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Iodine(V) reagents in organic synthesis. Dess–Martin periodinane mediated efficient one-pot oxidation of aldehydes to acyl azides

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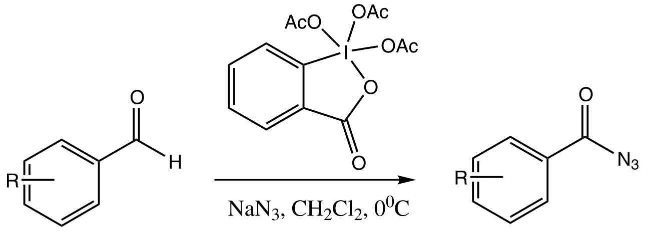
Abstract—A mild, efficient and general method for the one-step preparation of acyl azides from aldehydes using Dess–Martin periodinane and sodium azide is described. © 2003 Elsevier Science Ltd. All rights reserved.

The driving force for the development of new methodologies in organic synthesis has been the need for simple and efficient strategies to obtain complex natural products and their analogs. Acyl azides are valuable synthetic intermediates in preparative organic chemistry.[1] They are useful for the preparation of amides and heterocyclic compounds. They undergo facile thermal rearrangement to isocyanates from which urethanes, thiourethanes, amines, ketenimines, carbodiimides and ureas can be conveniently prepared. Acyl azides are usually prepared from acid derivatives such as acid halides and acyl hydrazides.[2] Even though several methods are available to accomplish this transformation,[3] the majority involve the conversion of carboxylic acids to acid chlorides or anhydrides, which are then reacted with azide reagents. There are a few reports on the direct conversion of carboxylic acids to acyl azides by using acid activators such as ethyl chloroformate,[4] diphenylphosphoryl azide (DDPA),[5] NCS-Ph_3P,[6] triphosgene,[7] and cyanuric chloride.[8] In view of this, investigations in this field have been mainly focused on the preparation of acyl azides directly from aldehydes by using combinations of chromic anhydride-trimethylsilyl azide,[9] and triazidochlorosilane-activated MnO_2.[10]

Oxidation of carbonyl compounds to the corresponding acyl azides is an important synthetic procedure, and the development of selective and efficient reagents for this conversion, especially when other oxidizable functional groups are also present, has interested organic chemists for a long time. In this context, notwithstanding the availability of many preparative methods, the restrictions that accompany some of them make new, mild, and selective procedures highly desirable.

In recent years, hypervalent iodine reagents have occupied an important place in the realm of natural and synthetic organic chemistry because of their potential applications in the construction of carbon–heteroatom and carbon–carbon bonds.[11] One of the field's most significant advances, the discovery of the Dess–Martin periodinane (DMP) reagent,[12] 1,1,1-triacetoxy-1,1-dihydro-1,2-benziodoxol-3(1*H*)-one, opened the door to a mild oxidation procedure allowing a myriad of alcohols to be converted to the corresponding carbonyl compounds. Its widespread use over the past decade attests to its benign nature and its uncanny ability to succeed in the most difficult of oxidation circumstances. As part of our ongoing program on the synthesis and development of new methodologies in organic synthesis,[13] we describe a new, efficient and practical route for the one-step conversion of aldehydes into the corresponding acyl azides by using Dess–Martin periodinane and sodium azide in CH_2Cl_2 at 0°C in high yields (Scheme 1). Moreover, the acyl azides can be isolated without



Scheme 1.

Keywords: aldehydes; Dess–Martin periodinane; acyl azides; oxidation.

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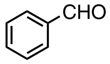
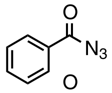
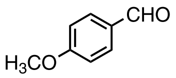
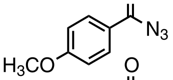
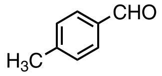
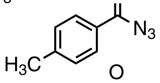
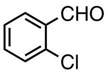
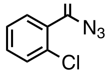
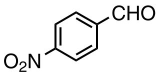
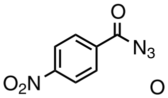
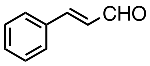
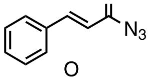
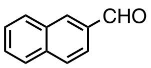
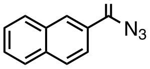
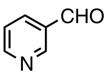
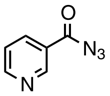
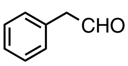
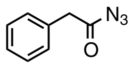
Curtius rearrangement leading to an alkyl isocyanate because the reaction conditions are so mild. To the best of our knowledge, however, the generality and applicability of DMP in the preparation of acyl azides from aldehydes is not known. The products were characterized by IR, ^{1}H NMR and mass spectral studies which were consistent with literature data.[14] *Caution*: *Azido compounds may represent an explosion hazard when being concentrated under vacuum or stored neat. A safety shield and appropriate handling procedures are recommended.*

To explore the generality and scope of this process, diverse aldehydes were studied to illustrate this novel and general method for the synthesis of acyl azides and the results are summarized in Table 1. Based on the susceptibility of the aldehydic C–H bonds to homolytic rupture,[15] the reaction may proceed via in situ generated 1,1,1-tris(azido)-1,1-dihydro-1,2-benziodoxol-3(1*H*)-one, which is formed by ligand exchange followed by homolytic decomposition to generate an azido radical.[16] The starting aldehyde may then be azidonated via H-abstraction and coupling.

The effect of substituents was observed by comparing the results with a strongly electron donating aryl group (entry 2, Table 1) and an electron withdrawing example (entry 5, Table 1). Aliphatic aldehydes were also oxidized to the corresponding acyl azides, but in these cases a fair amount of acyl azide rearranged to the alkyl isocyanate at room temperature. When the temperature was kept below 0°C, the rearrangement was completely suppressed, and acyl azide was produced in high yields.

In a typical procedure, *p*-methoxybenzaldehyde (0.68 g, 1.0 mmol) was treated under a N_2 atmosphere with Dess–Martin periodinane (2.54 g, 6.0 mmol) and sodium azide (1.13 g, 3.5 mmol) in CH_2Cl_2 at 0°C. The progress of the reaction was monitored by TLC. After completion, it was washed with H_2O (2×5 ml) and the reaction mixture was extracted with CH_2Cl_2 (2×10 ml). The combined organic phase was dried with anhydrous Na_2SO_4 and the solvent was removed in vacuo, to afford the crude product which was purified by column chromatography on silica gel (petroleum ether:EtOAc, 8:1) to give *p*-methoxybenzoyl azide (0.84 g, 95%) as a pale yellow solid.

Table 1. Synthesis of acyl azides from aldehydes and sodium azide using Dess–Martin periodinane

Entry	Aldehyde	Time (h)	Acyl Azide	Yield (%)[a]	Mp (^{0}C) [lit.][14a-c]
1		1.5		89	25-27(27)
2		1		95	68-70(70-71)
3		2		87	32-33(35)
4		2.5		91	oil(-)[b]
5		3		85	64-66(65)
6		1		83	82-84(-)
7		1		90	77-79(-)
8		3		86	oil(-)[b]
9		1		95	oil(-)[b]
10	$CH_3(CH_2)_4CHO$	4	$CH_3(CH_2)_4CON_3$	88	oil(-)[b]
11	$CH_3(CH_2)_6CHO$	4.5	$CH_3(CH_2)_6CON_3$	82	oil(-)[b]

[a] Yields of pure isolated products. [b] The acyl azides (neat) decompose upon standing in air.

In conclusion, the short reaction period, the simple work up, the good yield, and the fairly mild conditions of this method offer advantages over other procedures, and this approach should be of further interest in synthetic organic chemistry.

References

1. (a) Patai, S. *The Chemistry of the Azido Group*; Chichester Interscience: New York, 1971; p. 397; (b) Moore, H. W.; Goldish, D. M. In *Chem. Halides Pseudohalides and Azides*; Patai, S.; Rappoport, Z., Eds.; Wiley: Chichester, UK, 1983; Vol. 1, p. 321; (c) Scriven, E. F. V.; Turnbull, K. *Chem. Rev.* **1988**, *88*, 297.
2. Laszlo, P.; Polla, E. *Tetrahedron Lett.* **1984**, *25*, 3701.
3. (a) Grundmann, C. *Methoden der Org. Chem.*; Houben-Weyl, 1965; Vol. 10, p. 777; (b) Kricheldorf, H. R.; Leppert, E. *Synthesis* **1976**, 329; (c) Surya Prakash, G. K.; Iyer, P. S.; Arvanaghi, M.; Olah, G. A. *J. Org. Chem.* **1983**, *48*, 3358.
4. Kobyashi, S.; Kamiyama, K.; Limori, T.; Ohno, M. *Tetrahedron Lett.* **1984**, *25*, 2557.
5. Shao, H.; Colucci, M.; Tong, S.; Zhang, H.; Castelhano, A. L. *Tetrahedron Lett.* **1998**, *39*, 7235.
6. Froeyen, P. *Phosphorous Sulfur Silicon Relat. Elem.* **1994**, *89*, 57.
7. Gumaste, V. K.; Bhawal, B. M.; Deshmukh, A. R. *Tetrahedron Lett.* **2002**, *43*, 1345.
8. Bandgar, B. P.; Pandit, S. S. *Tetrahedron Lett.* **2002**, *43*, 3413.
9. (a) Lee, J. G.; Kwak, K. H. *Tetrahedron Lett.* **1992**, *33*, 3165; (b) Reddy, P. S.; Yadagiri, P.; Lumin, S.; Falck, J. R. *Synth. Commun.* **1988**, *18*, 545.
10. Elmorsy, S. S. *Tetrahedron Lett.* **1995**, *36*, 1341.
11. (a) Varvoglis, A. *Hypervalent Iodine in Organic Synthesis*; Academic Press: San Diego, 1997; p. 256; (b) Nicolaou, K. C.; Baran, P. S.; Zhong, Y.-L.; Sugita, K. *J. Am. Chem. Soc.* **2002**, *124*, 2212.
12. (a) Dess, D. B.; Martin, J. C. *J. Org. Chem.* **1983**, *48*, 4155; (b) Dess, D. B.; Martin, J. C. *J. Am. Chem. Soc.* **1991**, *113*, 7277.
13. (a) Bose, D. S.; Jayalakshmi, B. *J. Org. Chem.* **1999**, *64*, 1713; (b) Bose, D. S.; Rudra Das, A. P.; Mereyala, H. B. *Tetrahedron Lett.* **2002**, *43*, 9195.
14. Selected analytical data for acyl azides entries **1**, **2**, **3** and **7**: Compound **1**: IR (KBr): 2180, 2130, 1685, 1600 cm^{-1}. ^{1}H NMR (CDCl$_3$, 200 MHz): δ 7.15–8.25 (m, 5H). Compound **2**: IR (KBr): 2180, 2140, 1700, 1600, 1455, 1240, 1180, 990, 710 cm^{-1}. ^{1}H NMR (CDCl$_3$): δ 8.00 (d, $J=8.7$ Hz, 2H), 6.97 (d, $J=8.7$ Hz, 2H), 3.90 (s, 3H). EI MS: m/z (%) 177 (M^+ 37), 149 (22), 135 (100), 106 (81), 92 (25), 78 (40). Compound **3**: IR (KBr): 2180, 2150, 1690, 1600, 1460, 1240, 1180, 990, cm^{-1}. ^{1}H NMR (CDCl$_3$): δ 8.18 (d, $J=8.7$ Hz, 2H), 7.45 (d, $J=8.7$ Hz, 2H), 2.62 (s, 3H). EIMS: m/z (%) 161 (M^+ 25), 132 (27), 119 (100), 91 (95). Compound **7**: IR (KBr): 2180, 2140, 1690, 1600, 1525, 1430 cm^{-1}. ^{1}H NMR (CDCl$_3$): δ 7.42–7.65 (m, 2H), 7.81–8.08 (m, 4H), 8.55 (s, 1H). EIMS: m/z (%) 197 (M^+ 19), 169 (98), 155 (21), 141 (100), 127 (25), 114 (50). (a) Lieber, E.; Oftedahl, E. J. *J. Org. Chem.* **1959**, *24*, 1014; (b) Yukawa, Y.; Tsuno, Y. *J. Am. Chem. Soc.* **1957**, *79*, 5530; (c) *Handbook of Chemistry and Physics*, 66th ed.; Weast, R. C., Ed.; 1985–1986.
15. Chryssostomos, C.; David, C.; Mistuo, K.; Ilhyong, R. *Chem. Rev.* **1999**, *99*, 1991.
16. Kita, Y.; Tohma, H.; Takada, T.; Mitoh, S.; Fjuita, S.; Gyoten, M. *Synlett* **1994**, 427.