quantity of boron-trifluoride-etherate and excess carbonyl reagent as solvent" was the preferred method for preparing compound (1).