Nitrile oxide 1,3-dipolar cycloaddition by dehydration of nitromethane derivatives under continuous flow conditions.

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Abstract: Aliphatic nitrile oxides were generated in situ, by dehydration of terminal nitro compounds, and reacted with dipolarophiles using continuous flow techniques to afford substituted isoxazolines. The yields of cycloadducts were comparable with traditional flask-based reactions but the reaction times were much shorter. In-line scavenger cartridges conveniently removed by-produced and unreacted reagents to give almost pure crude products. The process was demonstrated up to gram scale.

Introduction

The 1,3-dipolar cycloaddition reaction is a convenient and versatile method for constructing a wide range of five-membered heterocycles. Nitrile oxide dipoles react with carbon dipolarophiles to give Δ²-isoxazolines and isoxazoles, which in turn are useful precursors to β-hydroxy ketones, β-amino alcohols, 1,3-diols and a range of other 1,3-disubstituted compounds. Regiochemical predictability makes this reaction particularly attractive for constructing spiro heterocycles from exocyclic methylene compounds. Nitrile oxides are reactive intermediates that are usually generated in situ by one of two broad methods: formal dehydration of aldoximes via dehydrohalogenation of hydroximoyl chlorides 1, or dehydration of nitromethyl compounds 2, with many reagent variations to facilitate this process. Cycloaddition proceeds to give isoxazolines with the main side reaction being dimerization
to give furanox by-products 5 (Scheme 1), which can be mitigated by maintaining the dipolarophile in excess or with steric auxiliaries.\textsuperscript{[13,14]}

Scheme 1

Generally, the dehydrohalogenation route is more convenient for aryl nitrile oxides (1, \( R = \text{Ar} \)) whereas the dehydration route is preferred for aliphatic nitrile oxides (2, \( R = \text{alkyl} \)). The latter process, as pioneered by Mukaiyama, involves the dehydration of primary nitroalkanes with an aryl isocyanate in the presence of triethylamine.\textsuperscript{[15]} Aliphatic nitrile oxides are quite unstable so this method is limited to \textit{in situ} transformations. For methodology development the majority of nitrile oxide cycloaddition literature is focussed on aryl nitrile oxides because of the operational ease in their generation, less complex by-product mixtures, and slower dimerization compared to aliphatic nitrile oxides.

In recent years the laboratory innovation of continuous flow and microreactor technology has been recognised as a competitive alternative to conventional round-bottom flask processing.\textsuperscript{[16–21]} Several distinct advantages have been attributed to flow chemistry including improved heat transfer, rapid and efficient mixing, safe handling of hazardous materials, and the ability to use pre-packed, immobilised reagent cartridges. In addition, immobilised scavenger cartridges and catch and release techniques\textsuperscript{[22,23]} can be used to circumvent traditional work-up and chromatographic purification, enabling multi-step downstream processing. Very recently, Conti and co-workers compared aryl nitrile oxide cycloadditions, using the dehydrohalogenation of hydroximoyl chlorides route, under conventional conditions, microwave-assisted, and in continuous flow.\textsuperscript{[24]} Their analysis showed clear advantages using the flow-based technique with an immobilised base to elicit dehydrohalogenation. Our interest in continuous flow processes\textsuperscript{[25–28]} prompted us to investigate whether nitrile oxide
cycloadditions via the dehydration of nitroalkanes could also be improved using flow techniques.

Results and Discussion

Hassner reported an improvement to the Mukaiyama procedure whereby a nitroalkane is treated with di-tert-butyl dicarbonate (Boc₂O) in the presence of 0.1 equivalents of 4-dimethylaminopyridine (DMAP) and a fivefold excess of a dipolarophile to give the cycloadduct.[29] In this procedure the nitro compound, dissolved in acetonitrile, was added in portions over a one hour period followed by a further three hour reaction. Yields were calculated by NMR against an internal standard and in two cases isolated and purified by column chromatography. This reaction was adapted for continuous flow using a Vapourtec® R2+/R4 instrument. The reagent streams were mixed through a T-piece and then directed through perfluoroalkoxy polymer tubing (PFA) to a convection–heated flow coil (10 mL). Pressure within the system was maintained using an in–line 100 psi back–pressure regulator and the reaction was heated at 50°C with a residence time of 40 minutes (Figure 1). Omnifit® columns packed with Quadrupure® benzyl amine resin (QP–BZA) and neutral alumina were used for in–line scavenging of excess Boc₂O, any furoxane dimer, and other by–products.

Figure 1. Schematic of the flow process for nitrile oxide 1,3–dipolar cycloaddition by dehydration of nitromethane compounds. QP–BZA = Quadrupure® benzyl amine resin.

A few years ago, Machetti and co–workers demonstrated that dehydration of activated primary nitro compounds to nitrile oxides could be promoted by base alone.[30] This reaction generally performed best in ethanol or chloroform, using either 1,4–diaza[2.2.2]octane (DABCO) or 1–methylimidazole as base. The reaction requires heating at 60°C for 40 hours and while the conversion to nitrile oxides was often quite good (using a substoichiometric amount of 10 to 20% of the base), the cycloaddition reaction was very sensitive to the solvent used, and was
occasionally plagued by furoxane by-products. We speculated that a shorter reaction time at
higher temperature could be achieved under continuous flow conditions to circumvent these
issues. Hence this reaction was also adapted to flow processing again using a Vapourtec
R2+/R4 instrument. The reagent streams (ethyl nitroacetate and the dipolarophile with
DABCO) were mixed through a T-piece and then directed through PFA tubing to a convection–
heated flow coil set at 100°C, with a residence time of 250 minutes. The pressure within the
system was maintained using an in-line 250 psi back-pressure regulator (Figure 2). In this
case the reaction mixture was collected at the reactor outlet and evaporated onto neutral
alumina, and then eluted through a short plug with ethyl acetate.

![Figure 2: Schematic of the flow process for base–promoted condensations of ethyl nitroacetate with alkenes.](image)

Using either the Boc₂O method (Figure 1) for unactivated nitroalkanes or the DABCO method
(Figure 2) for activated nitroalkanes gave isolated yields comparable to those published for
conventional flask–based methods (Scheme 2, Table 1). However, the in–line scavenger
method employed in the flow–based reaction produced crude products of at least 95% purity
by ¹H NMR. The formation of furoxane dimer that usually plagues aliphatic nitrile oxide
cycloaddition reactions was ameliorated by shorter reactions times, and where present it was
almost entirely scavenged from the reaction stream. Using flow methods the reaction times
were significantly shortened from 4 hours to 40 min in the Boc₂O procedure and from 40
hours to 250 min in the DABCO procedure. We attribute this to the greatly increased surface
to volume ratio in a flow apparatus compared to conventional flasks, which affords rapid heat
transfer. Hence the heating and cooling profiles of the reaction are much quicker and this,
combined with overall shorter reaction times at elevated temperatures, diminishes the
opportunity for unwanted side reactions and by–products. There were also operational
conveniences in that the conventional Boc:O procedure requires the addition of the nitroalkane in acetonitrile, in portions, over 3 hours. Under flow conditions the reactant streams in toluene were simply pumped, each at a rate of 130 μL/min, into a T-shaped mixing piece and through the heating coil for 40 mins to give the pure products. For the DABCO method the reactants were heated to 60°C for 40 hours in a sealed vessel (Schlenk) in anhydrous, ethanol–free chloroform. Under flow conditions the two reaction streams in ethanol were simply pumped, each at a rate of 60 μL/min, into a T-shaped mixer piece and through the heating coil for 250 mins at 100°C to give the product in essentially pure form. Either of these methods could be used as key steps in an in–line, multi–component flow synthesis procedure. Furthermore, the straightforward scalability of flow processing allows this class of products to be prepared in multi–gram scales. To demonstrate this, we prepared the cycloadduct 7a in a gram scale without significant modification of the developed flow method.

![Scheme 2](image-url)
Table 1. Isolated yields of cycloadducts (Scheme 2)

<table>
<thead>
<tr>
<th>Nitro-alkane</th>
<th>R²</th>
<th>Product</th>
<th>Method</th>
<th>Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>6a</td>
<td>-</td>
<td>7a</td>
<td>Boc₂O</td>
<td>65%</td>
</tr>
<tr>
<td>6b</td>
<td>-</td>
<td>7b</td>
<td>Boc₂O</td>
<td>66%</td>
</tr>
<tr>
<td>6a</td>
<td>Ph</td>
<td>8a</td>
<td>Boc₂O</td>
<td>66%</td>
</tr>
<tr>
<td>6a</td>
<td>CO₂Bu</td>
<td>8b</td>
<td>Boc₂O</td>
<td>54%</td>
</tr>
<tr>
<td>6b</td>
<td>OAc</td>
<td>8c</td>
<td>Boc₂O</td>
<td>60%</td>
</tr>
<tr>
<td>6b</td>
<td>OBu</td>
<td>8d</td>
<td>Boc₂O</td>
<td>83%</td>
</tr>
<tr>
<td>6c</td>
<td>Ph</td>
<td>8e</td>
<td>DABCO</td>
<td>73%</td>
</tr>
<tr>
<td>6c</td>
<td>CH₂Ph</td>
<td>8f</td>
<td>DABCO</td>
<td>55%</td>
</tr>
</tbody>
</table>

A Boc₂O method is described in Figure 1, DABCO method is described in Figure 2.
B 84:16 exo:endo
C 85:15 exo:endo

Conclusion

The flow-based reaction technology offers clear advantages in time, convenience, automation, scaling-up opportunities, and purification for nitrile oxide cycloaddition reactions when using dehydration of aliphatic nitroalkanes to generate nitrile oxides in situ. This reaction is suitable for an in-line, multi-component flow synthesis procedure.

Experimental

General: for general details see reference.¹⁰ NMR spectra were recorded at room temperature on a Bruker AV400 spectrometer operating at 400 MHz for ¹H and 100.6 MHz for ¹³C, using CDCl₃ as solvent and internal reference. Electron-impact mass spectra were run on a ThermoQuest MAT95XP mass spectrometer using an ionization energy of 70 eV. IR spectra were recorded with neat samples, on a Thermo Scientific Nicolet 6700 FT-IR/Smart iTR instrument. Commercial reagents were used without further purification, and anhydrous solvents were obtained by passing them through columns of activated alumina (toluene) or purchased from commercial suppliers (ethanol, ethyl acetate). Flow reactions were performed with Vapourtec® R2+/R4 instruments (www.vapourtec.co.uk), using perfluoroalkoxy polymer tubing (PFA) with an outer diameter of 1/16 inch and 1 mm inner diameter. Omnifit® columns (www.omnifit.com) were used for in-line purification.

General method for Boc₂O dehydration procedure.

The appropriate nitroalkane (1.00 mmol) was diluted to 2.00 mL volume with a stock solution of Boc₂O (1.20 M in toluene, equiv. of 2.25 mmol). The alkene dipolarophile (5.00 mmol) was
diluted to 2.00 mL volume with a stock solution of DMAP (0.10 M in toluene, equiv. of 0.14 mmol). The two solutions were pumped, each at a rate of 130 μL/min, into a T-shaped mixer piece. The resulting flow stream was directed into a flow coil (PFA, 10 mL), and heated to 50°C (residence time 38.5 min). The flow stream was directed through a cartridge (Omnifit®, 150 mm x 10 mm) filled with approximately 1.0 g QP-BZA (capacity 5.5 mmol/g), sand (1 cm bed height) and neutral alumina (activity I, 3 cm bed height) and through a back-pressure regulator (100 psi). The product solution was collected at the reactor outlet and evaporated to dryness to afford the crude products, which were analysed for purity by 1H NMR.

3-Butyl-3a,4,7,7a-tetrahydro-4,7-methanobenzod]isoxazole 7a.
The reaction between nitropentane and norbornadiene gave the product (125 mg, 65%) as a colorless oil in an exo/endo ratio of 84:16. Exo–isomer: δH 6.21 (dd, J 3.1, 5.8 Hz, 1H, =C–H), 5.99 (dd, J 3.3, 5.8 Hz, 1H, =C–H), 4.70 (td, J 1.2, 8.4 Hz, 1H, CH), 3.26 (d, J 8.4 Hz, 1H, CH), 2.94 (m, 1H, CH), 3.12 (m, 1H, CH), 2.29 (ddd, J 7.4, 8.4, 15.5, 1H, CH2), 2.14 (dddd, J 1.2, 5.8, 8.4, 15.5 Hz, 1H, CH3), 1.49–1.62 (m, 4H, 2 × CH2), 1.27–1.40 (m, 2H, CH2), 0.89 (t, J 7.4 Hz, 3H, CH3) ppm. δC 157.9 (s, C=N), 139.7 (C=C), 135.4 (C=C), 87.5 (CH), 59.7 (CH), 49.7 (CH), 44.9 (CH), 42.9 (CH2), 28.1 (CH2), 26.3 (CH2), 22.4 (CH2), 13.2 (CH3) ppm. Endo–isomer: δH 6.12 (dd, J 3.1, 5.8 Hz, 1H, =C–H), 6.01 (dd, J 3.0, 5.8 Hz, 1H, =C–H), 5.14 (dd, J 4.2, 9.5 Hz, 1H, CH), 3.66 (dd, J 4.2, 9.5 Hz, 1H, CH), 3.09 (m, 1H, CH3) ppm. Additional signals could not be unambiguously assigned from the mixture. δC characteristic signals: 157.6 (s, C=N), 134.6 (C=C), 134.4 (C=C), 85.7 (CH) ppm. Additional signals could not be unambiguously assigned from the mixture. IR (film): 3060, 2955, 2875, 1740, 1455, 1325, 1295, 1255, 920, 900, 860, 700 cm−1 (Found M+ 214.1214. C12H17NONa requires 214.1208). Scaled experiment: Nitropentane (1.46 g, 12.50 mmol) and Boc2O (6.00 g, 27.50 mmol) were diluted to 25 mL volume with toluene. Norbornadiene (5.76 g, 62.50 mmol) and DMAP (0.23 g, 1.88 mmol) were diluted to 25 mL volume with toluene. The two solutions were pumped, each at a rate of 260 μL/min, into a T-shaped mixer piece. The resulting flow stream was directed into a flow coil (PFA, 20 mL), and heated to 50°C (residence time 38.5 min). The flow stream was directed through a back–pressure regulator (100 psi). The product solution was collected at the reactor outlet and evaporated onto neutral alumina. The resulting powder was charged onto a short column of neutral alumina (activity I) and eluted with toluene. Evaporation of the filtrate afforded the product (1.48 g, 62%) as a yellow oil.
3-Phenyl-3a,4,7,7a-tetrahydro-4,7-methanobenzod[4]isoxazole 7b.

The reaction between phenylnitromethane norbornadiene gave the product (139 mg, 66%) of as a yellow oil in an exo/endo ratio of 85:15. Exo-Isomer: \( \delta_H \): 7.71–7.77 (m, 2H, Ph), 7.34–7.44 (m, 3H, Ph), 6.34 (dd, \( J = 3.0 \), 5.8 Hz, 1H, =C–H), 6.08 (dd, \( J = 3.2 \), 5.8 Hz, 1H, =C–H), 4.97 (td, \( J = 1.4 \), 8.2 Hz, 1H, CH), 3.78 (d, \( J = 8.2 \) Hz, 1H, CH), 3.27 (t, \( J = 1.4 \) Hz, 1H, CH), 3.14 (br. s, 1H, CH), 1.73 (d, \( J = 9.4 \) Hz, 1H, CH), 1.61 (td, \( J = 1.6 \), 9.4 Hz, 1H, CH) ppm. \( \delta_C \): 155.7 (C=N), 140.0 (C=C), 135.4 (C=C), 129.2 (ipso-Ph), 129.8 (Ph), 128.7 (Ph), 89.4 (CH), 57.6 (CH), 50.0 (CH), 45.1 (CH), 43.2 (CH) ppm.

Endo-Isomer: \( \delta_H \): 6.17 (dd, \( J = 3.2 \), 5.8 Hz, 1H, =C–H), 5.92 (dd, \( J = 3.0 \), 5.8 Hz, 1H, =C–H), 5.39 (dd, \( J = 4.4 \), 9.6 Hz, 1H, CH), 4.13 (dd, \( J = 4.1 \), 9.6 Hz, 1H, CH), 3.36 (m, 1H, CH), 1.46 (d, \( J = 8.9 \) Hz, 1H, CH) ppm. Additional signals could not be unambiguously assigned; \( \delta_C \): 156.5 (C=N), 135.1 (C=C), 134.1 (C=C), 128.7 (Ph), 126.5 (Ph), 48.9 (CH), 87.5 (CH), 57.2 (CH), 47.9 (CH), 46.8 (CH) ppm. Additional signals could not be assigned. The spectroscopic data are in agreement with those reported.[32]

3-Butyl-5-phenyl-4,5-dihydroisoxazole 8a.

The reaction between nitropentane and styrene gave the product (134 mg, 66%) as a yellow oil (purity >95% by \(^1\)H NMR). \( \delta_H \): 7.25–7.37 (m, 5H, Ph), 5.52 (dd, \( J = 8.2 \), 10.7 Hz, 1H, 5–H), 2.89 (dd, \( J = 8.2 \), 17.0 Hz, 1H, 4–H\(^b\)), 2.36 (t, \( J = 7.6 \) Hz, 2H, 1’–H), 1.50–1.60 (m, 2H, 2’–H), 1.37 (m, 2H, 3’–H), 0.93 (t, \( J = 7.2 \) Hz, 3H, 4’–H) ppm. \( \delta_C \): 158.5 (C–3), 141.4 (ipso–Ph), 128.6 (Ph), 127.9 (Ph), 125.7 (Ph), 81.2 (C–5), 45.3 (C–4), 28.4 and 27.3 (C–1’ and C–2’), 22.3 (C–3’), 13.7 (C–4’) ppm. The spectroscopic data are in agreement with those previously reported.[33]

Butyl 3-butyl-4,5-dihydroisoxazole-5-carboxylate 8b.

The reaction between nitropentane and butyl acrylate gave the product (123 mg, 54%) as a pale yellow oil. \( \delta_H \): 4.89 (dd, \( J = 8.0 \), 9.9 Hz, 1H, 5–H), 4.12 (t, \( J = 6.7 \) Hz, 2H, O–CH\(^2\)), 3.08–3.21 (m, 2H, 4–H), 2.31 (t, \( J = 7.5 \) Hz, 2H, 1’–H), 1.55–1.64 (m, 2H, CH\(^2\)), 1.45–1.54 (m, 2H, CH\(^2\)), 1.26–1.38 (m, 4H, 2 × CH\(^2\)), 0.87 (t, \( J = 7.5 \) Hz, 3H, CH\(^3\)), 0.86 (t, \( J = 7.5 \) Hz, 3H, CH\(^3\)) ppm. \( \delta_C \): 171.0 (CO), 158.3 (C–3), 76.8 (C–5), 65.4 (O–CH\(^2\)), 40.8 (C–4), 30.4 (CH\(^2\)), 28.2 (CH\(^2\)), 26.7 (CH\(^3\)), 22.0 (CH\(^2\)), 18.8 (CH\(^2\)), 13.5 (CH\(^3\)), 13.4 (CH\(^3\)) ppm. IR (film): 2960, 2935, 2875, 1740, 1465, 1280, 1200 cm\(^–1\) (Found M\(^+\) 227.1522. C\(_{12}\)H\(_{22}\)NO\(_3\) requires 227.1521).

3-Phenyl-4,5-dihydroisoxazol-5-yl acetate 8c.
The reaction between phenylnitromethane and vinyl acetate gave the product (124 mg, 60%) a pale yellow oil. \( \delta \)H 7.66–7.71 (m, 2H, Ph), 7.36–7.46 (m, 3H, Ph), 6.80 (dd, J 1.4, 6.9 Hz, 1H, 5–H), 3.58 (dd, J 6.9, 17.8 Hz, 1H, 4–H\(^{b}\)), 3.34 (dd, J 1.4, 17.8 Hz, 1H, 4–H\(^{a}\)), 2.04 (s, 3H, CH\(_{3}\)) ppm. \( \delta \)C 169.7 (CO), 157.0 (C–3), 128.3 (ipso-Ph), 130.8 (Ph), 128.9 (Ph), 127.0 (Ph), 95.9 (C–5), 41.3 (C–4), 21.0 (CH\(_{3}\)) ppm. The spectroscopic data are in agreement with those reported.

5–Butoxy–3–phenyl–4,5–dihydroisoxazole 8d.

The reaction between phenylnitromethane and butyl vinyl ether gave the product (181 mg, 83%) as a pale yellow oil. \( \delta \)H 7.63–7.70 (m, 2H, Ph), 7.34–7.40 (m, 3H, Ph), 5.64 (dd, J 1.5, 6.7 Hz, 1H, 5–H), 3.84 (td, J 6.7, 9.5 Hz, 1H, O–CH\(_{2}\)^{b}), 3.51, (td, J 6.7, 9.5 Hz, 1H, O–CH\(_{2}\)^{a}), 3.35 (dd, J 6.7, 17.4 Hz, 1H, 4–H\(^{b}\)), 3.18 (dd, J = 1.5, 17.4 Hz, 1H, 4–H\(^{a}\)), 1.49–1.60 (m, 2H, CH\(_{2}\)), 1.35 (m, 2H, CH\(_{2}\)), 0.90 (t, J 7.5 Hz, 3H, CH\(_{3}\)) ppm. \( \delta \)C 156.9 (C–3), 129.3 (ipso-Ph), 130.2 (Ph), 128.7 (Ph), 126.8 (Ph), 103.2 (C–5), 68.1 (O–CH\(_{2}\)), 41.5 (C–4), 31.6 (CH\(_{3}\)), 19.2 (CH\(_{2}\)), 13.8 (CH\(_{3}\)) ppm. The spectroscopic data are in agreement with those reported.

General method for base–promoted condensations of ethyl nitroacetate with alkenes.

Ethyl nitroacetate (550 μL, 5.00 mmol) was diluted to 2.00 mL volume with EtOH. The alkene dipolarophile (2.00 mmol) and DABCO (224 mg, 2.00 mmol) were diluted to 2.00 mL volume with EtOH. The two solutions were pumped, each at a rate of 60 μL/min, into a T-shaped mixer piece. The resulting flow stream was directed into a flow coil (PFA, 30 mL), and heated to 100°C (residence time 250 min). The flow stream was directed through a back-pressure regulator (250 psi) and the reaction mixture was collected at the reactor outlet and evaporated onto neutral alumina (activity I). The resulting powder was charged onto a short column of alumina and eluted with EtOAc. Evaporation of the filtrate afforded the product.

Ethyl 5–phenyl–4,5–dihydroisoxazole–3–carboxylate 8e.

The reaction between ethyl nitroacetate and styrene gave the product (320 mg, 73%) as a yellow oil. \( \delta \)H 7.23–7.40 (m, 5H, Ph), 5.74 (dd, J 8.9, 11.6 Hz, 1H, 5–H\(^{b}\)), 4.31 (q, J 7.3 Hz, 2H, O–CH\(_{2}\)), 3.60 (dd, J 11.6, 17.8 Hz, 1H, 4–H\(^{b}\)), 3.16 (dd, J 8.9, 17.8 Hz, 1H, 4–H\(^{a}\)), 1.33 (t, J 7.3 Hz, 3H, CH\(_{3}\)) ppm. \( \delta \)C 160.5 (CO), 151.1 (C–3), 139.6 (ipso-Ph), 128.8 (Ph), 128.6 (Ph), 125.8 (Ph), 84.9 (C–5), 62.0 (O–CH\(_{2}\)), 41.4 (C–4), 14.1 (CH\(_{3}\)) ppm. The spectroscopic data are in agreement with those reported.
**Ethyl 5-benzyl-4,5-dihydroisoxazole-3-carboxylate 8f.**

The reaction between ethyl nitroacetate and allylbenzene gave the product (258 mg, 55%) as a pale yellow oil. δH 7.27–7.33 (m, 2H, Ph), 7.18–7.26 (m, 3H, Ph), 5.03 (dddd, J 6.2, 7.0, 8.2, 10.9 Hz, 1H, 5−H), 4.31 (q, J 7.2 Hz, 2H, O−CH2), 3.16 (dd, J 10.9, 17.6 Hz, 1H, 4−Hα), 3.10 (dd, J 6.2, 14.0 Hz, 1H, CH2βPh), 2.92 (dd, J 8.2, 17.6 Hz, 1H, 4−Hβ), 2.87 (dd, J 7.0, 14.0 Hz, 1H, CH2αPh), 1.33 (t, J 7.2 Hz, 3H, CH3) ppm. δC 160.6 (CO), 151.4 (C−3), 136.1 (ipso−Ph), 129.4 (Ph), 126.9 (Ph), 128.6 (Ph), 84.3 (C−5), 61.9 (O−CH2), 40.7 (CH2Ph), 37.9 (C−4), 14.1 (CH3) ppm. IR (film): 2985, 1715, 1585, 1250, 1125 cm−1 (Found M+ 233.1054. C13H15NO3 requires 233.1052).
References


