ON THE REACTION OF 3-NITROIMIDAZO[1,2-*a*]PYRIDINE-2-CARBONITRILE WITH AMINO ACID DERIVATIVES.

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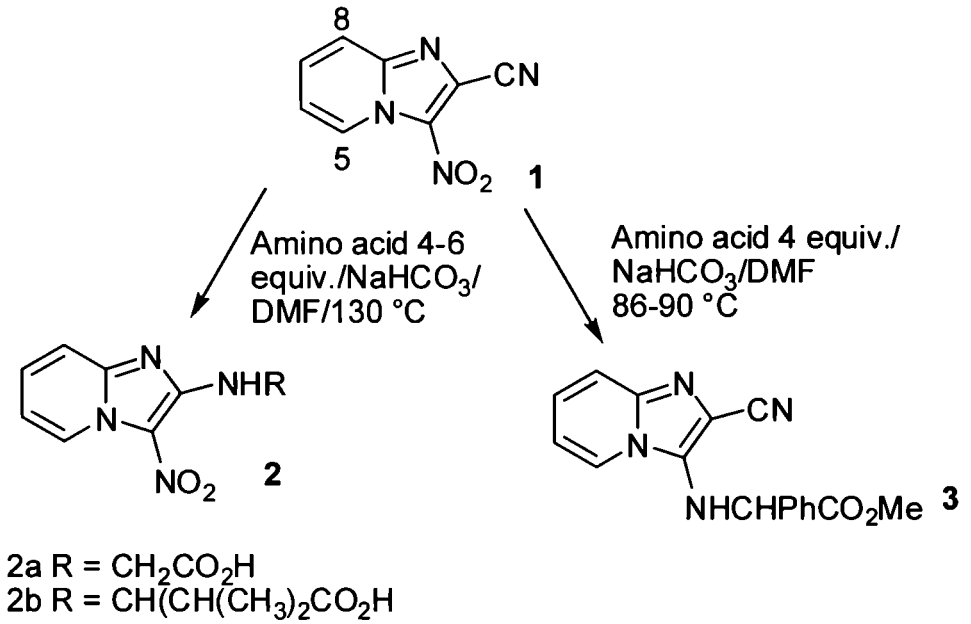
Abstract The displacement of the nitrile group in 3-nitroimidazo[1,2-*a*]pyridine-2-carbonitrile by amino acids led to the preparation of corresponding *N*-imidazo[1,2-a]pyridine-*N*-amino acid derivatives. In the case of amino acid derived bidentated nucleophiles, experimental conditions were found that permit the formation of β-aminoalcohols through the displacement of the nitrile moiety.

Introduction

The imidazo[1,2-*a*]pyridine system is a well recognized pharmacophore, which has raised a considerable pharmacological attention as demonstrated by the impressive number of investigations carried out on the heterocycle derivatives.[1] The reactivity associated to the imidazo[1,2-*a*]pyridine system is also a very attractive matter and both elctrophilic[2] and nuclephilic[3] reactions on this fused heterocycle have been studied. In an earlier investigation carried out on 3-nitroimidazo[1,2-*a*]pryridine-2-carbonitrile (**1**), it was shown that the nitrile group is nucleophilically displaced by amines in preference to the nitro group. In the same study, addition of hydroxylamine to the cyano group to give the corresponding amidooxime was observed as well.[4] As an extension of this investigation, the reactions of **1** with nitrogen nucleophiles carrying an additional functional group such as amino acid derivatives were undertaken. The results obtained are described herein.

Results and discussion

Treatment of **1** with 6 molar equivalents of glycine in $NaHCO_3$/DMF at 130 °C yielded the corresponding 2-(*N*-glycinyl)-3-nitroimidazo[1,2-*a*]pyridine **2a** in 24 % isolated yield. A smaller amount of glycine or a lower temperature of reaction did not result in any conversion. Likewise, compound **2b** was isolated in 50 % yield, whereas cysteine and asparagine failed to react. It was interesting to observe that the reaction of **1** with phenylglycine methyl ester furnished **3**, formed through nitro displacement (Scheme 1).

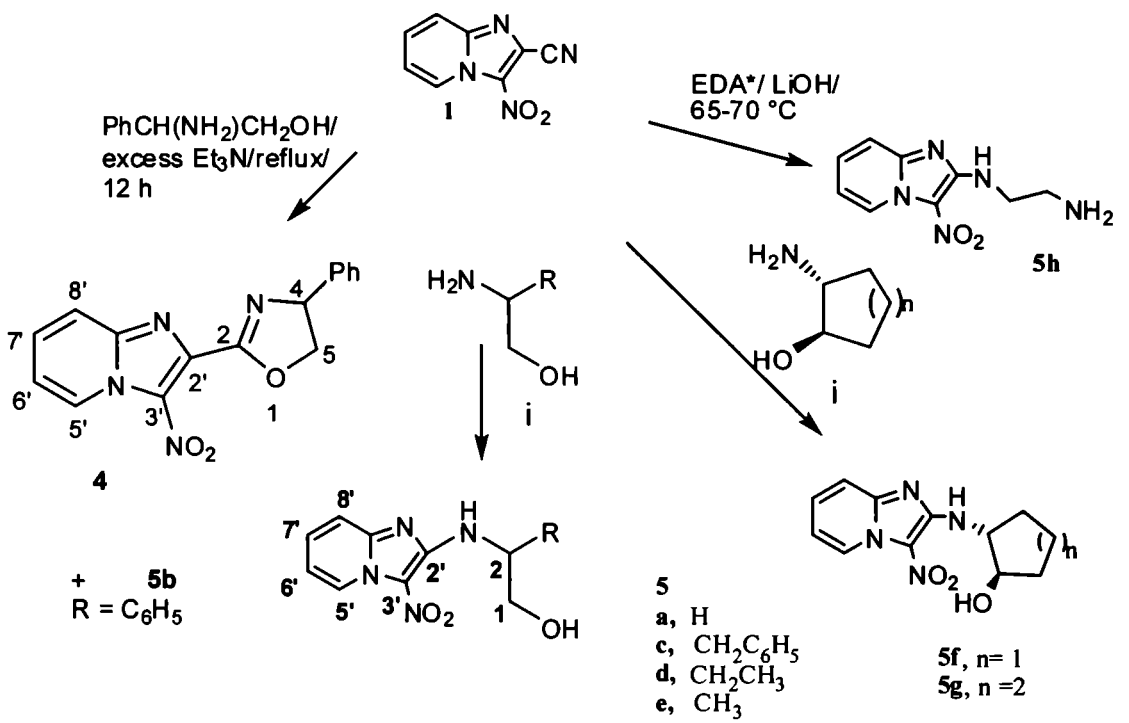


2a R = CH_2CO_2H
2b R = $CH(CH(CH_3)_2CO_2H$

Scheme 1

Next, the reaction of 3-nitroimidazo[1,2.-*a*]pyridine-2-carbonitrile with nucleophiles containing two nucleophilic centers was explored (Scheme 2). Thus, treatment of **1** with phenylglycinol and an excess of triethylamine gave both the phenyloxazoline **4** (10% yield) and the β-aminoalcohol **5b**. Since our main interest was the preparation of the *N*-aminoalcohols because of their potential use in asymmetric synthesis, [5] efforts were focussed to obtain the latter in better yield. Thus, treatment of phenylglycinol with an excess (7 molar eq.) of Li_2CO_3 and LiOH (3.5 molar eq.) in dry DMF gave the 2-*N*-phenylglycine derivative **5b**. The reaction performed under similar conditions with other β-aminoalcohols gave the corresponding *N*-imidazopyridine-*N*-amino alcohols **5c-g.** Treatment of **1** with ethanolamine or ethylene diamine and LiOH gave derivatives **5a** and **5h** in 90 % and 88% yield respectively.

The structure of products **5a-h** was confirmed by spectroscopic analysis: In the ^{1}H NMR spectra of products **5a-g**, the imidazopyridine moiety displayed the expected pattern, with H-5 showing as a doublet at low field (9.16-9.37 ppm) and the methylene protons, adjacent to the nitrogen and oxygen atoms gave distinctive signals in the aliphatic region. Further confirmation of the structure came from an X-ray analysis performed on compound **5d** and shown in Figure 1. Optical rotation measurement on selected compounds **5c** and **5g** showed that chirality was preserved



Reaction conditions: i) Li_2CO_3, LiOH, DMF, 70 °C to 75 °C.
* EDA = Ethylendiamine

Scheme-2

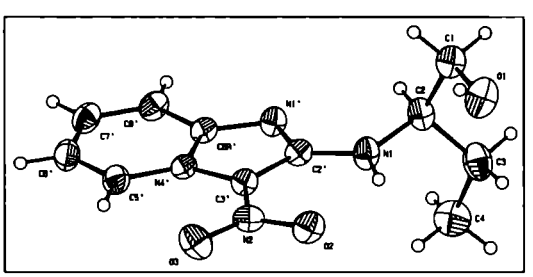


Figure 1 Ortep of compound **5d**

Conclusion

Conditions were found to obtain *2-N*-(3-nitroimidazo[1,2-*a*]pyridin-2-yl)amino acids and 2-*N*-(3-nitroimidazo[1,2-*a*]pyridin-2-yl)aminoalcohols via nitrile displacement in starting compound **1**. Under these conditions, the double nucleophilic addition of the di-nucleophile to the cyano group was not observed. Efforts are now underway to find further synthetic utility of prepared compounds.

Experimental

Melting points were measured on an Electrothermal melting point apparatus and are uncorrected. Optical rotations were measured with a Perkin-Elmer digital polarimeter in a 1-dm cell and $[\alpha]_D$ values are given in 10^{-1} deg $^{-1}$ g^{-1}. ^1H and ^{13}C nmr spectral data were recorded at 300 and 75 MHz respectively using a Bruker DPX 300 MHz NMR spectrometer. Chemical shifts (□) are given in parts per million downfield from TMS (□ = 0). Mass spectra were obtained with a Jeol JMSAX505HA instrument.

Chromatographic separations were performed on a column of SiO_2 (Merck 230-400 mesh). X- ray analysis was carried out in a Oxford Diffraction Xcalibur S apparatus.

Procedure for the synthesis of *N*-[2-(3-nitroimidazo[1,2-a]pyridine)]amino acids

3-Nitroimidazo[1,2-*a*]pyridine-2-carbonitrile **1**, (0.5 g, 2.65 mmol), an excess of amino acid (16 mmol) and $NaHCO_3$ (16 mmol) were suspended in dry DMF (12 mL). The reaction mixture was heated at 130-132 °C for 25 h, under an inert atmosphere. After this period the mixture was allowed to cool down at room temperature, water (10 mL) added and the pH adjusted to 2 by addition of concentrated HCl. The aqueous phase was saturated with salt and then extracted with ethyl acetate (7 x 50 mL). The organic extracts were combined, washed with water (3 x 15 mL), brine (20 mL) and dried (anh. Na_2SO_4). Solvent was removed under vacuum to yield a residue which was treated with a mixture EtOH - $CHCl_3$, the solid formed was collected by filtration and washed with $CHCl_3$.

***2-N*-(3-nitroimidazo[1,2-*a*]pyridin-2-yl)amino acetic acid (2a)**: This compound was obtained as a brownish solid in 24% yield, mp 169-171 °C. IR (KBr, cm^{-1}) □ 3340.2, 1690.1; 1334.6. ^1H NMR (DMSO-d_6), δ 9.29 (dt, *J* = 6.7, 1.3 Hz, H-5'); 8.16 (t, *J* = 6.1 Hz, NH); 7.74 (ddd, *J* = 8.7, 7.3, 1.3 Hz, H-7'); 7.54 (dd, *J* = 8.7, 1.3 Hz, H-8'); 7.21 (dd, *J* = 7.3, 1.3 Hz, H-6'); 4.21 (d, *J* = 6.3 Hz, CH_2). ^{13}C NMR (DMSO-d_6) δ 170.9, 153.4, 146.1, 133.9, 128.4, 114.7, 114.2, 43.5. Anal. Calcd. for $C_9H_8N_4O_4$: C, 45.78: H, 3.38; N, 23.72. Found: C, 46.1; H, 3.8.

2-*N*-(3-nitroimidazo[1,2-*a*]pyridin-3-yl)-2-isopropylamino acetic acid (2b): This compound was obtained as a yellow solid in 48% yield, mp 220-222 °C. IR (KBr, cm^{-1}) *v* 3350.3, 1723.31; 1331.3. ^1H NMR (DMSO-d_6) □ 9.25 (d, *J* = 6.7 Hz, H-5'), 7.74 (ddd, *J* = 8.6, 7.2, 1.2 Hz, H-7'), 7.67 (d, *J* = 8.7 Hz, NH), 7.53 (d, *J* = 8.7 Hz, H-8'), 7.21 (dd, *J* = 6.7, 1.2 Hz, H-6'), 4.58 (dd, *J* = 8.7, 4.7 Hz, CHNH), 2.33 (m, $CH_{Isopropyl}$), 1.00 (dd, *J* = 6.4, 4.0 Hz, CH_3); ^{13}C NMR (DMSO-d_6) δ 172.7, 153.8, 146.8, 134.8, 129.0, 118.3, 115.4, 114.9, 60.3, 30.9, 19.2, 18.2. Anal. Calcd. for $C_{12}H_{13}N_4O_4$: C, 51.79: H, 4.67; N, 20.14. Found: C, 52.01; H, 4.74.

Methyl α-[amino-*N*-(2-cyanoimidazo[1,2-*a*]pyridin-3-yl)]-α-phenyl acetate (3): This compound was obtained btained as a white solid in 77% yield, mp 190-192 °C. IR (KBr cm^{-1}) □ 3378.8; 2218.8; 1723.31. ^1H NMR(DMSO-d_6) δ 8.11 (d, *J* = 7.0 Hz, H-5'), 7.85 (d, *J* = 7.9 Hz, H-8'), 7.45 (m, Ph), 7.11 (dd, *J* = 7.9, 7.0 Hz, H-7'), 6.84 (dd, *J* = 7.0, 7.0 Hz, H-6'), 6.62 (s, NH); 4.61 (s, CH); ^{13}C NMR (DMSO-d_6) δ 168.6, 140.9, 139.3, 134.9, 131.9, 129.4, 129.1, 128.9, 128.6, 128.1, 125.3, 123.7, 118.2, 117.5, 112.8, 95.5. Anal. Calcd. for $C_{17}H_{14}N_4O_2$: C, 66.66: H, 4.57; N, 18.20. Found: C, 67.1; H, 4.90.

2-[(4'-phenyl)-2-oxazolin-2-yl]-3-nitroimidazo[1,2-*a*]pyridine 4 and 2-*N*-(3'-nitroimidazo [1,2-*a*]pyridin-2-yl)-2-phenylaminoethanol (5b)

A mixture of 3-nitroimidazo[1,2-*a*]pyridine-2-carbonitrile **1** (0.1g, 0.53 mmol), phenylglycinol (3 eq.) and Et_3N (3 mL) was refluxed for 12 h. Then the reaction mixture was allowed to cool to room temperature, excess of Et_3N was removed and the crude residue purified by column chromatography (ethyl acetate/hexane 3:1). A fraction (0.06) of unchanged **1** was recovered. Title compound **4** was isolated in 10% yield, as dense, amber like liquid. ^1H NMR ($CDCl_3$) □ 9.41 (d, *J* = 8.50 Hz, H-5'), 7.9 (d, *J* = 8.78 Hz, H-8'), 7.7 (t, *J* = 8.78, 1.5 Hz, H-7'), 7.69-7.33, (bs, H_{Arom} +H-6'), 5.55 (t, *J* = 10.3, 8.75, H-4), 4.96 (t, *J*=10.3, 8.39 Hz, H-5), 4.44 (t, J= 8.59, 855 Hz, H-5). ^{13}C NMR ($CDCl_3$) □ 158.67, 144.83, 141.26, 130.93, 128.83, 127.82, 127.35, 126.87, 125.86, 119.16, 117.61,

109.58, 75.74, 70.69. MS m/z: 308 (M^+, 2%). Compound **5b** was isolated in 20% yield, as amber oil. ^{1}H NMR ($CDCl_3$) □ 9.34 (d, *J* = 8.5 Hz, H-5'); 8.0 (d, *J* = 9.35 Hz, NH); 7.57 (t, *J* = 8.37, 1.67 Hz, H-7'); 7.43-7.32 (H_{Arom} + H-8' m);7.03 (t, *J* = 7.54, 1.51 Hz, H-6'); 5.37 (m H-2); 4.05 (d, *J* = 8.61 Hz, H-1); 3.4-2.9 (bs OH). ^{13}C NMR ($CDCl_3$)□ 153.9, 146.6, 138.7, 133.5, 129.0, 128.7, 128.1, 126.7, 115.3, 114.1, 108.6, 66.9, 58.9; MS m/z 281 (M^+- 17, 5%).

***N*-(3-nitroimidazo[1,2-*a*]pyridin-2-yl)-2-aminoethanol (5a).** A mixture of 3-nitroimidazo[1,2-a]pyridine-2-carbonitrile **1** (1.0 g, 5.3 mmol), 2-aminoethanol (19 eq.) and LiOH (0.204 g, 8.5 mmol, 1.6 eq) was heated at 70 °C for 1h, then the reaction mixture was allowed to cool and poured onto ice water whereupon a precipitate was formed. The solid was collected by filtration, washed with cold water and dried. The title compound was isolated in 90% yield as a light yellow solid, mp 195-197°C. ^{1}H NMR ($CDCl_3$ + DMSO-d_6) δ 9.36 (d, *J* = 9.49 Hz, H-5'); 7.81 (NH bs); 7.63 (t, *J* = 9.49 Hz, H-7'); 7.42 (d, *J* = 9.49 Hz, H-8'); 7.08 (t, *J* = 9.49, 1.12 Hz, H-6'); 4.68 (bs, OH); 3.78 (bs, H-1 + H-2).^{13}C NMR ($CDCl_3$ + DMSO-d_6) □ 153.81, 146.51, 133.05, 127.19, 114.30, 112.37, 60.11, 44.33. Anal. Calcd. for $C_9H_{10}N_4O_3$: C, 48.64: H, 4.50; N, 25.22. Found: C, 48.59; H, 4.88.

General procedure for preparation of *N*-(3-nitroimidazo[1,2-*a*]pyridin-2-yl)-2-aminoethanols 5c-g

Under a nitrogen atmosphere, a suspension of 3-nitroimidazo[1,2-*a*]pyridine-2-carbonitrile **1**, (0.1 g, 0.53 mmol), β-aminoalcohol (1.2-4.0 eq.), lithium carbonate (0.2749 g, 3.72 mmol, 7.0 eq.), lithium hydroxide (0.0446 g, 1.86 mmol, 3.5 eq.) in dry DMF (2 mL), was heated at 65 – 75 °C until disappearance of starting **1**. The reaction was allowed to cool to ambient temperature, water (20 mL) added and the mixture filtered. The aqueous phase was saturated with NaCl and extracted with an 8:2 solution of EtOAc-Ethanol (5 x 10 mL). Alcohol was removed under vacuum and the organic phase washed with brine, separated and dried (anh. Na_2SO_4). Solvent was removed under reduced pressure and the residue purified by column chromatography eluting with mixture ethyl acetate – hexane 3:1

2-Benzyl-*N*-(3-nitroimidazo[1,2-*a*]pyridin-2-yl)-2-aminoethanol (5c): This compound was obtained in 37 % yield as a yellow solid, mp 147-149°C. ^{1}H NMR ($CDCl_3$) □ 9.34 (d, *J* = 7.11 Hz, H-5'), 7.58 (t, *J* = 7.11, 1.15 Hz, H7'), 7.39 (d, *J* = 8.6 Hz, H-8'), 7.29 (H_{Arom} bs), 7.03 (t, *J* = 7.11, 1.15 Hz, H-6'), 4.43 (m, H2), 3.89 (dd, *J* = 2.96, 12.34 Hz, H-1), 3.77 (dd, *J* = 5.43, 12.34 Hz, H-1), 3.13-2.97 (m, H3); ^{13}C NMR ($CDCl_3$) □ 153.9, 146.5, 137.2, 133.5, 129.3, 128.9, 128.7, 126.8, 125.9, 115.0, 114.0, 64.7, 56.5, 53.9, 37.6; $[\square]_D^{25}$ -42° (0.02, $CHCl_3$). Anal. Calcd. for $C_{16}H_{16}N_4O_3$: C, 61.53: H, 5.12; N, 17.94. Found: C, 61.14; H, 4.89.

***N*-(3-nitroimidazo[1,2-*a*]pyridin-2-yl)-2-aminobutan-1-ol (5d)**: This compound was obtained in 45% yield as a yellow solid, mp 147-148 °C; ^{1}H NMR ($CDCl_3$) □ 9.37 (d, *J* = 8.7 Hz, H-5'), 7.6 (t, *J* = 8.7, 1.53 Hz, H-7'), 7.48 (bs NH), 7.4 (d, *J* = 8.7 Hz, H-8'), 7.05 (t, *J* = 8.7, 1.15 Hz, H-6'), 4.14-4.09 (m, H-2), 3.85 (dd, *J* = 11.28, 3.25 Hz, H-1), 3.77 (dd, *J* = 11.28, 3.25 Hz, H-1), 3.27 (bs, NH), 1.84-1.66 (m, H-3), 1.05 (t, *J* = 14.91, 7.26 Hz, H-4); ^{13}C NMR ($CDCl_3$) □ 154.5, 146.7, 133.7, 128.7, 115.0, 113.9, 65.7, 57.0, 24.6, 10.6; $[\square]_D^{25}$ -12.01° (0.015, $CHCl_3$). Anal. Calcd. for $C_{11}H_{14}N_4O_3$: C,52.80: H, 5.60; N, 22.40. Found: C, 52.68; H, 5.38.

***N*-(3-nitroimidazo[1,2-*a*]pyridin-2-yl)-2-aminopropan-1-ol (5e)**: This compound was obtained in 52% yield as a yellow solid, mp 210-211 °C; ^{1}H NMR (DMSO-d_6) □ 9.23 (d, J = 6.75Hz, H-5'), 7.7 (t, J = 7.75, 1.39 Hz, H-7'), 7.59 (d, J = 8.34 Hz, NH), 7.49 (d, J = 7.75 Hz, H-8'), 7.13 (t, J = 6.75, 1.39 Hz, H-6'), 4.97 (bs, OH), 4.19-4.14 (bs, H-1), 3.52 (d, J = 6.75 Hz, H-2), 1.23 (d, J = 6.75 Hz, H-3); ^{13}C NMR (DMSO-d_6) □ 153.4, 146.7, 134.2, 128.5, 114.6, 113.9, 63.8, 49.7, 17.20. Anal. Calcd. for $C_{10}H_{12}N_4O_3$: C, 50.84: H, 5.08; N, 23.72. Found: C, 51.28; H, 5.40.

***Trans*-*N*-(3-nitroimidazo[1,2-*a*]pyridin-2-yl)-2-aminocyclopenta-1-ol (5f)**: This compound was obtained in 24% yield as a yellow solid, mp 187-189 °C; ^{1}H NMR ($CDCl_3$) □ 9.25 (d, J = 7.11 Hz, H-5'), 7.74 (t, J = 7.11, 1.15 Hz, H-7'), 7.71 (d, J = 1.12 Hz, NH), 7.5 (d, J = 8.6 Hz, H-8'), 7.17 (t, J = 7.11, 1.15 Hz, H-6'), 4.98 (bs, OH), 4.17-4.10 (bs, H-1), 2.13-2.08 (bs, H-2), 1.92-1.83 (bs, H-5), 1.74-1.46 (bs, H-3,H-4); ^{13}C NMR ($CDCl_3$) □ 153.8, 146.6, 134.4, 128.6, 114.6, 114.1, 75.8, 60.7, 31.9, 29.6, 19.9. Anal. Calcd. for $C_{12}H_{14}N_4O_3$: C, 54.96: H, 5.34; N, 21.37. Found: C, 55.27; H, 5.18

***Trans*-*N*-(3-nitroimidazo[1,2-*a*]pyridin-2-yl)-2-aminocyclohexan-1-ol (5g)**: This compound was obtained in 20% yield as a yellow solid, mp 251-253°C; ^{1}H NMR ($CDCl_3$) □ 9.37 (d, J = 7.3 Hz, H-5'), 7.59 (t, J = 8.35, 1.2 Hz, H-7'); 7.43 (d, J = 8.35 Hz, H-8'); 7.40 (bs, NH); 7.05 (t, J = 8.35, 1.2 Hz, H-6'), 3.95 (m, H-2), 3.56 (m, H-1), 2.14 (m, H-3), 1.80 (m, H-6), 1.41 (m, H-4, H-5); ^{13}C NMR (MHz, $CDCl_3$) □ 154.6, 146.7, 133.7, 128.7, 125.9, 115.1, 114.0, 75.4, 584, 34.3, 32.0, 24.7, 24.00. $[\square]_D^{25}$ +19° (0.015, $CHCl_3$). Anal. Calcd. for $C_{13}H_{16}N_4O_3$: C, 56.52: H, 5.79; N, 20.28. Found: C, 56.09; H, 5.44.

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