

Mild Oxidation of Oxime Derivatives with KMnO_4 in Ionic Liquid Media

Javad Safaei-Ghomi^{a,*} and Abdol Reza Hajipour^b

^aDepartment of Chemistry, Faculty of Science, University of Kashan, Kashan 51167, Iran

^bPharmaceutical Research Laboratory, Department of Chemistry, Isfahan University of Technology, Isfahan 84156, IR, Iran; and Dept. of Pharmacology, University of Wisconsin, Medical School, 1300 University Avenue, Madison, 53706-1532, WI, USA

In this research, potassium permanganate in the presence of a catalytic amount of [bmim]Br under solvent free conditions is used as an efficient and chemoselective method for oxidative cleavage of some oximes to corresponding carbonyl compounds. This experiment was carried out in mild conditions without any further oxidation of aldehydes to corresponding acids.

Keywords: Oxime; Mild oxidation; Aldehyde; Ionic liquid; [bmim]Br; KMnO_4 .

INTRODUCTION

Highly crystalline oximes are very efficient derivatives for the isolation, purification and characterization of aldehydes and ketones.^{1,2} The regeneration of carbonyls from oximes provides an alternative method for the preparation of aldehydes and ketones. Several oxidative methods have been developed for deoxygenation in the literature.³⁻¹¹ However, some of these methods suffer from disadvantages such as long reaction times, low yields of the product and tedious work up. There has been considerable interest in the use of selective and cleaner oxidation methods such as heterogeneous oxidation and oxidation in ionic liquids in recent years.¹²⁻¹⁷ Ionic liquids have attracted extensive research interest in recent years as environmentally benign solvents due to their favorable properties like non-inflammability, negligible vapor pressure, reusability and high thermal stability. They have also been referred to as 'designer solvents' as their physical and chemical properties could be adjusted by a careful choice of cation and anion. Apart from this, they exhibit acidic properties. Combining these unique properties of ionic liquids, they are emerging as 'green reaction dual-purpose media' (catalyst + solvent). The use of ionic liquids as reaction medium may offer a convenient solution to both the solvent emission and catalytic recycling problems.¹⁸⁻²⁰

Some of these reactions such as Diels-Alder,^{21,22} nucleophilic substitution,^{23,24} reduction of aldehyde,²⁵ and electrophilic substitution of aromatic rings²⁶⁻³⁰ in ionic liquids as a solvent and catalyst have been reported. The ad-

vantage of these methods over conventional methods is that they provide greater selectivity, enhanced reaction rates, cleaner products and manipulative simplicity. Conversion of carbonyl functionalities into oximes is important not only for protection, purification and characterization of carbonyl groups, but also for various functional group transformations such as into nitrites,^{31,32} nitro compounds,^{33,34} nitrones,³⁵ amines⁶ and isoxazolines.^{36,37} The protection and deprotection of the carbonyl functional group plays an essential role in modern multistep synthesis including natural products and biological active molecules.

According to the development of methods which consists of using environmentally friendly reagents and in continuation of our ongoing program to develop environmentally benign methods, we used ionic liquid in the oxidation of oxime derivatives to their corresponding carbonyl compounds.

RESULTS AND DISCUSSION

In this research some oximes which were derived from their corresponding carbonyl compounds (Table 1) were oxidized with KMnO_4 in 1-Buthyl-3-methylimidazoliumbromide (Scheme I). At first the reaction temperature and amounts of reagents were optimized by the use of oximes derived from benzaldehyde. In this attempt the best results were obtained with a 1: 0.7: 0.4 ratio of oxime: IL: KMnO_4 at room temperature which was used for the other derivatives. The results for various oximes are listed in the

* Corresponding author. Fax: +98-361-5552935; E-mail: safaei@kashanu.ac.ir

Table 1. Oxidative deprotection of oximes derivatives in the presence of KMnO₄/[bmim]Br^{a,b}

Entry	R ¹	R ²	Time (min)	Yield (%)	mp (°C) (lit 38)	bp (°C) (lit 38)
1	C ₆ H ₅	H	40	95	----	176 (179)
2	4-O ₂ NC ₆ H ₄	H	9	> 98	105-106 (106)	----
3	3-O ₂ NC ₆ H ₄	H	18	95	55-57 (58)	----
4	4-MeOC ₆ H ₄	H	53	91	----	246 (248)
5	3-MeOC ₆ H ₄	H	42	94	----	231 (232)
6	2,4-(MeO) ₂ C ₆ H ₃	H	73	89	69 (67-70)	----
7	4-ClC ₆ H ₄	H	12	94	45-46 (47)	----
8	4-BrC ₆ H ₄	H	17	97	57-59 (59-60)	----
9	2,6-Cl ₂ C ₆ H ₃	H	23	91	70-72 (71)	----
10	2,4-Cl ₂ C ₆ H ₃	H	10	> 98	72-74 (74)	----
11	4-MeC ₆ H ₄	H	50	93	----	207 (204-205)
12	2-MeC ₆ H ₄	H	41	95	----	195 (197)
13	3-MeC ₆ H ₄	H	60	91	----	199 (201)
14	C ₆ H ₅	C ₆ H ₅	55	81	47 (47-49)	----
15	C ₆ H ₅	CH ₃	52	92	18-19 (20)	----
16	4-ClC ₆ H ₄	CH ₃	32	93	19-21 (20)	----
17	4-BrC ₆ H ₄	CH ₂ Br	17	93	108 (110-111)	----
18	2-HOC ₆ H ₄	CH ₃	28	90	----	241-242 (243)

^a The yields refer to the isolated products after purification.

^b All of the products were characterized by physical data (mp. or bp.) and their spectra (IR, TLC and ¹H NMR).

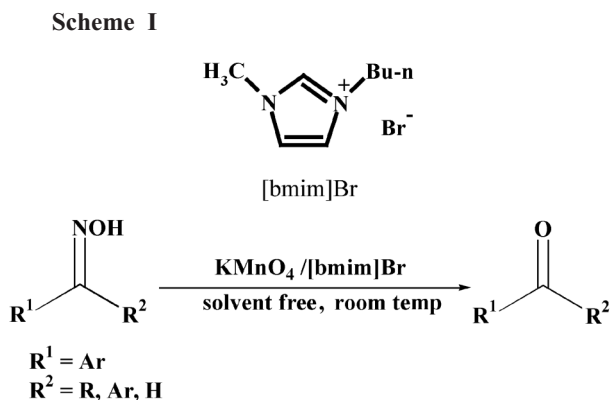


Table 1.

Since KMnO₄ is a strong oxidizing reagent, oxidation of oximes with this reagent occurs absolutely until produced aldehydes are converted to acid. Herein we wish to report the oxidative deprotection of oxime compounds to their corresponding carbonyl compounds under mild conditions without overoxidation to their carboxylic acids. But using KMnO₄ as an oxidizing agent, in opposite of mild desiring conditions, needs that inhibits to further oxidation of oximes to corresponding acids. The results illustrated in the table indicate that the reaction can be used for a variety of oximes.

Following the reaction by TLC shows that by elimi-

nating the starting material spots, the corresponding carbonyl compounds appeared as the only product without any by-product and with good to excellent yields.

In conclusion, ionic liquid acts as an inhibitor with a decrease in the oxidizing ability of KMnO₄ and an increase in the chemoselectivity of oxidation reaction.

EXPERIMENTAL

General

Yields refer to isolated pure products. The products were characterized by comparison of their spectral (IR, ¹H NMR), melting and boiling points with authentic samples. All of the reactions were carried out in a hood with strong ventilation. IR spectra were recorded on a Magna-550 IR spectrophotometer. Spectra of solids were carried out using KBr pellets. ¹H NMR spectra were determined on a Hitachi R-24, B-360 spectrometers at 60 MHz using CDCl₃ as solvent and TMS as internal standard.

Typical procedure for oxidative deprotection of oximes using KMnO₄ in the presence of a catalytic amount of [bmim]Br

In a rounded flask 1 mmol of oxime compound was dissolved in 0.7 mmol IL, BMIM, with stirring at room temperature and then 0.4 mmol of KMnO₄ was slowly added with stirring. The progress of the reaction was moni-

tored by TLC. After completion of reaction which was indicated by TLC, the reaction mixture was diluted with ether (4 × 5 mL) and filtered to remove the solids. Ionic liquid phase was recovered for further uses, the solvent was evaporated under reduced pressure and the mixture of the products was purified by the thick layer chromatography method (EtOAc: petroleum ether, 1:9). For example, 4-chlorobenzaldehydeoxime was converted to 4-chlorobenzaldehyde in 94%, mp 45-46 °C (lit.³⁸: 47).

Received June 11, 2008.

REFERENCES

1. Yoa, H. C.; Resnick, P. *J. Org. Chem.* **1965**, *30*, 2832.
2. Fusco, R.; Sannicola, F. *J. Org. Chem.* **1981**, *46*, 90.
3. Imanzadeh, G. H.; Hajipour, A. R.; Mallakpour, S. E. *Synth. Commun.* **2003**, *33*, 735.
4. Shaabani, A.; Naderi, S.; Rahmati, A.; Badri, Z.; Darvishi, M.; Lee, D. G. *Synthesis* **2005**, 3023.
5. Mohammadpoor-Baltork, I.; Khodaei, M. M.; Hajipour, A. R.; Aslani, E. *Monatsh. Chem.* **2003**, *134*, 539.
6. Hajipour, A. R.; Mallakpour, S. E.; Mohammadpoor-Baltork, I.; Khoee, S. *Synth. Commun.* **2001**, *31*, 1187.
7. Jadhav, V. K.; Wadgaonkar, P. P.; Joshi, P. L.; Salunkhe, M. M. *Synth. Commun.* **1999**, *29*, 1989.
8. Shirini, F.; Zolfigol, M. A.; Mallakpour, S. E.; Hajipour, A. R.; Mohammadpoor-Baltork, I. *Tetrahedron Lett.* **2002**, *43*, 1555.
9. Chavan, S. P.; Soni, P. *Tetrahedron Lett.* **2004**, *45*, 3161.
10. Hosseinzadeh, R.; Tajbakhsh, M.; Yazdani Niaki, M. *Tetrahedron Lett.* **2002**, *43*, 9413.
11. Heravi, M.; Tajbakhsh, M.; Bakooie, H.; Ajami, D. *Monatsh. Chem.* **1999**, *130*, 933.
12. Youn, J. H.; Herrmann, R. *Synthesis* **1987**, *1*, 72.
13. Barm, G.; Loupy, A.; Majdoub, M.; Gutierz, E.; Riz Hitzky, E. *Tetrahedron* **1990**, *46*, 5167.
14. Holbrey, J. D.; Seddon, K. R. *J. Chem. Soc., Dalton Trans.* **1999**, *13*, 2133.
15. Dupont, J.; De Souza, R. F.; Suarez, P. A. Z. *Chem. Rev.* **2002**, *102*, 3667.
16. Wasserscheid, P.; Keim, W. *Angew. Chem. Int. Ed.* **2000**, *39*, 3773.
17. Welton, T. *Chem. Rev.* **1999**, *99*, 2071.
18. Zhu, H. P.; Yang, F.; Tang, J.; He, M. Y. *Green Chem.* **2003**, *5*, 38.
19. Lu, N.; Chen, J. Y.; Fan, C. W.; Lin, Y. C.; Wen, Y. S.; Liu, L. K. *J. Chin Chem. Soc.* **2006**, *53*, 1517.
20. Bates, E. D.; Mayton, R. D.; Ntai, I.; Davis, J. H. *J. Am. Chem. Soc.* **2002**, *124*, 926.
21. Sun, I. W.; Wu, S. Y.; Su, C. H.; Shu, Y. L.; Wu, P. L. *J. Chin Chem. Soc.* **2004**, *51*, 367.
22. Fisher, T.; Sethi, A.; Welton, T.; Woolf, J. *Tetrahedron Lett.* **1999**, *40*, 793.
23. Badri, M.; Brunet, J. J. *Tetrahedron Lett.* **1992**, *33*, 4435.
24. Earle, M. J.; McCormac, P. B.; Seddon, K. R. *Chem. Commun.* **1998**, 2245.
25. Kabalka, G. W.; Malladi, R. R. *Chem. Commun.* **2000**, 2191.
26. Zhai, C. P.; Song, A. X.; Liu, W. M.; Wang, H. Q. *J. Chin Chem. Soc.* **2006**, *53*, 887.
27. Laali, K. K.; Gettewert, V. J. *J. Org. Chem.* **2001**, *66*, 35.
28. Zulficar, F.; Kitazume, T. *Green Chem.* **2000**, *2*, 296.
29. De Castro, C. P.; Sauvage, E.; Valkenberg, M. H.; Holderich, W. F. *J. Catal.* **2000**, *196*, 86.
30. Adams, C. J.; Earle, M. J.; Roberts, G.; Seddon, K. R. *Chem. Commun.* **1998**, 2097.
31. Kumar, H. M. S.; Reddy, B. V. S.; Reddy, P. T.; Yadav, J. S. *Synthesis* **1999**, *4*, 586.
32. Das, B.; Madhusudhan, P.; Venkataiah, B. *Synlett* **1999**, *10*, 1569.
33. Dave, P. R.; Axenrod, T. F. F.; Das, K. K.; Qi, L.; Watnick, C.; Yazdekhashti, H. *J. Org. Chem.* **1996**, *61*, 8897.
34. Ballistreri, F. P.; Barbuzzi, E.; Tomaselli, G. A.; Toscano, R. M. *Synlett* **1996**, *11*, 1093.
35. MalamidouXenikaki, E.; Stampelos, X. N.; Charalambis, T. A.; Karapostolou, C. C. *Tetrahedron* **1997**, *53*, 747.
36. Sasatani, S.; Miyazak, T.; Maruoka, K.; Yamamoto, H. *Tetrahedron Lett.* **1983**, *24*, 4711.
37. Negi, S.; Matsukura, M.; Mizuno, M.; Miyake, K.; Minami N. *Synthesis* **1996**, *8*, 991.
38. Kench, J. E. *Dictionary of Organic Compounds*, 6th ed.; Chapman and Hall: London, 1982.