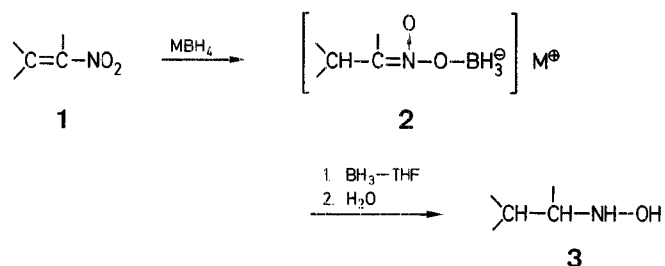


### Reduction of $\alpha,\beta$ -Unsaturated Nitroalkenes with Trialkylborohydrides; A Synthesis of Ketones

M. Scubei MOURAD, Rajender S. VARMA, George W. KABALKA\*

Department of Chemistry, University of Tennessee, Knoxville, Tennessee 37996-1600, U.S.A.



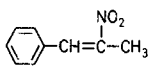
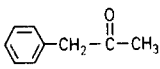
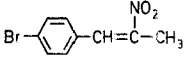
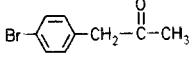
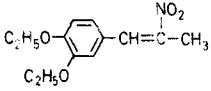
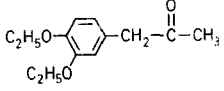
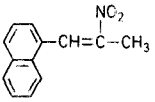
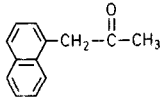
We recently described a novel preparation of *N*-substituted hydroxylamines (**3**) which involves the reduction of  $\alpha,\beta$ -unsaturated nitroalkenes (**1**) by borane-tetrahydrofuran in the presence of a catalytic amount of sodium borohydride<sup>1</sup>. The reaction presumably proceeds via a 1,4-addition of borohydride to the nitroalkene producing the corresponding nitronate (**2**), which is subsequently reduced by borane-tetrahydrofuran to afford hydroxylamines after hydrolysis.



We reasoned that the hydrolysis of intermediate **2** would produce the corresponding carbonyl compound (a modified Nef reaction<sup>2</sup>) if it could be intercepted before a complete reduction occurred. We investigated the use of trialkylborohydrides for the formation of intermediate **2** via the reduction of conjugated nitroalkenes because they had been successfully utilized in conjugate additions to  $\alpha,\beta$ -unsaturated carbonyl compounds<sup>3</sup>. We found that lithium triethylborohydride<sup>4</sup> and lithium tri-*sec*-butylborohydride<sup>5</sup> cleanly reduce a conjugated nitroalkene to the desired nitronate (**4**) which is then readily hydrolyzed<sup>6</sup> to the corresponding ketone (**5**).

To avoid the formation of a pyrophoric by-product (triethylborane) and to employ a comparatively mild nucleophile,

**Table.** Ketones (**5**) from Nitroalkenes (**1**) via Reduction and Hydrolysis<sup>a</sup>

Substrate <b>1</b>	Product <b>5</b>	Reaction Time [min]	Yield <sup>b</sup> [%]	b.p. [°C]/torr	
				found	reported
		30	81	58–60°/20	47°/15 <sup>13</sup>
		30	80	[187–189°] (80% ethanol)]	[186–187° <sup>10</sup> ] <sup>c</sup>
		30	82	70–72°/0.1 <sup>d</sup>	110°/0.3 <sup>11</sup>
		30	83 <sup>e</sup>	110–113°/0.1 <sup>d</sup>	125–130°/0.28 <sup>14</sup>
		90	81	93–97°/0.1 <sup>d</sup>	121–126°/0.77 <sup>15</sup>

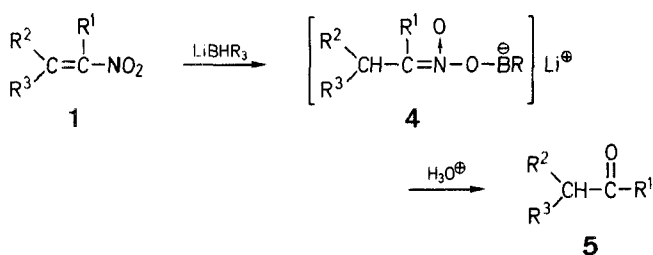
<sup>a</sup> Reduction with lithium tri-*sec*-butylborohydride and hydrolysis with 4 normal sulfuric acid.

<sup>b</sup> Yield of pure, isolated product.

<sup>c</sup> m.p. of semicarbazone.

<sup>d</sup> Kugelrohr distillation.

<sup>e</sup> <sup>1</sup>H-N.M.R. (CDCl<sub>3</sub>/TMS<sub>int</sub>); δ = 6.8–6.74 (m, 3 H<sub>arom</sub>); 4.06 (q, 4H, 2OCH<sub>2</sub>); 3.6 (s, 2H, CH<sub>2</sub>); 2.12 (s, 3H, CO—CH<sub>3</sub>); 1.43 ppm (t, 6H, 2CH<sub>3</sub>).



we confined the study to the use of lithium tri-*sec*-butylborohydride for the conjugate reduction. The results demonstrate that the reaction can be used to reduce a variety of conjugated nitroalkenes (**1**) to the corresponding ketones (**5**). Interestingly, the reduction of β-nitrostyrene derivatives produced white precipitates<sup>4</sup> upon reaction with borohydride solution. Acid hydrolysis of the reaction mixtures yielded saturated nitroalkanes predominantly; only traces of aldehydes were obtained.

The abstraction of hydrogen from a secondary nitroalkane<sup>4,8</sup> would also generate intermediate **4** which could then be hydrolysed to a ketone. In a related experiment, nitrocyclohexane was added to lithium triethylborohydride and the resultant intermediate (**4**) was subjected to acid hydrolysis: cyclohexanone was obtained in > 90% yield.

Several modifications of the Nef reaction<sup>2</sup> have been reported [e.g. reduction of nitro compounds with titanium(III) chloride<sup>8</sup>, ozonolysis<sup>8</sup> and permanganate oxidation<sup>9</sup> of nitronates, reverse addition of lithium aluminium hydride to nitroalkenes<sup>10</sup>, and reduction of nitroalkenes with iron/hydrochloric acid<sup>11</sup>]. However, the trialkylborohydride method has the advantages of simplicity, shorter reaction time, and higher yields.

All glassware was thoroughly flame-dried and cooled under dry nitrogen just before use. Tetrahydrofuran was dried with calcium hydride, distilled from lithium aluminium hydride, and stored under nitrogen. Air- and moisture-sensitive borohydride solutions were

transferred using oven-dried hypodermic syringes. 1-Nitrocyclohexene and the trialkylborohydrides were used as obtained from Aldrich Chemical Co. (L-Selectride<sup>®</sup>, 1.0 molar in tetrahydrofuran; Superhydride<sup>®</sup>, 1.0 molar in tetrahydrofuran). All other nitroalkenes were prepared as described earlier<sup>1</sup>.

The products were characterized by their physical properties and spectral characteristics (<sup>1</sup>H-N.M.R., <sup>13</sup>C-N.M.R., etc.). The N.M.R. spectra were recorded on a JEOL-FX 90 Q spectrometer.

#### Phenylacetone (**5b**) from 2-Nitro-1-phenylpropene (**1b**); Typical Procedure:

Lithium tri-*sec*-butylborohydride (11 ml of a 1.0 molar solution in tetrahydrofuran; 11 mmol) is placed in a flame-dried, nitrogen-flushed, 100 ml flask equipped with a septum inlet and a magnetic stirring bar. A solution of 2-nitro-1-phenylpropene (**1b**; 1.63 g, 10 mmol) in tetrahydrofuran (10 ml) is added dropwise to the stirred solution of the trialkylborohydride at room temperature. A mildly exothermic reaction ensues with the disappearance of yellow coloration (nitroalkene). The mixture is stirred for 30 min and then poured onto cold (–10°C) 4 normal sulfuric acid (50 ml). Ice/water (100 ml) is carefully added to the mixture which is stirred for 10 min. The product is extracted with ether (3 × 50 ml). The combined ether extracts are washed with water (2 × 50 ml), dried with magnesium sulfate, and evaporated under reduced pressure. The crude product is purified by column chromatography (silica gel; 4% ether/petroleum ether eluant) to give **5b** as an oil; yield: 1.1 g (80%); m.p. of **5b** semicarbazone: 187–188°C (Ref.<sup>10</sup>, m.p. 186–187°C).

<sup>1</sup>H-N.M.R. (acetone-*d*<sub>6</sub>/TMS<sub>int</sub>); δ = 7.24 (m, 5 H<sub>arom</sub>); 3.71 (s, 2H, CH<sub>2</sub>); 2.08 ppm (s, 3H, CO—CH<sub>3</sub>). [The <sup>13</sup>C-N.M.R. data agree with the literature data<sup>12</sup>].

We thank the Department of Energy for support of this research. One of us (M.S.M.) thanks Al-Baath University, Syria, for the financial support and sabbatical leave.

Received: September 10, 1984  
(Revised form: October 25, 1984)

\* Address for correspondence.

<sup>1</sup> Mourad, M. S., Varma, R. S., Kabalka, G. W. *J. Org. Chem.* **1985**, *50*, 133.

- <sup>2</sup> Nef, J. V. *Liebigs Ann. Chem.* **1894**, *280*, 264.  
Noland, W. E. *Chem. Rev.* **1955**, *55*, 137.
- <sup>3</sup> Seebach, D., Colvin, E. W., Lehr, F., Weller, T. *Chimia* **1979**, *33*, 1.
- <sup>3</sup> Fortunato, J. M., Ganem, B. *J. Org. Chem.* **1976**, *41*, 2194.
- <sup>4</sup> Brown, H. C., Kim, S. C., Krishnamurthy, S. *J. Org. Chem.* **1980**, *45*, 1.
- <sup>5</sup> Brown, H. C., Krishnamurthy, S. *J. Am. Chem. Soc.* **1972**, *94*, 7159.
- <sup>6</sup> Armand, J. *Bull. Soc. Chim. Fr.* **1965**, 3246.
- <sup>7</sup> Feuer, H., Bartlett, R. S., Vincent, B. F., Anderson, R. S. *J. Org. Chem.* **1965**, *30*, 2880.
- <sup>8</sup> McMurry, J. E. *Acc. Chem. Res.* **1974**, *7*, 281; and references cited therein.
- <sup>9</sup> Kornblum, N., Erickson, A. S., Kelly, W. J., Henggeler, B. *J. Org. Chem.* **1982**, *47*, 4534.
- <sup>10</sup> Gilsdorf, R. T., Nord, F. F. *J. Am. Chem. Soc.* **1952**, *74*, 1837.
- <sup>11</sup> Ferreira, A. B. B., Salisbury, K. *J. Chem. Soc. Perkin Trans. 2* **1978**, 995.
- <sup>12</sup> Vogt, H., Gompper, R. *Chem. Ber.* **1981**, *114*, 2884.
- <sup>13</sup> *Handbook of Chemistry and Physics*, 64th Edn., Weast, R. C., Ed., Chemical Rubber Co., Boca Raton, Florida, 1983/1984, p. C-251.
- <sup>14</sup> Shepard, E. R., Noth, J. F., Porter, H. D., Simmans, C. K. *J. Am. Chem. Soc.* **1952**, *74*, 4611.
- <sup>15</sup> Zimmerman, H. E., McKelvey, R. D. *J. Am. Chem. Soc.* **1971**, *93*, 3638.