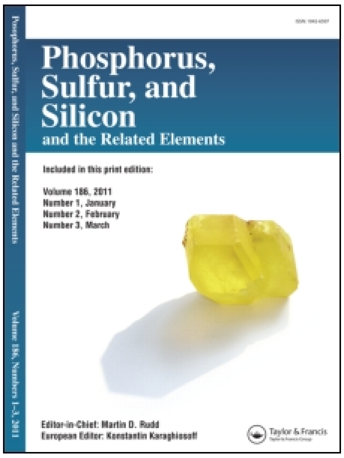

Phosphorus, Sulfur, and Silicon and the Related Elements
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713618290

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To cite this Article Munavalli, S. , Rohrbaugh, D. K. and Durst, H. D.(2003) 'Unusual Reaction of H-Dimethylphosphonate', Phosphorus, Sulfur, and Silicon and the Related Elements, 178: 1, 115 — 118
To link to this Article: DOI: 10.1080/10426500307815
URL: http://dx.doi.org/10.1080/10426500307815

Phosphorus, Sulfur and Silicon, 2003, Vol. 178:115–118

1042-6507/03 $12.00 + .00
DOI: 10.1080/10426500390170246

UNUSUAL REACTION OF H-DIMETHYLPHOSPHONATE

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(Received June 20, 2002)

Reaction of H-dimethylphosphonate with 1-nitro-1-cyclohexene furnishes N,N-dimethylaniline and 1-cyclohexenyl dimethylphosphonate.

Keywords: 1-Cyclohexenyl-1-dimethylphosphonate; 1-nitro-1-cyclohexene; H-dimethylphosphonate; N,N-dimethylaniline

INTRODUCTION

Dimethylphosphonates form a versatile group of reagents and their interesting chemistry has been discussed.[1] There is considerable current interest in the synthesis of phosphonic acid derivatives[2a–b] and nucleotides.[2c] Both acids and bases react with dialkylphosphonates suggesting a facile removal of the hydrogen attached directly to the phosphorus atom. Among other reactions, the phosphonates are known to add to the carbon-carbon double bond[3a–b] and carbonyl group.[3c] Although the phosphonates are resistant to oxidation, they undergo autooxidation[4] as well as free radical catalyzed oxidation.[5] Loss of the alkyl moiety during oxidation has been observed.[6] In continuation of our interest in the chemistry of the dialkylphosphonates,[5] the reaction of 1-nitro-1-cyclohexene (**1**) with H-dimethylphosphonate (**2**) was examined. This article describes the formation of unusual products and their mass spectral characterization.

RESULTS AND DISCUSSION

H-dialkylphosphonates have been found to be a useful application in the phosphorylation reactions and synthesis of oligonucleotides. They

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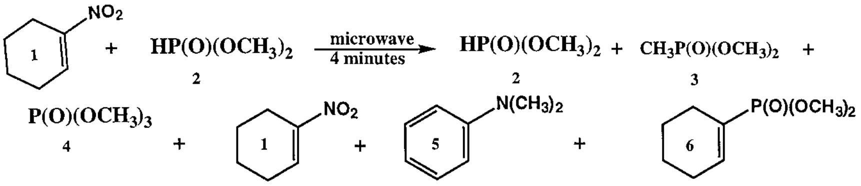

FIGURE 1 Reaction of 1-nitrocyclohexene with H-dimethylphosphonate.

are reported to react with aldehydes in the presence of trimethylsilyl chloride and triethylamine to furnish α-hydroxyphosphonates.[7] The same reagents react with imines to yield α-aminophosphonates. Substrates with conjugated double bond are said to give anti-Markovnikov adducts.[3] Microwave catalyzed reaction of 1-nitro-1-cyclohexene (**1**) with H-dimethylphosphonate (**2**) has been found to furnish (Figure 1): (1) dimethyl methylphosphonate (**3**), trimethylphosphate (**4**), N,N-dimethylaniline (**5**), and 1-cyclohexenyl-1-dimethylphosphonate (**6**) in addition to starting materials. Figure 2 attempts to rationalize the formation of compounds **5** and **6**, while the origin of the remaining compounds has been explained.[5] The mass spectral behavior of various compounds is given in Table I. It can be safely assumed that the substrate (**1**) is converted to nitrobenzene, which subsequently gets reduced to aniline, which in turn gets methylated to form N,N-dimethylaniline (**5**). Its mass spectrum is identical with that published in the literature.[8] Alkylphosphites are known to reduce the nitro group to amino group.[9] Alkyl moiety of the alkylphosphonate has been stated to alkylate the hydroxyl group.[10] The free radical initiated formation of 1-cyclohexenyl dimethylphosphonate (**6**) is straightforward (Figure 2). Table I describes the mass spectral fragmentation of the compounds cited in the text. The mass spectral breakdown pattern of the remaining phosphorus compounds has been described.[5]

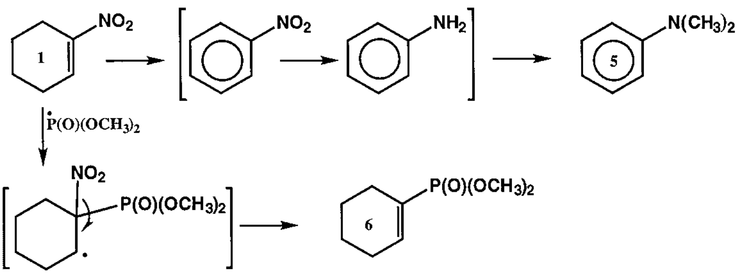

FIGURE 2 Probable mechanism of formation N,N-dimethylaniline, and 1-cyclohexenyl-1-dimethylphosphonate.

TABLE I Mass Spectral Fragmentation of Compounds Cited in the Text

1. Hydrogen dimethylphosphonate (**2**): M$^+$ = 110 (r.t. = 2.45 min, 73.4%); 109 (M-H); 95 (M-CH_3); 93 (M-OH); 80 (95-CH_3, 100%); 79 (M-OCH_3); 65 (80-CH_3); 63 (PO_2); 49 (PH_2O) and 47 (PO).
2. Trimethylphosphonate (**3**): M$^+$ = 124 (r.t. = 3.01, min 0.3%); 109 (M-H); 109 (M-CH_3); 94 (109-CH_3, 100%); 79 (94-CH_3); 79 (M-OCH_3); 65 (PH_2O_2); 63 (PO_2); 49 (PH_2O) and 47 (PO).
3. Trimethylphosphate (**4**): M$^+$ = 140 (r.t. = 3.42 min, 6.9%); 110 (M-OCH_2, 100%); 109 (M-OCH_3); 95 (110-CH_3, 100%); 79 [P(O)H (OCH_3)]; 79 (M-OCH_3); 65 (PH_2O_2) and 47 (PO).
4. 1-Nitrocyclohexene (**1**): M$^+$ = 127 (r.t. = 6.07 min, 10.6%); 97 (M-NO); 81 (97-O or M-NO_2, 100%); 77 (C_6H_5) and 51 (C_4H_3).
5. N,N-Dimethylamine (**5**): M$^+$ = 121 (r.t. = 5.09 min, 0.1%); 120 (M-H, 100%); 105 (M-CH_4); 91 (C_6H_5N); 77 (C_6H_5) and 51 (C_4H_3).
6. 1-Cyclohexenyl dimethylphosphonate (**6**): M$^+$ = 190 (r.t. = 8.42 min, <0.1%); 175 (M-CH_3); 162 (M-C_2H_4); 143 (175-CH_3OH); 111 HP(OH)$(OCH_3)_2$; 109 P(O)$(OCH_3)_2$; 81 (C_6H_9); 80 (C_6H_8); 79 [C_7H_7 or PH(O)-(OCH_3), 100%]; 77 (C_6H_5); 65 (C_5H_5); 63 P$(O)_2$; 55 (C_4H_7) and 51 (C_4H_3).

EXPERIMENTAL

Mass spectra were obtained using a Finnigan TSQ-7000 GC/MS/MS equipped with a 30 m × 0.25 mm. i.d. DB-5 capillary column (J and W Scientific, Folsom, CA) or a Finnigan 5100 GC/MS equipped with a 15 m × 0.25 mm. i.d.Rtx-5 capillary column (Restek, Bellefonte, PA). The conditions on 5100 were: oven temperature 60–270°C at 10°C/min, injection temperature was 210°, interface temperature 230°C, electron energy 70 eV, emission current 500 μA and scan time 1 s. The conditions on the TSQ-7000 were: oven temperature 60–270°C at 15°C/min, injection temperature 220°, interface temperature 250°C, source temperature 150°, electron energy 70 eV (EI) or 200 eV (CI), emission current 400 μA (EI) or 300 μA (CI), and scan time 0.7 s. Data was obtained in both the electron ionization mode (range 45–450 da) and chemical ionization mode (mass range 60–450 da). Ultrahigh purity methane was used as the CI agent gas with a source pressure of 0.5 Torr (5100) or 4 Torr (TSQ-7100). Routine GC analyses were accomplished with a Hewlett-Packard 5890A gas chromatograph equipped with a J and W Scientific 30 m × 0.53 mm i.d. DB-5 column (J and W Scientific, Folsom, CA). Stoichiometric amounts of the respective reagents were mixed in glass vials, vigorously shaken on a vibro-mixer and heated in the microwave oven for a specified period. The reaction mixture was allowed to come to ambient temperature; the cooled product was first analyzed by gas chromatography and then subjected to GC-MS analysis.

Reaction of 1-nitro-1-cyclohexene (**1**) with H-dimethylphosphonate (**2**): Stoichiometric amounts of H-dimethylphosphonate (**2**, 1.10 g, 0.01 mmol) and 1-nitro-1-cyclohexene (**1**, 1.27 g, 0.01 mmol) were mixed in a glass vial, stirred for a few minutes using the vibro-mixer and then heated in a table top microwave oven at power 7 for a total of 4 min. The reaction mixture was allowed to come to ambient temperature, analyzed first by gas chromatography. The GC-MS analysis showed the presence of: (1) 1-nitro-1-cyclohexene (**1**, rt = 6.07 min, 10.6%), (2) H-dimethylphosphonate (**2**, rt = 2.45 min, 73.4%), (3) dimethyl methylphosphonate (**3**, rt = 3.01 min, 3.0%), (4) trimethylphosphate (**4**, rt = 3.42 min, 6.9%), (5) N,N-diethylaniline (**5**, rt = 5.09 min, 0.2%) and 1-cyclohexenyl dimethylphosphonate (**6**, rt = 8.42 min, 0.2%).

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