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# Rapid and Efficient Method for Room Temperature Deoximation Reaction Under Solvent-Free Conditions

**Anindita Dewan,[*] Utpal Bora,[†] and Dilip K. Kakati**

*Department of Chemistry, Gauhati University, Guwahati 781014, Assam, India. [*]E-mail: ani_dewan@yahoo.co.in*
*[†]Department of Chemistry ,Dibrugarh University, Dibrugarh 786004, Assam, India*
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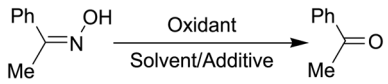
The cleavage of oximes to regenerate the parent carbonyl compounds is an important synthetic process as oximes are useful protecting groups in multistep organic synthesis[1] and have extensive applications in the purification and characterization of carbonyl compounds.[2] Further their synthesis from non-carbonyl compounds offer an alternative route for the synthesis of variety of aldehydes and ketones.[3] During last few years a number of publications and reviews have reflected the significance of deoximation reactions in contemporary organic chemistry.[4] In view of the importance of deoximation reaction, several metallic and nonmetallic deoximation reagents such as *tert*-butylhydroperoxide,[5] trimethyl ammonium chlorochromate,[6] pyridinium chlorochromate-$H_2O_2$,[7] thallium nitrate,[8] $KMnO_4$/alumina,[9] *N,N*-dibromo-*N,N*-1,3-propylene-bis[(4-methylphenyl)sulfonamide,[10] metalloporphyrins,[11] *N*-bromosuccinimide,[12] surfactant/$I_2$/water,[13] chloranil,[14] ammonium persulfate,[15] platinum(II) terpyridyl acetylide complex,[16] $NaHSO_4H_2O$-supported $CrO_3$,[17] periodic acid,[18] ferric nitrate,[19] *etc.* have been developed over the years. Very recently, conversion of oximes to the carbonyl compounds has been demonstrated with use of 2-nitro-4,5-dichloropyridazin-3(2*H*)-one under microwave irradiated conditions.[20] However, the main drawbacks associated with these systems are harmful and expensive metals, long reaction time, toxic organic solvents, and in majority of cases they require an elevated temperature or microwave heating for effective catalytic activity. Thus development of deoximation systems which are readily accessible, air/moisture stable, inexpensive, environmentally acceptable, that can promote deoximation under mild reaction conditions are still desirable.

Among the various transition metals, vanadium exists on the surface of the earth more abundantly and vanadium based oxidants are effectively used for various oxidation reactions.[21] Recently we have reported the syntheses and characterization of the crystal structure of novel vanadium polyoxometalate $[C_6H_5CH_2N(CH_3)_3]_3V_{10}O_{28}H_3\cdot 3H_2O]$, which was obtained by treating $V_2O_5$ with $H_2O_2$ in presence of benzyltrimethylammonium chloride.[22] Polyoxometalates are considered unique catalytic species due to their multifunctionality and structural mobility[23] and we were able to utilize the newly synthesized V-polyoxometalate for selective oxidation of benzyl alcohols under solvent free conditions.[24] To the best of our knowledge there is no report for deoximation with vanadium polyoxometalates under solvent free, room temperature conditions. The objective of the present study is to establish the viability of the newly synthesized vanadium polyoxometalates in deoximation reactions under a green and mild reaction conditions.

To investigate the effectiveness of the vanadium polyoxometalate complex in deoximation reaction, acetophenone oxime was choosen as a model substrate and reactions were performed under different reaction conditions. Initially, we carried out the deoximation reaction by treating acetophenone oxime (1 mmol) with vanadium polyoxometalate (0.05 mmol) using $H_2O$ (5 mL) as solvent under neutral conditions. But the reaction did not take place at room temperature or at 60 °C (Table 1, entry 1 & 2). However on acidification with 20% HCl, the deoximation took place with a moderate yield (Table 1, entry 3).

Recently, *p*-toluenesulphonic acid (PTSA) has shown the prospect to be used as substitute for conventional acidic materials.[25] Moreover, we found that the newly synthesized V-polyoxometalate works as a useful oxidant for selective and rapid oxidation of benzylic alcohols to the corresponding carbonyl compounds in the presence of PTSA.[24] Thus we carried out the deoximation reaction in the presence of PTSA (1.0 mmol). It has been observed that the reaction proceeded with better yield of product (Table 1, entry 4). Surprisingly, there was an abrupt change in the rate of the reaction when the reaction was carried out in absence of solvent. In this particular case the oxime was converted to its parent carbonyl derivative in very high yield wthin a minute of time, just on grinding the oxime and oxidant in presence of PTSA at room temperature (Table 1, entry 5).[26] However, no product formation was observed when the oxidant was replaced with $V_2O_5$, $H_2O_2$, benzyltrimethylammonium chloride (BTAC) under the same reaction conditions (Table 1, entry 6). Although not confirmed, it is believed that the reaction has been proceeded via free radical pathway as in the presence of free radical inhibitor hydroquinone, the yield was very poor (Table 1, entry 7). It is possible that during oxidation in presence of PTSA, the polymeric forms of V-polyoxometalate is broken down and initiate the reaction. The yield of the product was dramatically decreased when the reaction was carried under nitrogen atmosphere suggest-

**Table 1.** Optimization of reaction conditions for V-polyoxometalate mediated deoximation[a]




| Entry | Oxidant (mmol) | Solvent/Additive (mmol) | T/(°C) | Time | Yield (%) |
|---|---|---|---|---|---|
| 1 | V-polyoxometalate (0.05) | $H_2O$ | rt | 24 h | Nil |
| 2 | V-polyoxometalate (0.05) | $H_2O$ | 60 | 24 h | Nil |
| 3 | V-polyoxometalate (0.05) | $H_2O$/HCl | 60 | 4 h | 50 |
| 4 | V-polyoxometalate (0.05) | $H_2O$/PTSA | 60 | 4 h | 60 |
| 5 | V-polyoxometalate (0.05) | PTSA | rt | 1 min | 99 |
| 6 | $V_2O_5/H_2O_2$/BTAC[c] | PTSA | rt | 1 min | Nil |
| 7 | V-polyoxometalate (0.05)/hydroquinone | PTSA | rt | 1 min | 15 |
| 8 | V-polyoxometalate (0.05) | PTSA | rt | 1 min | 10[b] |
| 9 | V-polyoxometalate (0.001) | PTSA (2.00) | rt | 1 min | 15 |
| 10 | V-polyoxometalate (0.005) | PTSA (2.00) | rt | 1 min | 19 |
| 11 | V-polyoxometalate (0.01) | PTSA (2.00) | rt | 1 min | 35 |
| 12 | V-polyoxometalate (0.03) | PTSA (2.00) | rt | 1 min | 80 |
| 13 | V-polyoxometalate (0.05) | PTSA (2.00) | rt | 1 min | 99 |
| 14 | V-polyoxometalate (0.05) | PTSA (1.50) | rt | 1 min | 99 |
| 15 | V-polyoxometalate (0.05) | PTSA (1.00) | rt | 1 min | 97 |
| 16 | V-polyoxometalate (0.05) | PTSA (0.50) | rt | 1 min | 98 |
| 17 | - | PTSA (0.50) | rt | 1 min | 0 |
| 18 | V-polyoxometalate (0.05) | - | rt | 1 min | 0 |

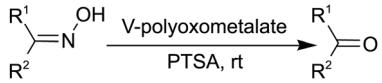
[a]Reaction conditions Acetophenone oxime (1.0 mmol); All yields refer to isolated yield. [b]Reaction were carried out under nitrogen atmosphere. [c]$V_2O_5$ (0.5 mmol), BTAC (0.5 mmol), 30% $H_2O_2$ (3 mmol)

ing the involvement of molecular oxygen in the deoximation reaction (Table 1, entry 8). Several test reactions were carried out using different amount of V-polyoxomatalate and PTSA (Table 1, entries 9-18). It was observed that 0.05 mmol of V-polyoxometalate is needed for deoximation of 1.0 mmol of the substrate.

To evaluate the scope and limitations of the current procedure, reactions of a wide array of electronically and structurally diverse aldoximes and ketoxime were examined using polyoxometalate complex. The results are summarized in Table 2. It has been seen from Table 2, that in general, a variety of oximes such as aliphatic (entries 1 & 2), cyclic (entries 3 & 4), and various phenyl ring substituted aldoxime (entries 5-12) and ketoxime (entries 13-19) underwent the deoximation reactions with excellent yields (85-98%). The electronic nature and the position of the substituents had less effect on the reaction process. However, the presence of substituent at position-2 on the phenyl ring required relatively longer reaction time (Table 2, entries 9 & 11). The oxidant was found to be highly effective for both aldoxime and ketoxime. No over oxidized product was observed in any of the oxime studied. Moreover, the active oxidant could be regenerated by addition of appropriate amount of benzyltrimethylammonium chloride and 30% $H_2O_2$ and reuse it in deoximation reaction.

In conclusion, we have developed an efficient method for rapid deoximation of a variety of aldoxime and ketoxime to the corresponding aldehydes and ketones under solvent less condition at room temperature within a minute in excellent yield. Synthesis of this oxidant is very simple and starting

**Table 2.** Solvent-less deoximation at room temperature




| Entry | $R^1$ | $R^2$ | Time | Yield (%) |
|---|---|---|---|---|
| 1 | Octyl | H | 1 min | 85 |
| 2 | Heptyl | H | 1 min | 80 |
| 3 | Cyclohexyl | - | 1 min | 88 |
| 4 | Cyclopentyl | - | 1 min | 85 |
| 5 | Ph | H | 1 min | 95 |
| 6 | *m*-$NO_2$-Ph | H | 2 min | 85 |
| 7 | *p*-$NO_2$-Ph | H | 1 min | 95 |
| 8 | *p*-Cl-Ph | H | 1 min | 93 |
| 9 | *o*-Cl-Ph | H | 3 min | 85 |
| 10 | *m*-OMe-Ph | H | 2 min | 87 |
| 11 | *o*-OH-Ph | H | 3 min | 90 |
| 12 | *p*-$(CH_3)_2$N-Ph | H | 1 min | 97 |
| 13 | Ph | Me | 1 min | 98 |
| 14 | *p*-OH-Ph | Me | 1 min | 96 |
| 15 | *p*-Br-Ph | Me | 1 min | 97 |
| 16 | *p*-$NH_2$-Ph | Me | 1 min | 95 |
| 17 | *p*-OMe-Ph | Me | 1 min | 90 |
| 18 | Ph | Ph | 1 min | 98 |
| 19 | *o*-Cl-Ph | Ph | 1 min | 98 |

Reaction conditions: 1.00 mmol of substrate; 0.05 mmol V-polyoxomatalate; 0.50 mmol of PTSA; Reactions were carried out at room temperature; All yields refer to isolated yields; All the products were characterized by IR spectra, mass spectra, $^1$H NMR spectroscopy and were compared with the authentic samples.

materials used are commercially available and cheap. The oxidant is also very stable hence can be stored and handled very easily. The reaction time is very short and no over-oxidized product was observed.

## References


1. Greene, T. W.; Wuts, P. G. M. In *Protective Groups in Organic Synthesis*; Wiley: New York, 1991; p 214.
2. Donaruma, L. G.; Heltd, W. Z. *Organic Reactions* **1960**, *11*, 1.
3. (a) Kabalka, G. W.; Pace, R. D.; Wadgaonkar, P. P. *Synth Commun*. **1990**, *20*, 2453. (b) Barton, D. H. R.; Beaton, J. M.; Geller, L. E.; Pechet, M. M. *J. Am. Chem. Soc*. **1961**, *83*, 4076. (c) Sakamoto, T.; Kikugawa, Y. *Synthesis* **1993**, 563.
4. (a) Corsaro, A.; Chiacchia, U.; Pistarà, V. *Synthesis* **2001**, 1903. (b) Corsaro, A.; Chiacchio, M. A.; Pistarà, V. *Current Organic Chemistry* **2008**, 482. (c) Sahu, S.; Sahu, S.; Patel, S.; Dash, S.; Mishra, B. K. *Indian Journal of Chemistry* **2008**, *47B*, 259.
5. Barhate, N. B.; Gajare, A. S.; Wakharkar, R. D.; Sudalai, A. *Tetrahedron Lett*. **1997**, *38*, 653.
6. Rao, C. G.; Radhakrishna, A. S.; Singh, B. B.; Bhatnagar, S. P. *Synthesis* **1983**, 808.
7. Drabowicz, J. *Synthesis* **1980**, 125.
8. McKillop, A.; Hunt, J. D.; Naylor, R. D.; Taylor, E. C. *J. Am. Chem. Soc*. **1971**, *93*, 4918.
9. Imanzadeh, G. H.; Hajipour, A. R.; Mallakpour, S. E. *Synth. Commun.* **2003**, *33*, 735.
10. Khazaei, A.; Manesh, A. A.; Ghasemi, A. H. *Synthesis* **2004**, 2784.
11. Zhou, X-T.; Yuan, Q-L.; Ji, H-B. *Tetrahedron Lett*. **2010**, *51*, 613.
12. Reddy, M. S.; Narender, N.; Rama Rao, K. *Synth Commun*. **2004**, *43*, 3881.
13. Gogoi, P.; Hazarika, P.; Konwar, D. *J. Org. Chem.* **2005**, *70*, 1934.
14. de Lijser, H. J. P.; Fardoun, F. H.; Sawyer, J. R.; Quant, M. *Org. Lett*. **2002**, *4*, 2325.
15. Imanzadeh, G. H.; Zamanloo, M. R.; Eskandari, H.; Banaei, A. R. *Bull. Korean Chem. Soc*. **2006**, *27*, 119.
16. Yang, Y.; Zhang, D.; Wu, L.-Z.; Chen, B.; Zhang, L.-P.; Tung, C.-H. *J. Org. Chem*. **2004**, *69*, 4788.
17. Shirini, F.; Mamaghani, M.; Rahmanzadeh, A. *Arkivoc.* **2007**, 34.
18. Li, Z.; Ding, R.-B.; Xing, Y.-L.; Shi, S.-Y. *Synth Commun*. **2005**, *35*, 2520.
19. Ghorbani-Choghamarani, A.; Shiri, L.; Zeinivand, J. *Bull. Korean Chem. Soc*. **2008**, *29*, 2496.
20. Kim, B. R.; Lee, H-G.; Kim, E. J.; Lee, S.-G.; Yoon, Y.-J. *J. Org. Chem*. **2010**, *75*, 484.
21. (a) Velusamy, S.; Punniyamurthy, T. *Org. Lett*. **2004**, *6*, 217. (b) Csanyi, L. J.; Jaky, K.; Dombi, G.; Evanics, F.; Dezso, G.; Kota, Z. *Journal of Molecular Catalysis A: Chemical* **2003**, *195*, 101. (c) Maeda, Y.; Kakiuchi, N.; Matsumura, S.; Nishimura, T.; Kawamura, T.; Uemura, S. *J. Org. Chem*. **2002**, *67*, 6718. (d) Kirihara, M.; Ochiai, Y.; Takizawa, S.; Takahata, H.; Nemoto, H. *Chem. Commun.* **1999**, 1387. (e) Kobayashi, H.; Yamanaka, I. *Chem. Lett.* **2007**, *36*, 114.
22. Dewan, A.; Kakati, D. K.; Das, B. K. *Indian Journal of Chemistry* **2010**, *49A*, 39.
23. (a) Maeda, Y.; Kakiuchi, N.; Mastsumura, S.; Nishimura, T.; Uemura, S. *Tetrahedron Lett*. **2001**, *42*, 8877. (b) Kodama, S.; Ueta, Y.; Yoshida, J.; Nomoto, A.; Yano, S.; Ueshima, M.; Ogawa, A. *Dalton Trans.* **2009**, 9708. (c) Radosevich, A. T. Musich, C.; Toste, F. D. *J. Am. Chem. Soc*. **2005**, *127*, 1090.
24. Dewan, A.; Sarma, T.; Bora, U.; Kakati, D. K. *Tetrahedron Lett.* **2011**, *52*, 2563.
25. Narasimhulu, M.; Mahesh, K. C.; Reddy, T. S.; Rajesh, K.; Venkateswarlu Y. *Tetrahedron Lett*. **2006**, *47*, 4381.
26. *Typical procedure for the deoximation*: Acetophenone oxime (0.135 mg, 1.0 mmol), vanadium polyoxometalate $[C_6H_5CH_2N(CH_3)_3]_3$-$V_{10}O_{28}H_3{\cdot}3H_2O$] (0.073 gm, 0.05 mmol) and PTSA·$H_2O$ (0.095 gm, 0.5 mmol) were mixed at room temperature, grinded thoroughly in a mortar. The yellow colour of the mixture became green instantaneously on grinding indicating progress of the reaction. The reaction mixture was diluted with ether (30 mL) and washed with water. The organic layer was washed with brine (3 × 20 mL), dried over anhydrous $Na_2SO_4$, concentrated under reduced pressure to obtain the acetophenone in 98% yield. The product was characterized by IR, mass, $^1$H NMR spectroscopy and was compared with the authentic sample.