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Indium-Mediated Aza-Henry Reaction of Imines: Access to 2-Nitroamines

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A new method has been developed to obtain 2-nitroamines by an indium-promoted reaction of bromonitromethane with a variety of imines. On the strength of these results, the reaction was also performed with 2-bromo-2-nitropropanes to afford 2,2-dialkyl-2-nitroamines. Moreover, the indium-mediated reaction of 1-bromo-1-nitroethane and imines afforded 1-methyl-2-nitroamines with remarkably high *anti* selectivity. The use of chiral sugar-derived imines furnished the corresponding 2-nitroamines with excellent stereoselectivity.

Introduction

The aza-Henry (or nitro-Mannich) reaction involves nucleophilic addition of nitroalkanes to imines. This reaction results in the formation of a carbon–carbon bond with concomitant generation of a β-nitroamine. By using this reaction a wide variety of other organic compounds can be derived by functional transformations of the nitro group into other chemical functionalities, such as amines,[1] carbonyl groups,[2] hydroxylamines[3] and oximes or nitriles.[4]

The aza-Henry reaction has long been known[5] and provides access to valuable functionalized structural motifs such as 1,2-diamines.[6] It is therefore conceivable that efforts may have been devoted over the years to improve yields and stereocontrol. Surprisingly, significant success was not achieved until very recently. Unlike the addition of nitronates to aldehydes, the addition to imines is not thermodynamically favored. Anderson et al. reasoned that, because nitronates are quite inert toward Schiff bases, the aid of a Lewis or Brønsted acid is required, and they reported an improved version of the classical nitro-Mannich reaction.[7] Subsequently, in 1999, Shibasaki et al. described the first asymmetric aza-Henry reaction in which binaphthoxide (binol)-based heterobimetallic complexes of ytterbium and aluminium were used as catalysts.[8]

Since Anderson and Shibasaki's pioneering work, the aza-Henry reaction has attracted considerable attention. So far, both racemic and asymmetric methods for the reactions with various nitroalkanes have been carried out by using inorganocatalysts,[9] organocatalysts[10] or chiral Lewis acid catalysts of ytterbium,[11] aluminium,[12] copper[13] and zinc[14] metals.

Despite the considerable synthetic effort and the advances made in this area, there are still limitations to the applicability of the aza-Henry reaction. The vast majority of the known procedures are restricted to imines derived from non-enolizable aldehydes, typically aromatic ones. The reason is that enolizable aldehyde-derived azomethines tend to undergo α-deprotonation rather than addition. Among the numerous literature examples, only a few aza-Henry reactions have been reported that give good selectivity for a broad range of reaction partners.

A valuable alternative to carry out the aza-Henry reaction with enolizable aldehydes would be the development of new, less basic nitronates derived from those metals characterized by the low basicity of their organometallic compounds. Taking advantage of the low basicity of the samarium reagents,[15] we recently described a reaction of bromonitromethane with a variety of imines under very mild conditions promoted by SmI_2 to afford nitroamines.[16] The use of substoichiometric amounts of SmI_2 to generate a nitronate intermediate is inconsistent with the typical role of SmI_2 as a monoelectronic reducing agent in a Barbier-type process through metallation of the C–Br bond. Thus, the proposed mechanism for the synthesis of nitroamines involves initiation by the release of iodide from traces of SmI_3 that are present in tetrahydrofuran (THF) solutions of SmI_2.

In connection with this work on the SmI_2-mediated aza-Henry reaction and our previous work on the indium-mediated Henry reaction,[17] we decided to investigate an alternative approach based on a Barbier-type addition of α-bromo-α-nitroalkanes to imines. Our aim was to develop an indium-promoted aza-Henry reaction, taking advantage of

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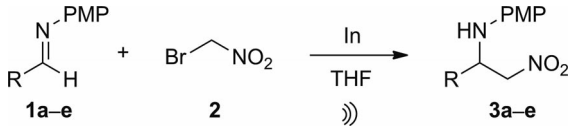
the very low first ionization energy of indium(0), which makes it an ideal candidate for use in single electron transfer (SET) reactions. This property, together with the stability of In^0 to oxygen and water, has prompted exhaustive studies focused on the chemistry of indium with organic molecules in the past several years.[18]

Results and Discussion

Initially, we studied the addition reaction of bromonitromethane to imine **1a** promoted by indium. The best results were achieved with solutions of 1 equiv. of imine **1a**, 1 equiv. of indium and 1.5 equiv. of bromonitromethane **2** in THF under sonication at room temp. for 4 h. It is noteworthy that no reaction occurred in the absence of sonication. On other hand, shorter reaction times resulted in lower conversion rates. By using these optimal reaction conditions, the reaction of bromonitromethane **2** and achiral *N*-(*p*-methoxyphenyl)imines **1b–e** derived from commercially available aldehydes was carried out (Scheme 1). As shown by the results in Table 1, under these conditions aliphatic linear imine **1b** and branched imines **1d** and **1e**, alicyclic imine **1c** and aromatic imine **1a** were efficiently converted into their corresponding 2-nitroamines **3a–3e**.



Scheme 1. Indium-mediated reaction of imines **1a–e** and bromonitromethane **2**.

Table 1. Synthesis of 2-nitroamines **3a–e**.

Entry	Imine	R	Nitroamine	Yield[a]
1	**1a**	C_6H_5	**3a**	61
2	**1b**	$CH_3(CH_2)_6$	**3b**	82
3	**1c**	C_6H_{11}	**3c**	80
4	**1d**	*i*Bu	**3d**	78
5	**1e**	*i*Pr	**3e**	68

[a] Isolated yield of pure compounds **3** after column chromatography relative to compounds **1**.

Regarding the mechanism of these indium-mediated transformations, it should be noted that in contrast to the SmI_2-mediated reaction of bromonitromethane with imines, which is promoted by the iodide released by traces of SmI_3, the synthesis of nitro alcohols **3a–e** by using 1.0 equiv. of indium is consistent with the typical role of indium as a monoelectronic reducing agent. In fact, recent studies on the structure of the intermediates formed upon sonication of mixtures of bromonitroalkanes and indium in THF suggested the formation of a RIn^{III}-type transient species.[19] Reaction of the indium species with aldehydes would give rise, after work-up, to the corresponding 2-nitroamines.

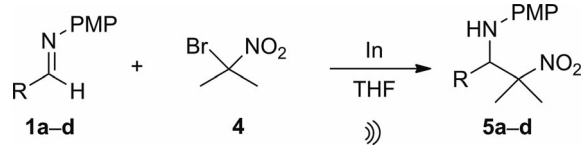
In subsequent experiments aimed at extending these studies to include hindered 1-bromo-1-nitroalkanes, the case of 2-bromo-2-nitropropane (**4**) was considered. Because sterically-hindered nitroalkanes are less reactive, the classical ionic nitro-Mannich reaction usually fails to give the desired products and only additions of nitromethane to imines have been reported in the literature. As expected, according to the proposed ionic mechanism, the SmI_2-mediated reaction of sterically hindered bromonitroalkanes with imines failed to give the corresponding nitroamines (Table 2, Entries 2 and 5), and the unreacted starting material was recovered in both cases.

Table 2. Synthesis of 2,2-alkyl-2-nitroamines **5a–d**.

Entry	Imine	R	Nitroamine	Yield[a]
1	**1a**	C_6H_5	**5a**	49
2[b]	**1a**	C_6H_5	[c]	[c]
3	**1b**	$CH_3(CH_2)_6$	**5b**	81
4	**1c**	C_6H_{11}	**5c**	78
5[b]	**1c**	C_6H_{11}	[c]	[c]
6	**1d**	*i*Bu	**5d**	69

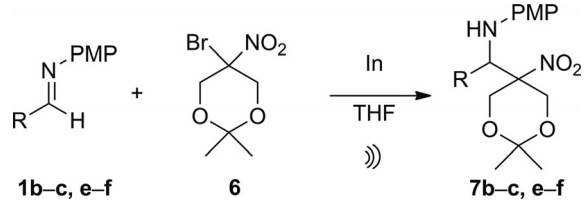
[a] Isolated yield of pure compounds **5** after column chromatography relative to compounds **1**. [b] Reaction mediated by samarium diiodide (1 equiv. imine, 1 equiv. 2-bromonitropropane, 1 equiv. SmI_2). [c] No reaction took place under these conditions.

However, because the mechanism for the indium-mediated addition of bromonitroalkanes to imines is an SET mechanism, **4** was successfully added to imines (Scheme 2). As shown in Table 2, the reaction of imines **1a–d** with **4** under the same reaction conditions described previously gave 2-nitroamines **5a–d** (Table 2, Entries 1, 3, 4 and 6).



Scheme 2. Indium-mediated reaction of imines **1a–d** and 2-bromo-2-nitropropane (**4**).

Given these satisfactory results, we decided to extend our studies to the conformationally restricted bromonitroalkane **6**, which is a highly valuable reagent for the preparation of branched-chain derivatives of biological interest (Scheme 3).[20]



Scheme 3. Indium-mediated reaction of imines **1b–c**, **e–f** and 5-bromo-2,2-dimethyl-5-nitro-1,3-dioxane (**6**).

5-Bromo-2,2-dimethyl-5-nitro-1,3-dioxane (**6**), which is easily prepared from the commercially available insecticide bronopol[21] (2-bromo-2-nitropropane-1,3-diol), reacted with imines **1b–c**, **e–f** to give the corresponding nitroamines **7b–c**, **e–f** in moderate to good yields (Table 3).

Table 3. Synthesis of 2,2-alkyl-2-nitroamines **7b–c**, **e–f**.

Entry	Imine	R	Nitroamine	Yield[a]
1	**1b**	$CH_3(CH_2)_6$	**7b**	79
2	**1c**	C_6H_{11}	**7c**	75
3	**1e**	*i*Pr	**7e**	64
4	**1f**	*p*MeOC_6H_4	**7f**	38

[a] Isolated yield of pure compounds **7** after column chromatography relative to compounds **1**.

The satisfactory results obtained in the synthesis of racemic 2-nitroamines **3**, **5** and **7** prompted us to test the usefulness of this methodology for the synthesis of enantiopure 2-nitroamines. Our preliminary studies were carried out with a panel consisting of chiral imines **1g–i** (Figure 1), which upon indium-mediated reaction with bromonitromethane (**2**), 2-bromo-2-nitropropane (**4**) or 5-bromo-2,2-dimethyl-5-nitro-1,3-dioxane (**6**) under the same reaction conditions as before, provided 2-nitroamines **3g–i**, **5g–i** and **7g–i** (Scheme 4, Table 4).

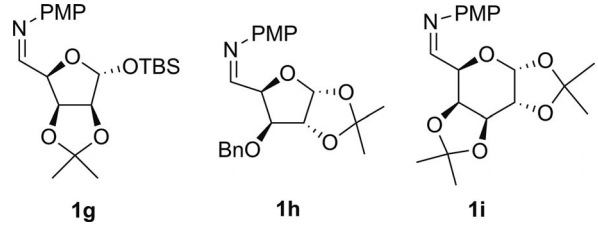
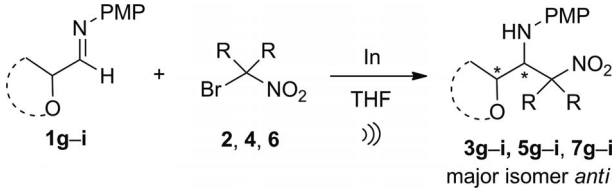


Figure 1. Chiral imines **1g–i**.



Scheme 4. Indium-mediated reaction of imines **1g–i** and bromoalkanes **2**, **4** and **6**.

Table 4. Synthesis of enantiopure 2-nitroamines **3g–i**, **5g–i** and **7g–i**.

Entry	Aldehyde	Bromonitroalkane	2-Nitroamine	Yield[a]	*syn*/*anti*[b]
1	**1g**	**2**	**3g**	85	1:4
2		**4**	**5g**	78	1:5
3		**6**	**7g**	80	1:5
4	**1h**	**2**	**3h**	79	1:4
5		**4**	**5h**	70	1:6
6		**6**	**7h**	71	1:6
7	**1i**	**2**	**3i**	75	1:3
8		**4**	**5i**	72	1:5
9		**6**	**7i**	71	1:6

[a] Isolated yields of epimeric mixtures of pure 2-nitroamines after column chromatography relative to compounds **1**. [b] *syn*/*anti* ratio was determined by 300 MHz ^{1}H NMR spectroscopic analysis of the corresponding crude products.

The excellent *anti* diastereoselectivity obtained can be explained in terms of a lowered C–N antibonding orbital that would bring about increased stabilization of a Felkin–Anh antiperiplanar nucleophilic addition of the organoindium species to the imine carbonyl,[22] as shown in Figure 2.

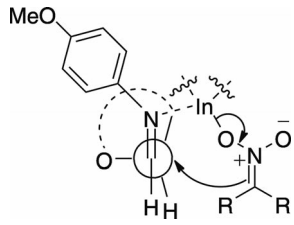
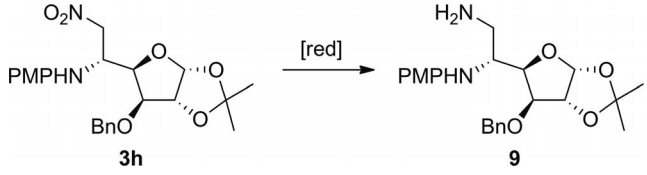


Figure 2. Felkin–Anh model for the attack on sugar imines **1g–i**.

The expected *anti* selectivity was confirmed by analysis of the NMR spectroscopic data for nitroamine **3h** and of a sample obtained by debromination[23] of the known bromonitroamine **8**[16] (Scheme 5).

Scheme 5. Debromination of bromonitroamine **8**.

Chiral enantiopure diamines are useful synthetic intermediates and are of great interest for the development of new chiral ligands for asymmetric synthesis. Particularly appropriate for those purposes are 1,2-diamines containing a sugar residue.[24] The resulting nitroamines **3g–i**, **5g–i** and **7g–i** could be suitable starting materials for the preparation of orthogonally protected sugar-derived diamines. To illustrate this synthetic possibility, reduction of compound **3h** to the corresponding diamine was investigated (Scheme 6). Although there are numerous protocols for the reduction of nitro compounds to amines,[25] the reduction of β-nitroamines is more complicated because of the inherent instability of this functional group.[26] SmI_2 has been widely used as a mild reductant for the conversion of β-nitroamines to 1,2-diamines.[27] *N*-Diphenylphosphanyl-β-nitroamines have been reduced with Zn/NH_4Cl[28] and with catalytic In with Zn as a stoichiometric reductant.[29]



Scheme 6. Reduction of β-nitroamine **3h** and preparation of orthogonally protected diamine **9**.

In our case, treatment of nitroamine **3h** with SmI_2/H_2O in the presence of pyrrolidine[30] afforded the corresponding 1,2-diamine **9** in good yield and without any loss of the

stereochemical integrity (Table 5). Similarly, the reduction can also be carried out with Zn powder in 2-propanol/dilute HCl. This procedure gave the 1,2-diamine **9** in moderate yield.

Table 5. Synthesis of diamine **9**.

Entry	Conditions	Yield[a]
1	SmI_2/H_2O/pyrrolidine	87
2	Zn/1 M HCl	69

[a] Isolated yield of pure compound **9** after column chromatography relative to compound **3h**.

Conclusions

In conclusion, we report a new synthetic route to 2-nitroamines. The process involves the indium-mediated addition of 1-bromo-1-nitroalkanes to imines. This strategy constitutes a promising and convenient alternative to the classical aza-Henry reaction. The approach is very simple from an experimental point of view and, because bases are not required, it is not subject to the limitations of the classical aza-Henry reaction. In addition, this approach may have many advantages with respect to a previously reported samarium-mediated Henry reaction of imines with bromonitromethane, which failed to give the desired 2-nitroamines when hindered bromonitroalkanes were employed.

Regarding the stereoselective version of this new approach to 2-nitroamines, promising results were achieved when chiral sugar-derived imines **1g**–**i** were treated with bromonitroalkanes **2**, **4** and **6**, with the *anti* 2-nitroamines obtained as major isomers in all cases. The corresponding 2-nitroamines can be easily reduced to afford the corresponding sugar-derived 1,2-diamines.

A systematic study of the mechanistic and stereochemical aspects of this new and highly promising access to 2-nitroamines is currently in progress. The development of an indium-catalytic procedure is also underway.

Experimental Section

General: Reactions under sonication were carried out in a Selecta cleaning bath (320 W) at 20 °C. Melting points were determined with a Kofler Thermogerate apparatus. Specific rotations were recorded on a JASCO DI-370 optical polarimeter. Nuclear magnetic resonance spectra were recorded with Varian Mercury 300 or Varian Inova 500 spectrometers. Mass spectral data were obtained with a Hewlett–Packard 5988A mass spectrometer. Thin-layer chromatography (TLC) was performed by using Merck GF-254 type 60 silica gel and ethyl acetate/hexane mixtures as eluants; the TLC spots were visualized with Hanessian mixture. Column chromatography was carried out by using Merck-type 9385 silica gel.

General Procedure for the Reaction of Bromonitroalkanes and Imines: To a suspension of indium powder (0.5 mmol) in THF (1 mL) was added the bromonitroalkane (0.75 mmol) and the mixture was sonicated for 20 min. The corresponding aldimine (0.5 mmol) was added and sonication was continued for a further 4 h. The reaction mixture was neutralized with saturated aqueous sodium hydrogen carbonate, diluted with water (10 mL) and extracted with diethyl ether (3 × 25 mL). The combined organic layers were dried with magnesium sulfate, filtered and the solvent was evaporated in vacuo. The residue was purified by flash column chromatography with mixtures of ethyl acetate/hexane as eluants to give the pure compounds shown in Tables 1, 2, 3 and 5.

4-Methoxy-*N*-(2-nitro-1-phenylethyl)benzenamine (3a): Brown oil. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 7.61–7.24 (m, 5 H), 6.73 (d, J = 9.0 Hz, 2 H), 6.58 (d, J = 9.0 Hz, 2 H), 6.23 (d, J = 7.4 Hz, 1 H), 5.09 (t, J = 6.7 Hz, 1 H), 4.69 (d, J = 6.7 Hz, 2 H), 3.71 (s, 3 H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 153.1 (C), 139.6 (C), 137.9 (C), 129.2 (2× CH), 128.5 (CH), 126.4 (2× CH), 115.6 (2× CH), 114.8 (2× CH), 80.0 (CH_2), 57.7 (CH), 55.6 (CH_3) ppm. MS (ESI$^+$): m/z (%) = 273 (4) [M + H]$^+$, 213 (7), 212 (100), 124 (7). HRMS (ESI$^+$): calcd. for $C_{15}H_{17}N_2O_3^+$ [M + H]$^+$ 273.1239; found 273.1233. IR (neat): $\tilde{\nu}$ = 3375, 1554, 1511, 1378, 1243 cm^{-1}. R_f = 0.23 (hexane/AcOEt, 3:1).

4-Methoxy-*N*-(1-nitrononan-2-yl)benzenamine (3b): Brown oil. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 6.80 (d, J = 8.5 Hz, 2 H), 6.64 (d, J = 8.5 Hz, 2 H), 4.51 (dd, J = 11.5, 4.9 Hz, 1 H), 4.41 (dd, J = 11.5, 5.7 Hz, 1 H), 3.98–3.87 (m, 1 H), 3.75 (s, 3 H), 1.71–1.27 (m, 12 H), 0.88 (t, J = 6.2 Hz, 3 H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 152.9 (C), 139.9 (C), 115.3 (2× CH), 115.0 (2× CH), 78.0 (CH_2), 55.6 (CH_3), 53.5 (CH), 32.8 (CH_2), 31.6 (CH_2), 29.2 (CH_2), 28.9 (CH_2), 25.8 (CH_2), 22.5 (CH_2), 13.9 (CH_3) ppm. MS (ESI$^+$): m/z (%) = 295 (100) [M + H]$^+$, 234 (5), 214 (4), 201 (7). HRMS (ESI$^+$): calcd. for $C_{16}H_{27}N_2O_3^+$ [M + H]$^+$ 295.2022; found 295.2016. IR (neat): $\tilde{\nu}$ = 3380, 1550, 1513, 1381, 1243 cm^{-1}. R_f = 0.48 (hexane/EtOAc, 5:1).

***N*-(1-Cyclohexyl-2-nitroethyl)-4-methoxybenzenamine (3c):** Brown oil. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 6.76 (d, J = 9.0 Hz, 2 H), 6.65 (d, J = 9.0 Hz, 2 H), 4.72 (dd, J = 12.3, 5.2 Hz, 1 H), 4.46 (dd, J = 12.3, 7.4 Hz, 1 H), 4.08–4.04 (m, 1 H), 3.73 (s, 3 H), 2.73 (s, 11 H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 152.7 (C), 141.0 (C), 115.0 (2× CH), 114.9 (2× CH), 75.7 (CH_2), 60.9 (CH), 55.7 (CH_3), 43.0 (CH), 34.7 (2× CH_2), 25.2 (CH_2), 21.6 (2× CH_2) ppm. MS (ESI$^+$): m/z (%) = 279 (6) [M + H]$^+$, 234 (19), 216 (100), 214 (28). HRMS (ESI$^+$): calcd. for $C_{15}H_{23}N_2O_3^+$ [M + H]$^+$ 279.1709; found 279.1703. R_f = 0.22, (hexane/EtOAc, 3:1).

4-Methoxy-*N*-(4-methyl-1-nitropentan-2-yl)benzenamine (3d): Brown oil. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 6.76 (d, J = 9.1 Hz, 2 H), 6.65 (d, J = 9.0 Hz, 2 H), 4.70 (dd, J = 12.5, 1.7 Hz, 1 H), 4.45 (dd, J = 12.5, 1.8 Hz, 1 H), 4.15–4.05 (m, 1 H), 3.72 (s, 3 H), 1.74–1.48 (m, 1 H), 1.28–1.23 (m, 2 H), 0.95 (t, J = 7.2 Hz, 3 H), 0.88 (t, J = 7.5 Hz, 3 H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 152.6 (C), 140.9 (C), 114.9 (2× CH), 114.8 (2× CH), 76.1 (CH_2), 75.1 (CH), 74.7 (CH), 55.6 (CH_3), 32.1 (CH), 23.3 (CH_2), 8.0 (CH_3), 7.7 (CH_3) ppm. MS (ESI$^+$): m/z (%) = 275 [M + Na]$^+$, (100), 270 [M + NH_4]$^+$, (47), 253 [M + H]$^+$, (12), 209 (6), 206 (4). HRMS (ESI$^+$): calcd. for $C_{13}H_{21}N_2O_3^+$ [M + H]$^+$ 253.1552; found 253.1548. R_f = 0.53, (hexane/EtOAc, 1:1).

4-Methoxy-*N*-(3-methyl-1-nitrobutan-2-yl)benzenamine (3e): Brown oil. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 6.79 (d, J = 7.2 Hz, 2 H), 6.64 (d, J = 7.2 Hz, 2 H), 4.48 (d, J = 5.9 Hz, 1 H), 4.12 (q, J = 7.1 Hz, 1 H), 3.89–3.74 (m, 2 H), 3.70 (s, 3 H), 1.29–1.23 (m, 1 H), 1.03 (apparent t, J = 7.0 Hz, 6 H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 152.8 (C), 140.3 (C), 115.2 (2× CH), 115.0 (2× CH), 76.5 (CH_2), 58.9 (CH), 55.7 (CH_3), 30.4 (CH), 19.0 (CH_3), 18.1 (CH_3) ppm. MS (ESI$^+$): m/z (%) = 239 (100) [M + H]$^+$, 232 (29), 208 (20), 176 (24). HRMS (ESI$^+$): calcd. for $C_{12}H_{19}N_2O_3^+$ [M + H]$^+$ 239.1396; found 239.1390. R_f = 0.53, (hexane/EtOAc, 3:1).

4-Methoxy-*N*-(2,2-dimethyl-2-nitro-1-phenylethyl)benzenamine (5a): Brown oil. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 7.34–7.25 (m, 5 H), 6.66 (d, J = 9.1 Hz, 2 H), 6.51 (d, J = 9.1 Hz, 2 H), 4.85 (s, 1 H), 4.25 (br. s, 1 H), 3.67 (s, 3 H), 1.61 (s, 3 H), 1.62 (s, 3 H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 152.9 (C), 140.3 (C), 137.5 (C), 128.7 (2× CH), 128.5 (CH), 128.3 (2× CH), 115.8 (2× CH), 114.8 (2× CH), 91.4 (C), 65.9 (CH), 55.7 (CH_3), 25.7 (CH_3), 21.0 (CH_3) ppm. MS (ESI$^+$): m/z (%) = 301.15 (75) [M + H]$^+$, 124.07 (100). HRMS (ESI$^+$): calcd. for $C_{17}H_{21}N_2O_3^+$ [M + H]$^+$ 301.1547; found 301.1537. R_f = 0.29, (hexane/AcOEt, 7:1).

4-Methoxy-*N*-(2,2-dimethyl-1-nitrononan-2-yl)benzenamine (5b): Brown oil. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 6.82 (d, J = 8.9 Hz, 2 H), 6.53 (d, J = 8.9 Hz, 2 H), 3.80 (s, 1 H), 3.76 (br. s, 1 H), 3.71 (s, 3 H), 1.64–1.13 (m, 18 H), 0.93–0.82 (m, 3 H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 152.3 (C), 138.7 (C), 115.8 (2× CH), 114.3 (2× CH), 91.5 (C), 62.7 (CH), 55.9 (CH_3), 32.0 (CH_2), 29.9 (CH_2), 29.3 (CH_2), 28.2 (CH_2), 26.5 (CH_2), 25.1 (CH_3), 22.9 (CH_2), 22.8 (CH_3), 14.3 (CH_3) ppm. MS (ESI$^+$): m/z (%) = 323.23 (12) [M + H]$^+$. HRMS (ESI$^+$): calcd. for $C_{18}H_{31}N_2O_3^+$ [M + H]$^+$ 323.2335; found 323.2342. R_f = 0.28, (hexane/EtOAc, 9:1).

***N*-(1-Cyclohexyl-2,2-dimethyl-2-nitroethyl)-4-methoxybenzenamine (5c):** Brown oil. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 6.76 (d, J = 9.0 Hz, 2 H), 6.63 (d, J = 9.0 Hz, 2 H), 3.80 (s, 1 H), 3.74 (s, 3 H), 3.54 (br. s, 1 H), 1.80–1.64 (m, 4 H), 1.62 (s, 3 H), 1.60 (s, 3 H), 1.32–0.79 (m, 7 H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 152.3 (C), 142.9 (C), 115.1 (2× CH), 114.3 (2× CH), 92.2 (C), 65.3 (CH), 55.9 (CH_3), 40.9 (CH), 33.6 (CH_2), 28.4 (CH_2), 26.7 (CH_2), 26.3 (CH_2), 26.1 (CH_2), 25.2 (CH_3), 23.2 (CH_3) ppm. MS (ESI$^+$): m/z (%) = 307.20 (29) [M + H]$^+$, 124 (100). HRMS (ESI$^+$): calcd. for $C_{17}H_{27}N_2O_3^+$ [M + H]$^+$ 307.2016; found 307.2027. R_f = 0.29, (hexane/EtOAc, 9:1).

4-Methoxy-*N*-(2,2,4-trimethyl-1-nitropentan-2-yl)benzenamine (5d): Brown oil. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 6.75 (d, J = 9.0 Hz, 2 H), 6.62 (d, J = 9.0 Hz, 2 H), 3.97 (br. s, 1 H), 3.93 (s, 1 H), 3.74 (s, 3 H), 1.73–1.64 (m, 1 H), 1.61 (s, 3 H), 1.57 (s, 3 H), 1.34 (d, J = 6.8 Hz, 1 H), 2.01 (d, J = 6.8 Hz, 1 H), 0.89, 0.86, 0.84, 0.81 (4s, 6 H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 152.3 (C), 142.3 (C), 115.1 (2× CH), 114.0 (2× CH), 92.6 (C), 59.4 (CH), 55.9 (CH_3), 42.0 (CH_2), 24.9 (CH), 24.1 (CH_3), 24.0 (CH_3), 22.4 (CH_3), 21.6 (CH_3) ppm. MS (ESI$^+$): m/z (%) = 281.18 (100) [M + H]$^+$, 258.18 (82). HRMS (ESI$^+$): calcd. for $C_{15}H_{25}N_2O_3^+$ [M + H]$^+$ 281.1860; found 281.1855. R_f = 0.30, (hexane/EtOAc, 9:1).

***N*-[1-(2,2-Dimethyl-5-nitro-1,3-dioxan-5-yl)octyl]-4-methoxyaniline (7b):** Brown oil. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 6.82 (d, J = 8.9 Hz, 2 H), 6.52 (d, J = 8.9 Hz, 2 H), 4.77 (d, J = 13.2 Hz, 2 H), 4.27 (d, J = 13.2 Hz, 2 H), 3.76 (s, 1 H), 3.75 (br. s, 1 H), 3.71 (s, 3 H), 1.53 (s, 3 H), 1.37 (s, 3 H), 1.35–1.18 (m, 12 H), 0.93–0.82 (m, 3 H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 152.1 (C), 141.2 (C), 115.8 (2× CH), 115.1 (2× CH), 99.8 (C), 93.9 (C), 32.7 (CH_2), 29.9 (CH_2), 29.3 (CH_2), 28.2 (CH_2), 26.5 (2× CH_3), 25.3, (CH_2), 22.9 (CH_2), 14.2 (CH_3) ppm. MS (ESI$^+$): m/z (%) = 395.25 (17) [M + H]$^+$. HRMS (ESI$^+$): calcd. for $C_{21}H_{35}N_2O_5^+$ [M + H]$^+$ 395.2546; found 395.2555. R_f = 0.30, (hexane/EtOAc, 5:1).

***N*-[Cyclohexyl(2,2-dimethyl-5-nitro-1,3-dioxan-5-yl)methyl]-4-methoxyaniline (7c):** Brown oil. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 6.79 (d, J = 8.9 Hz, 2 H), 6.64 (d, J = 8.9 Hz, 2 H), 4.58 (d, J = 12.6 Hz, 1 H), 4.43 (d, J = 12.6 Hz, 1 H), 4.08 (d, J = 12.6 Hz, 2 H), 3.80 (s, 1 H), 3.75 (s, 3 H), 3.65 (br. s, 1 H), 1.72–1.45 (m, 4 H), 1.38 (s, 3 H), 1.35 (s, 3 H), 1.30–0.92 (m, 7 H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 152.5 (C), 142.3 (C), 115.2 (2× CH), 114.4 (2× CH), 99.4 (C), 90.7 (C), 63.3 (CH_2), 63.1 (CH_2), 61.7 (CH), 55.8 (CH_3), 39.5 (CH), 33.8 (CH_2), 27.0 (CH_2), 26.6 (CH_2), 26.1 (CH_2), 26.0 (CH_2), 25.5 (CH_3), 21.4 (CH_3) ppm. MS (ESI$^+$): m/z (%) = 379.22 (15) [M + H]$^+$, 124.08. HRMS (ESI$^+$): calcd. for $C_{20}H_{31}N_2O_3^+$ [M + H]$^+$ 379.2233; found 379.2227. R_f = 0.29, (hexane/EtOAc, 5:1).

4-Methoxy-*N*-[2-methyl-1-(2,2-dimethyl-5-nitro-1,3-dioxan-5-yl)propyl]benzenamine (7e): Brown oil. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 6.74 (d, J = 8.9 Hz, 2 H), 6.63 (d, J = 8.9 Hz, 2 H), 4.72 (d, J = 12.9 Hz, 2 H), 4.25 (d, J = 12.9 Hz, 2 H), 3.75–3.78 (m, 1 H), 3.74 (s, 3 H), 1.88–1.74 (m, 1 H), 1.51 (s, 3 H), 1.47 (s, 3 H), 0.98–0.81 (m, 6 H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 153.1 (C), 142.0 (C), 115.1 (2× CH), 114.5 (2× CH), 101.2 (C), 94.5 (C), 63.3 (CH_2), 63.1 (CH_2), 55.9 (CH_3), 53.4 (CH), 27.2 (CH), 25.2 (CH_3), 24.5 (CH_3), 18.4 (CH_3), 16.6 (CH_3) ppm. MS (ESI$^+$): m/z (%) = 339.19 (31) [M + H]$^+$. HRMS (ESI$^+$): calcd. for $C_{17}H_{27}N_2O_5^+$ [M + H]$^+$ 339.1920; found 339.1929. R_f = 0.30, (hexane/EtOAc, 5:1).

4-Methoxy-*N*-[(4-methoxyphenyl)(2,2-dimethyl-5-nitro-1,3-dioxan-5-yl)methyl]benzenamine (7f): Brown oil. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 7.85–7.82 (m, 2 H), 7.26–7.19 (m, 2 H), 6.99–6.90 (m, 4 H), 4.50 (dd, J = 12.5, 4.0 Hz, 2 H), 4.38–4.32 (m, 1 H), 4.25 (dd, J = 12.5, 4.0 Hz, 2 H), 3.87 (s, 3 H), 3.83 (s, 3 H), 1.46 (s, 3 H), 1.42 (s, 3 H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 162.0 (C), 145.2 (C), 132.0 (C), 130.2 (2× CH), 129.4 (C) 122.0 (2× CH), 114.3 (2× CH), 114.1 (2× CH), 99.1 (C), 59.7 (2× CH_2), 55.5 (CH_3), 55.4 (CH_3), 25.3 (CH_3), 21.2 (CH_3) ppm. MS (ESI$^+$): m/z (%) = 403.19 (40) [M + H]$^+$. HRMS (ESI$^+$): calcd. for $C_{21}H_{27}N_2O_6^+$ [M + H]$^+$ 403.1869; found 403,1858. R_f = 0.41, (hexane/EtOAc, 5:1).

1-*O*-*tert*-Butyldimethylsilyl-5,6-deoxy-2,3-di-*O*-isopropylidene-5-[(*p*-methoxyphenyl)amino]-6-nitro-α-D-mannofuranose and L-Gulofuranose (3 g): Orange oil. $[a]_D^{26}$ = +7.5 (c = 1.4, in $CHCl_3$). ^{1}H NMR (500 MHz, $CDCl_3$): δ = 6.78 (d, J = 8.7 Hz, 4 H), 6.71 (d, J = 8.7 Hz, 4 H), 5.64 (d, J = 1.7 Hz, 2 H), 5.33 (s, 1 H), 5.30 (s, 1 H), 4.82–4.65 (m, 4 H), 4.60–4.53 (m, 4 H), 4.42–4.32 (m, 2 H), 4.17 (dd, J = 7.5, 2.4 Hz, 1 H); 4.10 (dd, J = 7.1, 1.7 Hz, 1 H), 3.72 (s, 3 H), 3.71 (s, 3 H), 1.50 (s, 3 H), 1.48 (s, 3 H), 1.29, (s, 6 H), 0.89 (s, 9 H), 0.88 (s, 9 H), 0.12 (s, 3 H), 0.11 (s, 3 H), 0.09 (s, 3 H), 0.08 (s, 3 H) ppm. ^{13}C NMR (125 MHz, $CDCl_3$): major isomer D-*manno* (*anti*): δ = 153.1 (C), 139.3 (C), 116.5 (2× CH), 115.2 (CH), 114.6 (2× CH), 112.2 (C), 101.0 (CH), 86.6 (CH), 79.4 (CH), 75.2 (CH_2), 55.2 (CH_3), 52.5 (CH), 25.7 (CH_3), 25.3 (3× CH_3), 24.3 (CH_3), 17.5 (C), –4.8 (CH_3), –5.8 (CH_3) ppm; minor isomer L-*gulo* (*syn*): δ 152.8 (C), 139.7 (C), 116.5 (2× CH), 115.2 (CH), 114.6 (2× CH), 112.4 (C), 101.0 (CH), 79.0 (CH), 78.0 (CH), 76.1 (CH_2), 55.2 (CH_3), 53.0 (CH), 25.5 (CH_3), 25.3 (3× CH_3), 23.9 (CH_3), 17.5 (C), –4.7 (CH_3), –5.7 (CH_3) ppm. MS (ESI$^+$): m/z (%) = 491 (2) [M + Na]$^+$, 469 (100) [[M + H]$^+$], 408 (13), 337 (9). HRMS (ESI$^+$): calcd. for $C_{22}H_{37}N_2O_7Si^+$ [M + H]$^+$ 469.2370; found 469.2365. R_f = 0.53, (hexane/AcOEt, 3:1).

3-*O*-Benzyl-5,6-dideoxy-1,2-*O*-isopropylidene-5-[(*p*-methoxyphenyl)-amino]-6-nitro-α-D-glucofuranose (3h): Yellow oil. $[a]_D^{27}$ = –9.2 (c = 0.6 in $CHCl_3$). ^{1}H NMR (500 MHz, $CDCl_3$): δ = 7.34–7.12 (m, 5 H), 6.54 (d, J = 9.0 Hz, 2 H), 6.34 (d, J = 9.0 Hz, 2 H), 5.83 (d, J = 3.6 Hz, 1 H), 4.67 (dd, J = 13.1, 3.9 Hz, 1 H), 4.59–4.44 (m, 3 H), 4.42–4.38 (m, 1 H), 4.24–4.17 (m, 3 H), 4.02 (d, J = 3.1 Hz, 1 H), 3.73 (s, 3 H), 1.47 (s, 3 H); 1.31 (s, 3 H) ppm. ^{13}C NMR (125 MHz, $CDCl_3$): δ = 153.3 (C), 139.3 (C), 136.9 (C), 128.4 (2× CH), 128.0 (CH), 127.9 (2× CH), 116.3 (2× CH), 114.9 (2× CH), 112.1 (C), 104.9 (CH), 81.9 (CH), 81.2 (CH), 79.9 (CH), 75.8 (CH_2), 72.1 (CH_2), 55.6 (CH_3), 51.9 (CH), 26.7 (CH_3), 26.2 (CH_3) ppm. MS (ESI$^+$): m/z (%) = 445 (100) [M + H]$^+$, 444 (1), 316 (5), 289 (1), 288 (21). HRMS (ESI$^+$): calcd. for $C_{23}H_{29}N_2O_7^+$ [M + H]$^+$ 445.1975; found 445.1969. R_f = 0.28, (hexane/AcOEt, 3:1).

6,7-Dideoxy-1,2:3,4-di-*O*-isopropylidene-6-[(*p*-methoxyphenyl)-amino]-7-nitro-*glycero*-β-D-*galacto*-heptose (3i): Orange oil. $[\alpha]_D^{20}$ = +12.1 (*c* = 0.7 in $CHCl_3$). ^1H NMR (300 MHz, $CDCl_3$): δ = 6.80–6.65 (m, 8 H), 5.59 (d, *J* = 3.1 Hz, 1 H), 5.56 (d, *J* = 3.1 Hz, 1 H), 4.87 (dd, *J* = 8.0, 2.3 Hz, 1 H), 4.81 (dd, *J* = 7.8, 3.0 Hz, 1 H), 4.67 (dd, *J* = 7.9, 4.4 Hz, 1 H), 4.61–4.57 (m, 3 H), 4.44–4.40 (m, 1 H), 4.38 (dd, *J* = 4.9, 1.1 Hz, 1 H); 4.35 (dd, *J* = 4.8, 1.1 Hz, 1 H), 4.32 (dd, *J* = 3.0, 1.4 Hz, 1 H), 4.29 (dd, *J* = 3.0, 1.4 Hz, 1 H), 4.28–4.27 (m, 2 H), 4.12 (dd, *J* = 3.4, 1.0 Hz, 1 H), 3.95 (dd, *J* = 3.6, 1.0 Hz, 1 H), 3.74 (s, 6 H), 1.46 (s, 8 H), 1.33–1.32 (m, 13 H), 1.29 (s, 4 H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): major isomer D-*glycero* (*anti*) δ 153.5 (C), 139.8 (C), 117.0 (2× CH), 114.9 (2× CH), 109.4 (C), 108.8 (C), 96.3 (CH), 75.1 (CH_2), 71.1 (CH), 70.9 (CH), 70.7 (CH), 67.0 (CH), 55.6 (CH_3), 54.6 (CH), 25.8 (CH_3), 25.7 (CH_3), 24.8 (CH_3), 24.0 (CH_3) ppm; minor isomer L-*glycero* (*syn*): δ = 153.0 (C), 139.9 (C), 115.1 (2× CH), 115.0 (2× CH), 109.6 (C), 108.9 (C), 96.5 (CH), 76.0 (CH_2), 70.9 (2× CH), 70.4 (CH), 65.4 (CH), 55.6 (CH_3), 54.8 (CH), 25.8 (2× CH_3), 24.8 (CH_3), 24.0 (CH_3) ppm. MS (ESI^+): *m*/*z* (%) = 447 (5) $[M + Na]^+$, 424 (100) $[M + H]^+$, 386 (22), 364 (26). HRMS (ESI^+): calcd. for $C_{20}H_{29}N_2O_8^+$ $[M + H]^+$ 425.1924; found 425.1918. R_f = 0.46, (hexane/AcOEt, 3:1).

1-*O*-*tert*-Butyldimethylsilyl-5-deoxy-2,3-di-*O*-isopropylidene-5-[(*p*-methoxyphenyl)amino]-5-(1-methyl-1-nitroethyl)-α-D-lyxofuranose (5 g): Major isomer 5*R* (*anti*): orange oil. $[\alpha]_D^{24}$ = +101.4 (*c* = 0.9 in $CHCl_3$). ^1H NMR (300 MHz, $CDCl_3$): δ = 6.78–6.69 (m, 4 H), 5.22 (s, 1 H), 4.75 (dd, *J* = 5.8, 3.4 Hz, 1 H), 4.65–4.56 (m, 2 H), 4.45 (d, *J* = 5.8 Hz, 1 H), 3.95 (dd, *J* = 9.3, 3.4 Hz, 1 H), 3.73 (s, 3 H), 1.63 (s, 3 H), 1.60 (s, 3 H), 1.52 (s, 3 H), 1.24 (s, 3 H), 0.87 (s, 9 H), 0.09 (s, 3 H), 0.08 (s, 3 H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 152.4 (C), 141.4 (C), 114.9 (4× CH), 112.6 (C), 101.6 (CH), 90.8 (C), 86.4 (CH), 80.6 (2× CH), 57.9 (CH_3), 55.8 (CH), 26.5 (CH_3), 26.3 (3× CH_3), 25.5 (CH_3), 25.3 (CH_3), 22.8 (CH_3), 18.0 (C), –4.4 (CH_3), –5.5 (CH_3) ppm. MS (ESI^+): *m*/*z* (%) = 497.27 (100) $[M + H]^+$. HRMS (ESI^+): calcd. for $C_{24}H_{41}N_2O_7Si^+$ $[M + H]^+$ 497.2683; found 497.2678. R_f = 0.35, (hexane/AcOEt, 7:1). Minor isomer 5*S* (*syn*): orange oil. $[\alpha]_D^{24}$ = –71.8 (*c* = 0.9 in $CHCl_3$). ^1H NMR (300 MHz, $CDCl_3$): δ = 6.74 (d, *J* = 9.0 Hz, 2 H), 6.64 (d, *J* = 9.0 Hz, 2 H), 5.34 (s, 1 H), 4.65 (dd, *J* = 5.8, 4.0 Hz, 1 H), 4.54–4.46 (m, 1 H), 4.42 (d, *J* = 5.8 Hz, 1 H), 3.91 (d, *J* = 4.0 Hz, 1 H), 3.79–3.68 (m, 4 H), 1.63 (s, 3 H), 1.61 (s, 3 H), 1.25 (s, 3 H), 1.14 (s, 3 H), 0.88 (s, 9 H), 0.12 (s, 3 H), 0.11 (s, 3 H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 152.1 (C), 142.0 (C), 114.6 (4× CH), 112.5 (C), 101.0 (CH), 93.1 (C), 86.2 (CH), 81.0 (CH), 76.7 (CH) 56.7 (CH_3), 55.9 (CH), 25.7 (2× CH_3), 25.6 (CH_3), 25.5 (CH_3), 24.9 (CH_3), 24.1 (CH_3), 20.5 (CH_3), 18.0 (C), –4.3 (CH_3), –5.2 (CH_3) ppm. MS (ESI^+): *m*/*z* (%) = 497.27 (100) $[M + H]^+$. HRMS (ESI^+): calcd. for $C_{24}H_{41}N_2O_7Si^+$ $[M + H]^+$ 497.2678; found 497.2673. R_f = 0.29, (hexane/AcOEt, 9:1).

(5*R*)-3-*O*-Benzyl-6-deoxy-1,2-*O*-isopropylidene-5-[(*p*-methoxyphenyl)amino]-5-(1-methyl-1-nitroethyl)-α-D-xylofuranose (5h): Yellow oil. ^1H NMR (300 MHz, $CDCl_3$): δ = 7.38–7.28 (m, 3 H), 7.15–7.12 (m, 2 H), 6.67–6.61 (m, 4 H), 5.86 (d, *J* = 3.7 Hz, 1 H), 4.67–4.50 (m, 1 H), 4.43 (d, *J* = 3.7 Hz, 1 H), 4.24 (d, *J* = 11.3 Hz, 1 H), 4.04 (dd, *J* = 9.6, 3.0 Hz, 1 H), 3.87–3.82 (m, 2 H), 3.68 (s, 3 H), 3.36 (d, *J* = 9.6 Hz, 1 H), 1.70 (s, 3 H), 1.67 (s, 3 H), 1.49 (s, 3 H), 1.28 (s, 3 H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 152.7 (C), 140.9 (C), 137.4 (C), 128.4 (2× CH), 127.8 (CH), 127.6 (2× CH), 115.1 (2× CH), 114.9 (2× CH), 111.9 (C), 105.3 (CH), 91.2 (C), 82.2 (CH), 80.9 (CH), 80.8 (CH), 71.5 (CH_2), 57.9 (CH), 55.8 (CH_3), 27.1 (CH_3), 26.3 (CH_3), 24.2 (CH_3), 23.5 (CH_3) ppm. MS (ESI^+): *m*/*z* (%) = 473.23 (100) $[M + H]^+$, 406 (69). HRMS (ESI^+): calcd. for $C_{25}H_{33}N_2O_7^+$ $[M + H]^+$ 473.2282; found 473.2270. R_f = 0.31, (hexane/AcOEt, 5:1).

(6*R*)-6,7-Dideoxy-6-deoxy-1,2:3,4-di-*O*-isopropylidene-6-[(*p*-methoxyphenyl)amino]-6-(1-methyl-1-nitroethyl)-β-D-*galacto*-heptose (5i): Yellow oil. ^1H NMR (300 MHz, $CDCl_3$): δ = 6.96–6.57 (m, 4 H), 5.44 (d, *J* = 5.0 Hz, 1 H), 4.75 (d, *J* = 13.4 Hz, 1 H), 4.58–4.53 (m, 1 H), 4.34–4.34 (m, 2 H), 4.14 (d, *J* = 13.4 Hz, 1 H), 4.05 (d, *J* = 13.4 Hz, 1 H), 3.75 (s, 3 H), 1.54 (s, 3 H), 1.48 (s, 3 H), 1.35 (s, 6 H), 1.30 (s, 3 H), 1.25 (s, 3 H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 152.8 (C), 141.2 (C), 115.1 (2× CH), 115.0 (2× CH), 109.3 (C), 99.6 (C), 96.4 (CH), 91.7 (C), 70.8 (CH), 70.7 (CH), 64.0 (CH), 63.5 (CH), 57.1 (CH), 55.8 (CH_3), 26.2 (CH_3), 25.9 (CH_3), 25.2 (CH_3), 24.9 (CH_3), 24.5 (CH_3), 21.8 (CH_3) ppm. MS (ESI^+): *m*/*z* (%) = 453.22 ($[M + H]^+$, 100). HRMS (ESI^+): calcd. for $C_{22}H_{33}N_2O_8^+$ $[M + H]^+$ 453.2237; found 453.2246. R_f = 0.46, (hexane/AcOEt, 3:1).

1-*O*-*tert*-Butyldimethylsilyl-5-deoxy-2,3-di-*O*-isopropylidene-5-[(*p*-methoxyphenyl)amino]-5-(2,2-dimethyl-5-nitro-1,3-dioxan-5-yl)-α-D-lyxofuranose (7 g): Orange oil. $[\alpha]_D^{24}$ = –26.2 (*c* = 2.2 in $CHCl_3$). ^1H NMR (300 MHz, $CDCl_3$): δ = 6.80–6.58 (m, 8 H), 5.34 (s, 1 H, 1-H*anti*), 5.24 (s, 1 H, 1-H*syn*), 4.81–4.67 (m, 3 H), 4.65–4.49 (m, 3 H), 4.44–4.42 (m, 2 H), 4.38–4.25 (m, 4 H), 4.24–4.12 (m, 2 H), 4.11–3.98 (m, 3 H), 3.93 (dd, *J* = 9.2, 3.3 Hz, 1 H), 3.74 (2s, 6 H), 1.52 (s, 3 H), 1.39 (s, 3 H), 1.36 (s, 3 H), 1.34 (s, 3 H), 1.33 (s, 3 H), 1.25 (s, 6 H), 1.13 (s, 3 H), 0.89 (s, 9 H), 0.87 (s, 9 H), 0.16 (s, 3 H), 0.14 (s, 3 H), 0.11 (s, 6 H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 152.8 (C), 152.5 (C), 141.1 (2× C), 115.1 (2× CH), 115.0 (2× CH), 114.7 (2× CH), 114.6 (2× CH), 112.7 (C), 112.4 (C), 101.6 (CH), 101.0 (CH), 99.3 (C), 98.7 (C), 91.7 (C), 91.6 (C), 86.3 (CH), 86.0 (CH), 80.8 (CH), 80.6 (CH), 80.2 (CH), 75.3 (CH), 63.8 (CH_2), 63.6 (CH_2), 63.4 (CH_2), 60.5 (CH_2), 55.8 (CH_3), 55.5 (CH_3), 54.1 (2× CH), 27.6 (CH_3), 26.4 (2× CH_3), 25.9 (CH_3), 25.7 (4× CH_3), 25.2 (CH_3), 24.9 (2× CH_3), 23.9 (CH_3), 21.1 (CH_3), 19.6 (CH_3), 18.0 (2× C), –4.3 (CH_3), –4.6 (CH_3), –5.3 (CH_3), –5.6 (CH_3) ppm. MS (ESI^+): *m*/*z* (%) = 569.29 ($[M + H]^+$, 100), 430.20 (35). HRMS (ESI^+): calcd. for $C_{27}H_{45}N_2O_9Si^+$ $[M + H]^+$ 569.2889; found 569.2871. R_f = 0.30, (hexane/AcOEt, 7:1).

3-*O*-Benzyl-6-deoxy-1,2-*O*-isopropylidene-5-[(*p*-methoxyphenyl)-amino]-5-(2,2-dimethyl-5-nitro-1,3-dioxan-5-yl)-α-D-xylofuranose (7h): Major isomer 5*R* (*anti*): orange oil. $[\alpha]_D^{24}$ = –67.4 (*c* = 0.8 in $CHCl_3$). ^1H NMR (300 MHz, $CDCl_3$): δ = 7.22–7.13 (m, 3 H), 6.76 (d, *J* = 8.9 Hz, 2 H), 6.74–6.70 (m, 2 H), 6.53 (d, *J* = 8.9 Hz, 2 H), 5.95 (d, *J* = 3.7 Hz, 1 H), 4.70–4.54 (m, 2 H), 4.49 (d, *J* = 3.7 Hz, 1 H), 4.37 (d, *J* = 13.0 Hz, 1 H), 4.30–4.25 (m, 2 H), 4.21 (d, *J* = 3.4 Hz, 1 H), 4.12 (d, *J* = 11.7 Hz, 1 H), 3.98 (br. s, 1 H), 3.78 (d, *J* = 3.4 Hz, 1 H), 3.75 (s, 3 H), 3.71 (s, 1 H), 1.46 (s, 3 H), 1.39 (s, 3 H), 1.33 (s, 3 H), 1.30 (s, 3 H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 152.9 (C), 141.6 (C), 136.3 (C), 128.2 (2× CH), 128.0 (CH), 127.08 (2× CH), 114.7 (4× CH), 112.5 (C), 104.8 (CH), 98.7 (C), 92.0 (C), 83.4 (CH), 80.8 (CH), 81.3 (CH), 72.0 (CH_2), 63.3 (CH_2), 60.4 (CH_2), 56.4 (CH_3), 55.6 (CH), 27.4 (CH_3), 26.9 (CH_3), 26.4 (CH_3), 19.5 (CH_3) ppm. MS (ESI^+): *m*/*z* (%) = 545.25 (100) $[M + H]^+$. HRMS (ESI^+): calcd. for $C_{28}H_{37}N_2O_9^+$ $[M + H]^+$ 545.2499; found 545.2441. R_f = 0.32, (hexane/AcOEt, 3:1). Minor isomer 5*S* (*syn*): orange oil. ^1H NMR (300 MHz, $CDCl_3$): δ = 7.32–7.29 (m, 3 H), 7.15–7.11 (m, 2 H), 6.68 (d, *J* = 9.1 Hz, 2 H), 6.62 (d, *J* = 9.1 Hz, 2 H), 5.88 (d, *J* = 3.5 Hz, 1 H), 4.81 (d, *J* = 13.6 Hz, 1 H), 4.43 (d, *J* = 3.5 Hz, 1 H), 4.38–4.29 (m, 2 H), 4.28–4.23 (m, 2 H), 4.15 (d, *J* = 9.0 Hz, 1 H), 4.10–3.93 (m, 3 H), 3.91 (d, *J* = 2.7 Hz, 1 H), 3.71 (s, 3 H), 1.47 (s, 3 H), 1.38 (s, 3 H), 1.34 (s, 3 H), 1.28 (s, 3 H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 152.9 (C), 140.7 (C), 137.2 (C), 128.5 (2× CH), 128.0 (CH), 128.0 (2× CH), 115.1

(4× CH), 112.5 (C), 105.5 (CH), 99.3 (C), 91.8 (C), 82.4 (CH), 80.8 (CH), 80.4 (CH), 72.0 (CH_2), 63.7 (CH_2), 63.0 (CH_2), 55.8 (CH_3), 54.7 (CH), 27.0 (CH_3), 26.6 (CH3), 25.9 (CH_3), 21.1 (CH_3) ppm. R_f = 0.28 (hexane/AcOEt, 3:1).

(6*R*)-6,7-Dideoxy-6-deoxy-1,2:3,4-di-*O*-isopropylidene-6-[(*p*-methoxyphenyl)amino]-6-(2,2-dimethyl-5-nitro-1,3-dioxan-5-yl)-β-D-*gal*-*acto*-heptose (7i): Orange oil. $[\alpha]_D^{20}$ = +12.1 (*c* = 0.7 in $CHCl_3$). ^{1}H NMR (300 MHz, $CDCl_3$): δ = 6.80–6.65 (m, 8 H), 5.59 (d, *J* = 3.1 Hz, 1 H), 5.56 (d, *J* = 3.1 Hz, 1 H), 4.87 (dd, *J* = 8.0, 2.3 Hz, 1 H), 4.81 (dd, *J* = 7.8, 3.0 Hz, 1 H), 4.67 (dd, *J* = 7.9, 4.4 Hz, 1 H), 4.61–4.57 (m, 3 H), 4.44–4.40 (m, 1 H), 4.38 (dd, *J* = 4.9, 1.1 Hz, 1 H); 4.35 (dd, *J* = 4.8, 1.1 Hz, 1 H), 4.32 (dd, *J* = 3.0, 1.4 Hz, 1 H), 4.29 (dd, *J* = 3.0, 1.4 Hz, 1 H), 4.28–4.27 (m, 2 H), 4.12 (dd, *J* = 3.4, 1.0 Hz, 1 H), 3.95 (dd, *J* = 3.6, 1.0 Hz, 1 H), 3.74 (s, 6 H), 1.46 (s, 8 H), 1.33–1.32 (m, 13 H), 1.29 (s, 4 H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): major isomer δ = 153.5 (C), 139.8 (C), 117.0 (2×CH), 114.9 (2×CH), 109.4 (C), 108.8 (C), 96.3 (CH), 75.1 (CH_2), 71.1 (CH), 70.9 (CH), 70.7 (CH), 67.0 (CH), 55.6 (CH_3), 54.6 (CH), 25.8 (CH_3), 25.7 (CH_3), 24.8 (CH_3), 24.0 (CH_3) ppm; minor isomer; δ 153.0 (C), 139.9 (C), 115.1 (2×CH), 115.0 (2×CH), 109.6 (C), 108.9 (C), 96.5 (CH), 76.0 (CH_2), 70.9 (2×CH), 70.4 (CH), 65.4 (CH), 55.6 (CH_3), 54.8 (CH), 25.8 (2×CH_3), 24.8 (CH_3), 24.0 (CH_3) ppm. MS (ESI^+): *m*/*z* (%) = 525.24 ([M + H]$^+$, 100). HRMS (ESI^+): calcd. for $C_{25}H_{37}N_2O_{10}^+$ [M + H]$^+$ 525.2448; found 525.2441. R_f = 0.46, (hexane/AcOEt, 3:1).

3-*O*-Benzyl-5,6-dideoxy-1,2-*O*-isopropylidene-5-[(*p*-methoxyphenyl)-amino]-6-nitro-α-D-glucofuranose (3h): (6*R*)-3-*O*-Benzyl-6-bromo-5,6-dideoxy-1,2-*O*-isopropylidene-5-*p*-methoxyphenylamino-6-nitro-α-D-glucofuranose (**8**) (28 mg, 0.053 mmol), Bu_3SnH (0.063 mmol) and 2-2′-azoisobutyronitrile (AIBN) (0.01 mmol) were dissolved in dry distilled benzene (0.5 mL). The solution was deoxygenated with nitrogen and irradiated for 6 h. The ^{1}H NMR spectrum of the crude reaction mixture indicated the presence of nitroamine **3h**.

6-Amino-3-*O*-benzyl-5,6-dideoxy-1,2-*O*-isopropylidene-5-[(*p*-methoxyphenyl)amino]-α-D-glucofuranose (9). Method A: To a solution of SmI_2 (0.1 M, 20 mL, 1.95 mmol) in THF was added nitroamine **3h** (88 mg, 0.195 mmol) followed by water (10 μL, 0.58 mmol) and pyrrolidine (35 μL, 0.38 mmol) under a nitrogen atmosphere. The resulting mixture was diluted with diethyl ether (2 mL) and treated with a solution of potassium sodium tartrate and potassium carbonate (10% w/w each). The aqueous phase was extracted with two portions of diethyl ether. The combined organic extracts were dried and evaporated and the resulting residue was purified by flash column chromatography (CH_2Cl_2/MeOH, 9:1) to afford diamine **9** (71 mg, 87%) as an amorphous beige solid.

Method B: To a solution of nitroamine **3h** (92 mg, 0.21 mmol) in a mixture of 2-propanol (5 mL) and aqueous hydrochloric acid (1 M, 2.7 mL), zinc powder (0.27 g, 4.20 mmol) was added in 4 portions. The mixture was stirred for 7 h, filtered through a Celite pad, washing with ethyl acetate, and the filtrate was diluted with water and extracted with ethyl acetate. The combined organic extracts were dried and evaporated and the resulting residue was purified by flash column chromatography (CH_2Cl_2/MeOH, 9:1) to afford diamine **9** (59 mg, 69%) as an amorphous beige solid. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 7.27–7.22 (m, 3 H), 7.21–7.16 (m, 2 H), 6.71 (d, *J* = 9.1 Hz, 2 H), 6.64 (d, *J* = 9.1 Hz, 2 H), 5.82 (d, *J* = 3.8 Hz, 1 H), 4.44 (d, *J* = 3.8 Hz, 1 H), 4.37 (d, *J* = 11.5 Hz, 1 H), 4.20 (dd, *J* = 7.8 Hz, 2.8 Hz, 1 H), 4.11–4.02 (m, 2 H), 3.83 (d, *J* = 2.8 Hz, 1 H), 3.63 (s, 3 H), 3.28 (dd, *J* = 13.1, 4.5 Hz, 1 H), 3.16 (dd, *J* = 13.1, 6.6 Hz, 1 H), 1.43 (s, 3 H), 1.19 (s, 3 H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ 153.0 (C), 140.1 (C), 137.3 (C), 129.0 (2×CH), 128.6 (CH), 128.0 (2×CH), 116.7 (2×CH), 115.0 (2×CH), 112.2 (C), 104.8 (CH), 81.9 (CH), 81.4 (CH), 81.2 (CH), 71.9 (CH_2), 55.8 (CH_3), 41.8 (CH_2), 31.1 (CH), 26.8 (CH_3), 26.2 (CH_3) ppm. MS (ESI^+): *m*/*z* (%) =415.22 ([M + H]$^+$, 100). HRMS (ESI^+): calcd. for $C_{23}H_{31}N_2O_{10}^+$ [M + H]$^+$ 415.2227; found 415.2228. R_f = 0.39, (CH_2Cl_2/MeOH, 9:1).

Supporting Information (see footnote on the first page of this article): Copies of the ^{1}H and ^{13}C NMR spectra for nitroamines **3**, **5** and **7** and diamines **9** and **10**.

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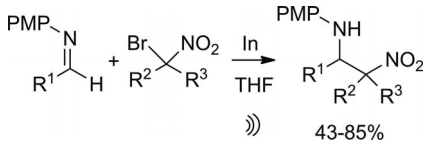
A new method to obtain 2-amines by reaction of bromonitromethane with a variety of imines, 2-bromo-2-nitropropanes and chiral sugar-derived aldehydes, promoted by indium is reported. This is the first example of the preparation of 2,2-dialkyl-2-nitroamines by addition to imines. The sugar-derived aldehydes furnished the corresponding 2-nitroamines with excellent stereoselectivity.



Keywords: Synthetic methods / Nucleophilic addition / Aza-Henry reactions / Indium / Amines

