

0040-4039(94)02406-5

Selective 1,4-Reduction of Conjugated Aldehydes and Ketones in the Presence of Unconjugated Aldehydes and Ketones with Sodium Dithionite

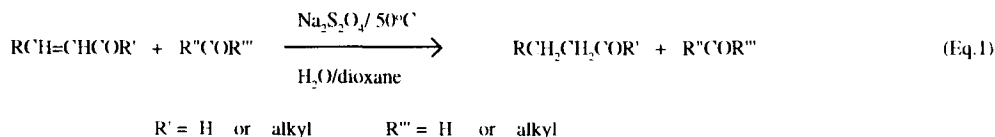
Ranjit S. Dhillon*, Rupinder P. Singh and Daljit Kaur

Department of Chemistry, Punjab Agricultural University,
Ludhiana-141 004, India

Abstract: Chemoselective 1,4-reduction of α,β -unsaturated aldehydes or ketones has been achieved with sodium dithionite in H_2O /dioxane at $50^\circ C$ in the presence of unsaturated (nonconjugated) and saturated aldehydes or ketones.

Sodium dithionite, a commercial reductant used in vat dyeing and as a bleaching agent¹, is also a versatile reagent for the reduction of azo², diazo³, diazonium⁴, N-nitroso⁵, nitro compounds^{2,6}, imines^{7,9}, pyridinium salts⁸, oximes⁹, nitroxides¹⁰ and quinones¹¹. The reagent dehalogenates vicinal dihalides to the corresponding alkenes.¹² de Vries and Kellogg¹³ reported the reduction of aldehydes and ketones to the corresponding alcohols in H_2O /dioxane and Louis-Andre and Gelbard¹⁴ described 1,4-reduction of α,β -unsaturated aldehydes and ketones to afford exclusively the saturated aldehydes and ketones in the presence of phase transfer catalyst.

As a part of our search for cheap reagents for chemoselective reaction¹⁵, we found that sodium dithionite under the reported conditions reduces two component mixture (Table 1) to a product mixture resulting both from 1,2- and 1,4-reduction. However, the same two component mixture (Table 1) with sodium dithionite at $50^\circ C$ in H_2O /dioxane undergoes 1,4-reduction of C=C of α,β -unsaturated aldehydes and ketones to the corresponding saturated carbonyl compounds while the carbonyl moiety of both components remains untouched (Eq. 1).



The reaction procedure and isolation of products are convenient. The reaction yields similar results for the 1,4-reduction of α,β -unsaturated aldehydes or ketones even in the absence of saturated or nonconjugated aldehydes or ketones. The reagent has significant importance with regard to $\Delta^{4,5}$ -3-one steroids which undergo stereospecific reduction to afford trans A/B ring juncture with 5 α -H. The results of this study are presented in Table 1.

Typical Procedure: A solution of 4-cholesten-3-one (10mmol) and 10-undecenal (10 mmol) in dioxane (35 ml) was added to water (35 ml) containing NaHCO_3 (65 mmol, 5.5 g), under nitrogen. Sodium dithionite (14.36 mmol, 2.5 g) was added all at once and reaction mixture was stirred at $50^\circ C$ for 1 hour, during which time additional sodium dithionite was added in three portions of 2.5 g each. The reaction mixture was cooled to room temperature and cold water was added until the solution became clear. Thereafter, the solution was extracted with ether (3x25 ml), dried (Na_2SO_4), distilled and chromatographed to afford 5 α -cholestan-3-one (mp 129 - $130^\circ C$, mmp 128 - $130^\circ C$) and 10-undecenal in 88 and 92% yields, respectively.

Table 1. Selective Reduction of Conjugated Aldehydes and Ketones with Sodium Dithionite

Entry	Substrate	Product ^d (Isolated %, Yield)
1.	3,7-Dimethyl-2(E), 6-octadienal + 10-Undecenal	3,7-Dimethyl-6-octenal (82) + 10-Undecenal (91)
2.	3,7-Dimethyl-2(E), 6-octadienal + 5 α -Cholestan-3-one	3,7-Dimethyl-6-octenal (85) + 5 α -Cholestan-3-one (94)
3.	C ₆ H ₅ CH=CHCHO+10-Undecenal	C ₆ H ₅ CH ₂ CH ₂ CHO (83) + 10-Undecenal (94)
4.	C ₆ H ₅ CH=CHCHO+5 α -Cholestan-3-one	C ₆ H ₅ CH ₂ CH ₂ CHO (84) + 5 α -Cholestan-3-one (92)
5.	C ₆ H ₅ CH=CHCOCH ₃ + 10-Undecenal	C ₆ H ₅ CH ₂ CH ₂ COCH ₃ (83) + 10-Undecenal (91)
6.	C ₆ H ₅ CH=CHCOCH ₃ + 2-Methyldecenal	C ₆ H ₅ CH ₂ CH ₂ COCH ₃ (86) + 2-Methyldecenal (92)
7.	Carvone + C ₆ H ₅ CH ₂ CH ₂ COCH ₃	Dihydrocarvone ^b (86) + C ₆ H ₅ CH ₂ CH ₂ COCH ₃ (94)
8.	Carvone + 10-Undecenal	Dihydrocarvone ^b (82) + 10-Undecenal (93)
9.	α -Ionone + 2-Methyldecenal	1-(Butan-3-one)-2,6,6-trimethylcyclohex-2-ene (85) + 2-Methyldecenal (94)
10.	α -Ionone + C ₆ H ₅ CH ₂ CH ₂ COCH ₃	1-(Butan-3-one)-2,6,6-trimethylcyclohex-2-ene (82) + C ₆ H ₅ CH ₂ CH ₂ COCH ₃ (92)
11.	4-Cholesten-3-one+10-Undecenal	5 α -Cholestan-3-one ^c (88) + 10-Undecenal (92)
12.	4-Cholesten-3-one+Dihydrocarvone	5 α -Cholestan-3-one ^c (89) + Dihydrocarvone (91)
13.	Stigmasta-4,22-dien-3-one+Dihydrocarvone	5 α -Stigmasta-22-en-3-one ^d (88) + Dihydrocarvone (91)

^aThe dihydroproducts were identified by ¹HNMR, IR and elemental analyses only, 4 to 6% of conjugated aldehydes or ketones do not undergo reduction; structures of unreacted aldehydes and ketones were confirmed by IR and ¹HNMR.

^bR,S mixture of newly formed asymmetric centre. ^cmp 129-130°C, ^dmp¹⁶ 165-166°C.

Acknowledgement : We thank CSIR and UGC, New Delhi for financial assistance.

References :

- Baumgarte, U.J. *Tesetilveredlung* 1967, **2**, 896.
- Grandmougin, E. *J. Prakt. Chem.* 1907, **76**, 124.
- Denisou, N.T.; Solovera, S.A.; Shilor, A.E. *Kinet. Kastel.* 1971, **12**, 579.
- Grandmougin, E. *Chem. Ber.* 1907, **40**, 422.
- Overberger, C.G.; McGill, E.V.; Anselme, J.P. *J. Am. Chem. Soc.* 1969, **91**, 687.
- Grandmougin, E. *Chem. Ber.* 1906, **39**iv, 3561.
- Hawthorne, J.O.; Mihelic, E.L.; Morgan, M.S.; Wilt, M.H. *J. Org. Chem.* 1963, **28**, 2831.
- Eisner, U.; Kuthan, J. *Chem. Rev.* 1972, **1**, 72.
- Pojer, P.M. *Aust. J. Chem.* 1979, **32**, 201.
- Haddadin, M.J.; Alkaysi, H.N.; Saheb, S.E. *Tetrahedron*, 1970, **26**, 1115.
- Furusawa, M.; Iwasaki, S.; Matswara, Y. *Nippon Kagaku Kaishi.* 1974, **11**, 2228.
- Brandstron, A.; Junggren, U.; Lamm, B. *Tetrahedron Lett.* 1972, **31**, 3173.
- de Vries, J.G.; Kellogg, R.M. *J. Org. Chem.* 1980, **45**, 4126.
- Louis-Andre, O.; Gelbard, G. *Tetrahedron Lett.* 1985, **26**, 831.
- (a) Gautam, V.K.; Singh, J.; Dhillon, R.S. *J. Org. Chem.* 1988, **53**, 187.
(b) Dhillon, R.S.; Nayyar, K.; Singh, J. *Tetrahedron Lett.* 1992, **33**, 6015.
- Barton, D.H.R.; Brooks, C.J.W. *J. Am. Chem. Soc.* 1950, **72**, 1633.

(Received in UK 31 October 1994; revised 8 December 1994; accepted 9 December 1994)