Reactions of Fischer’s base with cyclic and acyclic conjugated nitro-olefins and nitrovinyl ethers

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Dedicated to Professor Domenico Spinelli on the occasion of his 70th birthday
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Abstract
The reactions of 2,3-dihydro-2-methylene-1,3,3-trimethyl-1H-indole (Fischer’s base) with nitro-olefins and alkoxy- nitro-olefins have been examined. Formation of the corresponding Michael-type adducts has been observed in all cases with the exception of 2-nitropropene for which the spiro- 1,2-oxazine N-oxide derivative could be isolated. The Michael-type adducts derived from alkoxy- nitro-olefins underwent a rapid elimination reaction resulting in the eventual formal nitro-olefination of the Fischer’s base. The geometry of the products has been determined by means of DIFNOE experiments and their UV properties have been examined.

Keywords: 2,3-Dihydro-2-methylene-1,3,3-trimethyl-1H-indole, nitro-olefins, spiro- 1,2-oxazine N-oxides, nitrodienes, spectroscopy

Introduction
At the beginning of the 1960s, the pioneering work of Stork and his coworkers on enamine chemistry opened the way to an impressive amount of work in this field. Several reviews, books, and a few volumes of the series of The Chemistry of Functional Groups have been devoted to the chemistry of enamines. Special classes of substituted enamines have also been reviewed.

However, the first reaction of an enamine system was the double alkylation of 1,3,3-trimethyl-2-methyleneindoline, the so-called Fischer’s base, which was performed with methyl iodide by Zotti and Ferratini in 1890. Subsequently, other electrophilic reagents such as acyl halides, diketene, sulfonyl- and sulfonyl halides, isocyanates, diazonium salts, and several other electrophiles were reacted with Fischer’s base. Strangely enough, among this sequence of reactants the electrophilic olefins, which are important partners for enamines, are missing—
with the exception of tetracyanoethene (TCNE), the reactivity with Fischer’s base has been studied in detail.

Among the electrophilic olefins, nitro-olefins occupy a special position. Owing to the continuing interest in nitro-aliphatic compounds, and our particular interest in the reactivity of nitro-olefins towards enamine systems, we have investigated Fischer’s base as the nucleophilic counterpart of conjugated nitro-olefins and nitrovinyl ethers. One of our aims was to look for the possible formation of 1,2-oxazine N-oxide derivatives, whose formation in the reactions of nitro-olefins with enamines from aldehydes and ketones is well known.

Results and Discussion

The electrophiles used in this study are listed in Figure 1. The nitro-olefins 2a, b and 3 and the nitrovinyl ethers 4a, c and 5 are known, while 4b was prepared by a literature method used for the synthesis of 4a. All of them are in the E-configuration. For 4b this was proved by means of difference NOE experiments: irradiation of the methyl group caused enhancement (4%) of the methylene quartet of the ethoxy group.

![Figure 1](image_url)

Reactions with the nitro-olefins

The reaction between the Fischer’s base and the nitro-olefins 2a, b and 3 (Figure 2) have been carried out in ether, under argon at temperatures ranging from –15°C to –5°C. The reaction with nitroethylene 2a was carried out in the presence of hydroquinone to minimize the polymerization of the olefin which was otherwise rapid even below –20°C.

The reaction products were the corresponding Michael-type adducts, namely 7a, b starting from the linear nitro-olefins 2a, b and a mixture of cis- and trans- diastereomers 8 and 9, respectively, starting from the cyclic nitro-olefin 3.
All compounds were characterized spectroscopically by means of $^1$H–$^1$H- and $^1$H–$^{13}$C- 2D experiments. Compounds 7a,b are in the E-configuration, as proved by difference NOE experiments, whose results are summarized in Table 1.

Only in one case, namely when the nitro-olefin was 2-nitropropene 2b, could the corresponding spiro-oxazine N-oxide 6b be isolated, since it precipitated from the ethereal solution. While in the solid state it was rather stable and could be stored at –20°C for long periods, in chloroform solution it underwent nucleophilic ring fission to the corresponding open-chain product 7b.

The opening of the heterocycle 6b into 7b was followed by monitoring the reaction by IR and $^1$H-NMR spectroscopies. The stretching band at 1620 cm$^{-1}$, characteristic of the C=N+O$^-$ group,$^{17,19}$ slowly disappeared in favor of two absorption bands at 1670 cm$^{-1}$ and 1555 cm$^{-1}$, owing to the stretching of the conjugated carbon–carbon double bond, and to the asymmetric NO$_2$ stretching band respectively. The $^1$H- NMR spectrum recorded at –20°C, showed no vinyl proton signal and no nitromethine proton signal, a result which is consistent with the spiro-structure assigned. The signals of the vinyl and nitromethine protons appeared slowly, even at –20°C, the opening reaction being surely catalyzed by traces of acid present in the deuteriated chloroform used as solvent. Opening of 6b was complete within a few hours and the Michael-type adduct 7b was isolated as a single diastereomer.

From the reaction of 1-nitrocyclohexene, 3, with Fischer’s base, 1, two diastereomeric Michael-type adducts were identified, namely 8 and 9, differing in the orientation of the nitro group. The geometry of the double bond was E- in both cases, as shown by difference NOE measurements. The stereochemical assignment relative to the stereo-centers was possible since the axial- and equatorial- orientations of the nitro group were easily recognizable from the position and pattern of the relative nitromethine proton signals. In fact, in the cis- isomer 8 the
equatorial nitromethine proton resonated at lower field than the same proton in the trans- isomer 9 (4.72 ppm vs. 4.45 ppm). The two signals also exhibited different values of $W_H$, namely 12 Hz for 8 and 26 Hz for 9 (actually this latter signal was resolved into a doublet of double doublets, ddd, $J_1 = 11.9$ Hz, $J_2 = 9.5$ Hz, $J_3 = 4.0$ Hz), values which are in accordance with equatorial and axial orientations, respectively, of the nitromethine protons.

The foregoing attribution was further confirmed by an analysis of the corresponding $^{13}$C NMR spectra. In the cis- isomer, 8, the carbocyclic carbon signals were upfield with respect to those of the trans- isomer 9, thus demonstrating the presence of steric interactions in the former compound bearing the nitro group in the axial orientation. On standing, the cis- diastereomer 8 was converted into the more stable trans- 9. The eventual composition was 4:1 in favor of 9. Since the cis- compound was the kinetically formed product, its formation was helpful in determining the reaction mechanism, as will be discussed later.

**Table 1.** The most meaningful data of the DIFNOE measurements

<table>
<thead>
<tr>
<th>Compounds</th>
<th>Irradiated proton</th>
<th>Enhanced signal (% $\eta$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7a</td>
<td>NCH$_3$</td>
<td>H-1´ (8)</td>
</tr>
<tr>
<td>7b</td>
<td>H-1´</td>
<td>NCH$_3$ (4)</td>
</tr>
<tr>
<td>8</td>
<td>NCH$_3$</td>
<td>H-1´ (4)</td>
</tr>
<tr>
<td>9</td>
<td>NCH$_3$</td>
<td>H-1´ (6)</td>
</tr>
<tr>
<td>11</td>
<td>NCH$_3$</td>
<td>H-1´ (4)</td>
</tr>
<tr>
<td></td>
<td>CHO</td>
<td>CHNO$_2$ (8)</td>
</tr>
<tr>
<td>12</td>
<td>NCH$_3$</td>
<td>H-1´ (8)</td>
</tr>
<tr>
<td></td>
<td>CHNO$_2$</td>
<td>H-1´ (6)</td>
</tr>
<tr>
<td>13a</td>
<td>NCH$_3$</td>
<td>H-1´ (14)</td>
</tr>
<tr>
<td>13b</td>
<td>NCH$_3$</td>
<td>H-1´ (11)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CH$_3$ at C-3 (11)</td>
</tr>
<tr>
<td>13c</td>
<td>NCH$_3$</td>
<td>H-1´ (7)</td>
</tr>
<tr>
<td>14</td>
<td>NCH$_3$</td>
<td>H-1´ (11)</td>
</tr>
<tr>
<td></td>
<td>H-1´</td>
<td>H-4´ (12)</td>
</tr>
</tbody>
</table>

**Reactions with the nitrovinyl ethers**

The reactions between Fischer’s base and the nitrovinyl ethers 4a–c and 5 followed the same pathway as above, namely that the corresponding Michael-type adducts 10a–c and 11,12 were the first-formed products (Figure 3).

However, only compounds 10a, 11 and 12 were isolated, whereas 10b and 10c converted easily into the corresponding nitrodiene derivatives 13b,c by loss of ethanol.

The cis- and trans- diastereomers 11 and 12, obtained from the reaction with 3-nitro-5,6-dihydro-4H-pyran, 5, could be differentiated in the same manner as discussed above for the analogous compounds 8 and 9 bearing the carbocyclic six-membered ring. The equatorial nitromethine proton in 11 ($W_H$ 12 Hz) resonated at lower field than the analogous axial proton in
12 (W_H 26 Hz) (4.70 ppm vs. 4.39 ppm). The adjacent CH-O proton was axial in both compounds, as demonstrated by the patterns of their signals and the values of their respective vicinal coupling constants (11: dd, 3J_{1\'-2} = 10.2 Hz, 3J_{2\'-3} = 3.7 Hz; 12: t, 3J_{1\'-2} = 3J_{2\'-3} = 9.5 Hz). A comparison of their respective $^{13}$C NMR data strongly support this attribution (Experimental Section). It seems important to stress the easy formation of the open-chain derivative 14, occurring without catalyst being added. Evidently the formation of a conjugated nitrodiene is such a strong driving force that opening of a tetrahydropyran ring is fully counterbalanced.

Of the nitrodiene derivatives, 13a, 13b and 14 were in the E,E-configuration, as established by DIFNOE measurements (Table 1) and by an analysis of the vicinal coupling constants between H-1’ and H-2’ and between H-2’ and H-3’ in 13a. Compound 13c was a 3:2 mixture of E,E-: E,Z- diastereomers, the conjugation of the ethoxycarbonyl group with the carbon–carbon double bonds being in competition with that of the nitro group. No assignment was made, although it seems reasonable that the E,E- form could slightly prevail in the mixture, owing to the stronger electron-withdrawing power of the nitro group.

Figure 3

Compounds 13a and 13b were crystalline, with high melting points, while 13c, which was an isomeric mixture, and 14 were sticky oils.
All the nitrodiene derivatives have an intense orange–red color. Their electronic spectra, recorded in three different solvents, are characterized by the presence of many intense absorption bands whose positions and intensities are listed in Table 2. The position of band 4 is particularly affected by solvent polarity. Band 2, which is present in the spectrum of 13c in all solvents, might be attributed to the chromophore -CO₂Et, conjugated with the diene system. For the other derivatives the band at the same wavelength is visible only in cyclohexane.

Table 2. Electronic absorption spectra of compounds 13a,b,c and 14: \( \lambda_{\text{max}} \) [nm] (log \( \varepsilon \))

<table>
<thead>
<tr>
<th>Solvent</th>
<th>Band 1</th>
<th>Band 2</th>
<th>Band 3</th>
<th>Band 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>13a CH₃OH</td>
<td>211 (4.08)</td>
<td>277 (3.94)</td>
<td>481 (4.43)</td>
<td></td>
</tr>
<tr>
<td>13a CH₃CN</td>
<td>196 (4.46)</td>
<td>280 (4.04)</td>
<td>474 (4.56)</td>
<td></td>
</tr>
<tr>
<td>13a CyH\textsuperscript{a}</td>
<td>215 (3.95)</td>
<td>251 (3.86)</td>
<td>275 (3.83)</td>
<td>438 (4.08)\textsuperscript{b}</td>
</tr>
<tr>
<td>13b CH₃OH</td>
<td>207 (4.34)</td>
<td>282 (4.09)</td>
<td>488 (4.55)</td>
<td></td>
</tr>
<tr>
<td>13b CH₃CN</td>
<td>197 (4.45)</td>
<td>282 (4.06)</td>
<td>480 (4.53)</td>
<td></td>
</tr>
<tr>
<td>13b CyH\textsuperscript{a}</td>
<td>214 (3.99)</td>
<td>246 (3.89)</td>
<td>278 (3.96)</td>
<td>446 (4.30)\textsuperscript{b}</td>
</tr>
<tr>
<td>13c CH₃OH</td>
<td>210 (4.17)</td>
<td>258 (3.96)</td>
<td>308 sh (3.92)</td>
<td>469 (4.86)</td>
</tr>
<tr>
<td>13c CH₃CN</td>
<td>200 (4.21)</td>
<td>258 (3.86)</td>
<td>307 (3.81)</td>
<td>471 (4.80)</td>
</tr>
<tr>
<td>13c CyH\textsuperscript{a}</td>
<td>216 (3.88)</td>
<td>254 (3.92)</td>
<td>302 (3.77)</td>
<td>450 (4.42)\textsuperscript{b}</td>
</tr>
<tr>
<td>14 CH₃OH</td>
<td>208 (4.38)</td>
<td>283 (4.17)</td>
<td>491 (4.58)</td>
<td></td>
</tr>
<tr>
<td>14 CH₃CN</td>
<td>196 (4.38)</td>
<td>284 (4.01)</td>
<td>481 (4.43)</td>
<td></td>
</tr>
<tr>
<td>14 CyH\textsuperscript{a}</td>
<td>214 (4.03)</td>
<td>249 (3.90)</td>
<td>280 (4.01)</td>
<td>451 (4.35)\textsuperscript{b}</td>
</tr>
</tbody>
</table>

\( \textsuperscript{a} \) CyH, Cyclohexane; \( \textsuperscript{b} \) fine structure (vibrationally resolved).

Mechanism of the reactions

The isolation of the products in the reactions of the cyclic electrophiles 3 and 5 with Fischer’s base, under kinetically controlled conditions, allows a mechanism to be postulated. In accordance with the topological rule of Seebach and Golinski,\textsuperscript{21} although the enamine β-carbon atom is not prochiral, the approach of the reactants is likely to occur as depicted in Figure 4. The resulting zwitterion intermediate 15 in its chair–chair conformation, 15’ would abstract either diastereomeric proton generating the carbon–carbon double bond in the \( E \)- configuration. Then the nitronic acid carbon atom in 16 would be protonated from the less hindered side of the ring, giving rise to the \textit{cis}- diastereoisomer 8 (or 11) having the nitro group in the axial orientation.
**Conclusions**

The reactions between Fischer’s base and the nitro-olefins and, maybe more interestingly, with the nitrovinylic ethers, give the corresponding Michael-type adducts as oily products which present some curious physical properties, such as that of climbing up the walls of glass vessels by forming strongly adherent films. However, the simple nitroalkylated compounds are not very stable. When left in the air for some period they decompose, probably under the action of oxygen, as happens with the Fischer’s base itself, which is easily oxidized to the corresponding oxindole derivative. In only one case was the desired spiro compound formed and this is probably related to the type and steric demand of the substituents at the electrophilic double bond. In contrast, the nitrodiene derivatives proved very stable, and could be stored for months in the air without any modification in their structure.

**Experimental Section**

**General Procedures.** Melting points were determined with a Büchi 510 apparatus and are uncorrected. Column chromatography was performed on silica gel (Merck 60, 70–230 mesh). TLC was performed on Polygram Sil G/UV254 silica gel pre-coated plastic sheets (eluent: light petroleum–ethyl acetate). NMR spectra were recorded on a Jeol 400 (9.4 Tesla, 400.13 MHz for 1H, 100.62 MHz for 13C) spectrometer. Chemical shifts (δ in ppm) are given from internal
CHCl₃ (7.26) for ^1^H- and ^1^3CDCl₃ (77.0) for ^1^3C- NMR. Coupling constants (J, Hz) are accurate to ± 0.2 Hz for ^1^H. Mass spectra (MS) at 70 eV using the electron-impact mode was performed on a VG 7070 spectrometer by. “Laboratorio di Spettrometria di Massa, Università di Trieste.” IR spectra were run on a Thermo Nicolet 320 FT-IR spectrometer for CHCl₃ solutions or neat; the absorption values are given in cm⁻¹. Absorption spectra were obtained with a Shimadzu UV-2501PC spectrometer in solvents of Merck Uvasol grades at room temperature.

**Reactants.** The Fischer’s base was purchased from Aldrich, the nitro-olefins were prepared in accordance with literature procedures, as follows: nitro-ethene (2a),²³ 2-nitropropene (2b),²³ 1-nitrocyclohexene (3),²⁴ 2-ethoxy-1-nitro-ethene (4a),²⁰ ethyl 3-ethoxy-2-nitro-acrylate (4c),²⁵ 3,4-dihydro-5-nitro-2H-pyran (5).²⁶

**1-Ethoxy-2-nitropropene (4b).** Reaction of 1-ethoxypropene with a mixture of acetic anhydride and nitric acid at −33°C furnished the intermediate product as a 1:1 diastereomeric mixture, which was pure enough to be used as such. 1-Acetoxy-1-ethoxy-2-nitropropane: NMR data: δ^H (CDCl₃) 6.15 (1 H, t, O-CH-O), 4.62 (1 H, 2dq, CHNO₂), 3.77 (1 H, m, OCH₂CH₃), 3.62 (1 H, m, OCH₂CH₃), 2.05 (1.5 H, s, CH₂CO), 1.57 (1.5 H, d, CH₃), 1.51 (1.5 H, d, CH₃), 1.15 (1.5H, t, OCH₂CH₃), 1.13 (1.5H, t, OCH₂CH₃). δ^C (CDCl₃) 170.1 (s), 170.0 (s), 95.2 (d), 95.1 (d), 83.6 (d), 83.1 (d), 66.6 (t), 66.5 (t), 20.71 (q), 20.68 (q), 14.7 (q), 14.6 (q), 13.9 (q), 13.6 (q). Elimination of acetic acid by means of triethylamine gave an oil, which was freed from volatile substances under argon for a few hours. After this treatment the product was practically pure and no distillation was necessary. 1-Ethoxy-2-nitropropene (4b): IR, 3072 1664, 1557, 1498, 1218, 991, 861. NMR, δ^H (CDCl₃) 8.03 (1 H, s, vinyl-H), 4.17 (2 H, q, OCH₂CH₃), 2.04 (3 H, s, CH₃), 1.38 (3 H, t, OCH₂CH₃). δ^C (CDCl₃) 157.1 (d), 131.9 (s), 72.0 (t), 15.3 (q), 10.2 (q).

**General procedure for the reactions between Fischer’s base and nitro-olefins**

To a solution of Fischer’s base (0.173 g, 1.0 mmol) in diethyl ether (2 mL) the appropriate nitro-olefin (1.0 mmol) in the same solvent (1 mL) was slowly added, keeping the temperature between −15°C and −5°C (the reaction with nitro-ethene 2a was carried out in the presence of hydroquinone (1 eq.) to prevent polymerization of the nitro-olefin. The reaction mixture was kept in the refrigerator for 12 h. In the reaction of compound 1 with 2-nitropropene 2b, the spiro[1,2]oxazine N-oxide 4b precipitated from the ethereal solution, and was filtered off. In the other cases the resulting products 7a and 8, 9 were purified by flash chromatography (eluens, light petroleum–ethyl acetate, 95%). The products 13a,b,c and 14 were formed from their respective parent compounds 10a–c and 11, 12 at room temperature without addition of any catalyst. The products were purified by flash chromatography (eluens, light petroleum–ethyl acetate, gradient).

**Spiro[1,3-dihydro-1,3,3-trimethyl-2H-indole-2,6’-(5’,6’-dihydro-3’-methyl-4’H-[1,2]oxazine 2’-oxide] (6b).** m.p. 65–66 °C. IR data, 1623 (C=N'), 1604, 1491 (Ar). NMR, δ^H (CDCl₃, −20°C) 7.11 (1 H, t, H-6), 7.01 (1 H, d, H-4), 6.79 (1 H, t, H-5), 6.50 (1 H, d, H-7), 2.92 (3 H, s,
NCH₃), 2.66 (2 H, t, CH₂CH₂C=N), 2.30 (2 H, bt, CH₂CH₂C=N), 2.08 (3 H, s, CH₃), 1.31 (6 H, very broad s, gem- CH₃). δC (CDCl₃, –20°C) 147.4 (s, C-7a), 135.6 (s, C-3a), 127.5 (d, C-6), 121.0 (d, C-4), 120.1 (s, C=N-O -), 108.9 (s, C-2), 106.7 (d, C-7), 49.6 (s, C-3), 28.0 (q, NCH₃), 28.7 (t, CH₂C=N), 21.4 (t, CH₂CH₂C=N), 18.1 (q, CH₃). The signals for the gem-dimethyl carbon atoms were too broad to be detected. MS (70 eV), 260 (M⁺, 3), 186 (6), 175 (56), 160 (100), 132 (18), 117 (12), 84 (14), 77 (10).

2,3-Dihydro-2-[3-nitro)propylidene]-1,3,3-trimethyl-1H-indole (7a). IR, 1650, 1554, 1366, 1210, 1196, 1067, 738. NMR, δH (CDCl₃) 7.12 (1 H, t, H-6), 7.04 (1 H, d, H-4), 6.74 (1 H, t, H-5), 6.47 (1 H, d, H-7), 4.42 (2 H, t, CH₂NO₂), 4.08 (1 H, t, H-1´), 3.06 (2 H, q, CH₂NO₂), 2.95 (3 H, s, NCH₃), 1.50 (6 H, s, gem- CH₃). δC (CDCl₃) 156.4 (s, C-2), 145.8 (s, C-7a), 137.5 (s, C-3a), 127.6 (d, C-6), 121.2 (d, C-4), 118.2 (d, C-5), 104.6 (d, C-7), 86.2 (d, H-1´), 75.8 (t, CH₂NO₂), 44.3 (s, C-3), 28.7 (q, NCH₃), 27.6 (2q, gem- CH₃).

2,3-Dihydro-2-[3-nitro)butylidene]-1,3,3-trimethyl-1H-indole (7b). IR, 1655, 1551, 1363, 1210, 1196, 1067, 738. NMR, δH (CDCl₃) 7.10 (1 H, t, H-6), 7.04 (1 H, d, H-4), 6.73 (1 H, t, H-5), 6.47 (1 H, d, H-7), 4.58 (1 H, sext., J = 6.6 Hz, CHNO₂), 4.06 (1 H, d, J = 7.7 Hz, H-1´), 3.22 (3 H, s, NCH₃), 3.03 (1 H, m, CHNO₂), 2.80 (1 H, m, CHNO₂), 1.60 (3 H, d, J = 6.6 Hz, CH₃), 1.48 (6 H, s, gem- CH₃). δC (CDCl₃) 156.4 (s, C-2), 145.8 (s, C-7a), 137.7 (s, C-4a), 127.6 (d, C-6), 121.3 (d, C-4), 118.2 (d, C-5), 104.7 (d, C-7), 86.2 (d, C-1´), 84.8 (d, CHNO₂), 44.3 (s, C-3), 32.5 (t, CH₂NO₂), 28.9 (q, NCH₃), 27.9 (2q, gem- CH₃), 18.5 (q, CH₃). MS (70 eV): 260 (M⁺, 12), 214 (8), 198 (13), 186 (37), 175 (37), 171 (15), 160 (100), 145 (13), 144 (17), 132 (16), 126 (17), 117 (12), 77 (13), 74 (25).

cis-2,3-Dihydro-2-[(2-nitrocyclohexyl)methylidene]-1,3,3-trimethyl-1H-indole (8), and trans-2,3-dihydro-2-[(2-nitrocyclohexyl)methylidene]-1,3,3-trimethyl-1H-indole (9). Chromatography (light petroleum–ethyl acetate 95:5) of the two diastereomers furnished the pure trans- isomer 9, and a 1:4 mixture of 8 and 9.

**Compound 8.** NMR, δH (CDCl₃) 7.08 (1 H, t, H-6), 7.01 (1 H, d, H-4), 6.71 (1 H, t, H-5), 6.45 (1 H, d, H-7), 4.76 (1H, dt, J₁ = J₂ = 4.8 Hz, J₃ = 9.5 Hz, W₇₂ = 16.5 Hz, CHNO₂), 4.34 (1H, d, J = 11.4 Hz, H-1´), 3.51 (1H, m, W₇₂ = 21.5 Hz, CHCHNO₂), 2.95 (3H, s, NCH₃), 2.26 (1H, m, ring H), 2.0 (3 H, m, ring H), 1.78 (1 H, m, ring H), 1.45 (3H, s, CH₃ at C-3), 1.41 (3H, s, CH₃ at C-3), 1.40 (1 H, m, ring H), 1.20 (1 H, m, ring H). δC (CDCl₃) 155.7 (s, C-2), 145.9 (s, C-7a), 137.9 (s, C-3a), 127.6 (d, C-6), 121.2 (d, C-4), 118.1 (d, C-5), 104.6 (d, C-7), 89.4 (d, C-1´), 87.6 (d, CHNO₂), 44.5 (s, C-3), 36.1 (d, CHCHNO₂), 32.3 (t, CH₂), 29.0 (q, NCH₃), 28.5 (q, CH₃ at C-3), 28.4 (q, CH₃ at C-3), 26.0 (t, CH₂), 22.8 (t, CH₂), 21.3 (t, CH₂).

**Compound 9.** IR, 3052, 3028, 1658, 1606, 1546, 1496, 1372, 911, 736. NMR, δH (CDCl₃) 7.07 (1 H, t, H-6), 7.01 (1 H, d, H-4), 6.70 (1 H, t, H-5), 6.43 (1 H, d, H-7), 4.25 (1H, ddd, J₁ = J₂ = 11.7 Hz, J₃ = 10.6 Hz, W₇₂ = 27.5 Hz, CHNO₂), 4.05 (1H, d, J = 10.6 Hz, H-1´), 3.05 (1 H, dq, J₁ = J₂ = 10.6 Hz, J₄ = 10.6 Hz, J₅ = 3.7 Hz, CHCHNO₂), 2.92 (3H, s, NCH₃), 2.26 (1 H, m, ring H), 2.01 (1H, dq, ring H), 1.96 (3 H, m, ring H), 1.76 (2H, m, ring H), 1.50 (1 H, m, ring H), 1.46 (4 H, s + m, CH₃ at C-3, ring H), 1.42 (3H, s, CH₃ at C-3). δC (CDCl₃) 155.5 (s, C-2), 145.9 (s, C-7a), 138.0 (s, C-3a), 127.7 (d, C-6), 121.3 (d, C-4), 118.0 (d, C-5), 104.7 (d, C-7),
94.3 (d, C-1'), 92.4 (d, CHNO2), 44.6 (s, C-3), 40.3 (d, CHCHNO2), 34.9 (t, CH2), 31.2 (t, CH2), 29.0 (q, NCH3), 28.65 (q, CH3 at C-3), 28.58 (q, CH3 at C-3), 24.9 (t, CH2), 24.3 (t, CH2). MS (70 eV): 300 (M+•, 50), 285 (9), 254 (38), 238 (15), 212 (28), 188 (21), 184 (14), 182 (13), 175 (17), 172 (23), 160 (100), 158 (31), 145 (16), 144 (15), 86 (18), 84 (31), 77 (8).

2,3-Dihydro-2-[(2-ethoxy-3-nitro)propylidene]-1,3,3-trimethyl-1H-indole (10a). IR, 3066, 3034, 1642, 1630, 1500, 1125, 996, 790, 775. NMR, δH (CDCl3) 7.14 (1 H, t, H-6), 7.09 (1 H, d, H-4), 6.80 (1 H, t, H-5), 6.54 (1 H, d, H-7), 5.18 (1 H, m, W H = 10.2 Hz, CH-O), 4.52 (1 H, m, CHNO2), 4.34 (1 H, m, CHNO2), 4.06 (1 H, d, J = 10.2 Hz, H-1'), 3.68 (1 H, m, CH2), 2.98 (3 H, s, NCH3), 1.37 (3 H, s, CH3 at C-3), 1.35 (3 H, s, CH3 at C-3), 2.18 (1H, m, CH2). δC (CDCl3) 169.4 (s, C-2), 143.5 (s, C-7a), 139.5 (s, C-3a), 138.5 (d, C-6), 127.6 (d, C-4), 121.4 (d, C-5), 105.2 (d, C-7) 88.9 (d, C-1'). 80.6 (t, CHNO2), 72.4 (t, CH2), 63.5 (t, OCH2CH3), 47.1 (t, C-3), 30.3 (q, NCH3), 28.5, 27.8 (2q, gem-CH3), 15.8 (q, OCH2CH3).

cis- and trans- 2-(2,3-Dihydro-1,3,3-trimethyl-1H-indolylidene)methyl-3-nitro-tetrahydro-2H-pyran, (11) and (12). Although it was not possible to separate the two diastereomers, their spectroscopic data are given separately for the sake of clarity.

Compound 11. NMR, δH (CDCl3) 7.12 (1 H, t, H-6), 7.05 (1 H, d, H-4), 6.84 (1 H, t, H-5), 6.52 (1 H, m, CH-O), 4.72 (1 H, m, W H = 12.0 Hz, CHNO2), 4.39 (1 H, m, H eq of OCH2 grouping) 3.61 (1 H, m, H ax of OCH2 grouping), 2.98 (3 H, s, NCH3), 1.83 (1 H, m, CH2). δC (CDCl3) 160.2 (s, C-2), 145.4 (s, C-7a), 138.0 (s, C-3a), 127.8 (d, C-6), 121.8 (d, C-4), 119.0 (d, C-5), 105.9 (d, C-7) 85.6 (d, C-1'), 82.0 (d, CHNO2), 71.3 (d, CH2), 64.2 (t, OCH2CH3), 29.0 (t, CH2).

Compound 12. NMR, δH (CDCl3) 7.12 (1 H, t, H-6), 7.05 (1 H, d, H-4), 6.84 (1 H, t, H-5), 6.52 (1 H, m, CH-O), 4.65 (1 H, m, W H = 9.5 Hz, CH-O), 4.45 (1H, m, CH-O), 4.28 (1 H, m, CH-O), 3.30 (3 H, s, NCH3), 1.64 (6 H, m, CH3).

2,3-Dihydro-2-[(3-nitro)propenylidene]-1,3,3-trimethyl-1H-indole (13a). m.p. 161–162°C. IR, 1577, 1561, 1460, 1376, 1276, 926, 798, 756, 722. NMR, δH (CDCl3) 8.38 (1 H, d, J = 13.2 Hz, J1 = 12.1 Hz H-2'), 7.27 (2 H, t + d, H-6 and H-4), 7.10 (1 H, d, J = 12.1 Hz H-3'), 7.06 (1 H, t, H-5), 6.85 (1 H, d, H-7), 5.46 (1 H, d, J = 13.2 Hz, N-C=CH), 3.30 (3 H, s, NCH3), 1.64 (6 H, s, gem-CH3). δC (CDCl3) 169.4 (s, C-2), 143.2 (s, C-7a), 139.5 (s, C-3a), 138.6 (d, C-2'), 129.2 (d, C-3'), 128.1 (d, C-6), 122.5 (d, C-5), 121.8 (d, C-4), 107.9 (d, C-7), 89.6 (d, N-C=CH), 47.4 (s, C-3), 29.7 (q, NCH3), 28.6 (2q, gem-CH3). MS (70 eV): 244 (M+•, 4), 200 (4), 186 (5), 175 (33), 160 (100), 159 (8), 158 (12), 146 (11), 132 (16), 117 (11), 91 (7), 77 (8).
2,3-Dihydro-2-[(3-nitro)-2-butenylidene]-1,3,3-trimethyl-1\(H\)-indole (13b). m.p. 191–192°C; IR, 1618, 1597, 1563, 1462, 1262, 928, 816, 796, 758, 721. NMR, \(\delta_1\) (CDCl\(_3\)) 8.50 (1 H, d, J = 13.2 Hz, H-2´), 7.27 (1 H, t, H-6), 7.24 (1 H, d, H-4), 7.03 (1 H, t, H-5), 6.84 (1 H, d, H-7), 5.30 (1 H, d, J = 13.2 Hz, H-1´), 3.32 (3 H, s, NCH\(_3\)), 2.25 (3 H, s, CH\(_3\)), 1.64 (6 H, s, gem- CH\(_3\)). \(\delta_C\) (CDCl\(_3\)) 167.6 (s, C-2), 143.6 (s, C-7a), 139.4 (s, C-3a), 136.0 (s, H-3´), 133.7 (d, C-2´), 128.0 (d, C-6), 122.1 (d, C-4), 121.8 (d, C-5), 107.6 (d, C-7), 90.3 (d, C-1´), 47.1 (s, C-3), 29.6 (q, NCH\(_3\)), 28.6 (2q, gem- CH\(_3\)), 11.9 (q, CH\(_3\)). MS (70 eV): 258 (M\(^{+}\), 62), 212 (15), 198 (39), 197 (47), 182 (37), 181 (22), 180 (23), 175 (24), 167 (25), 160 (79), 159 (76), 158 (100), 145 (16), 144 (33), 132 (12), 116 (12), 77 (18).

Cis- and trans Ethyl 4-(2,3-dihydro-1,3,3-trimethyl-1\(H\)-indolylidene)-2-nitro-2-butenoate (13c). IR, 1713, 1617, 1568, 1488, 1480, 1362, 1358, 977, 805, 749. NMR data for the major component, \(\delta_H\) (CDCl\(_3\)) 8.72 (1 H, d, J = 14.3 Hz, H-2´), 7.33, 7.30 (2 H, t + d, H-6, H-4), 7.15 (1 H, t, H-5), 6.96 (1 H, d, H-7), 6.34 (1 H, d, J = 14.3 Hz, H-1´), 4.38 (2 H, q, OCH\(_2\)), 3.43 (3 H, s, NCH\(_3\)), 1.67 (6 H, s, gem- CH\(_3\)), 1.39 (3H, t, CH\(_3\)). \(\delta_C\) (CDCl\(_3\)) 173.8 (s, CO), 162.2 (s, C-2), 142.8 (s, C-7a), 140.1 (s, C-3a), 139.4 (d, C-2´), 129.2 (s, C-3´), 123.32 (d, C-4), 122.0 (d, C-5), 109.0 (d, C-7), 92.2 (d, C-1´), 61.2 (t, OCH\(_2\)), 48.2 (s, C-3), 30.3 (q, NCH\(_3\)), 28.7 (2q, gem- CH\(_3\)), 14.30 (q, CH\(_3\)). NMR data for the minor component, \(\delta_H\) (CDCl\(_3\)) 8.23 (1 H, d, J = 13.6 Hz, H-2´), 7.33, 7.30 (2 H, t + d, H-6, H-4), 7.15 (1 H, t, H-5), 6.96 (1 H, d, H-7), 6.51 (1 H, d, J = 13.6 Hz, H-1´), 4.31 (2 H, q, OCH\(_2\)), 3.43 (3 H, s, NCH\(_3\)), 1.67 (6 H, s, gem- CH\(_3\)), 1.36 (3H, t, CH\(_3\)). \(\delta_C\) (CDCl\(_3\)) 173.9 (s, CO), 162.6 (s, C-2), 142.9 (s, C-7a), 142.4 (d, C-2´), 140.0 (s, C-3a), 128.35 (d, C-6), 127.8 (s, C-3´), 123.87 (d, C-4), 121.9 (d, C-5), 109.1 (d, C-7), 92.8 (d, C-1´), 61.1 (t, OCH\(_2\)), 48.2 (s, C-3), 30.4 (q, NCH\(_3\)), 28.6 (2q, gem- CH\(_3\)), 14.26 (q, CH\(_3\)). MS data: 316 (M\(^{+}\), 25), 300 (7), 271 (13), 269 (20), 197 (17), 182 (28), 175 (36), 172 (16), 168 (19), 167 (22), 160 (85), 159 (100), 158 (57), 144 (24), 132 (27), 117 (20), 116 (34), 91 (42), 90 (26), 89 (43), 77 (30).

2,3-Dihydro-2-[(6-hydroxy-3-nitro)hexylidene]-1,3,3-trimethyl-1\(H\)-indole (14). IR, 3431, 3056, 1619, 1579, 1490, 1469, 1356, 1262, 1246, 1287, 929, 799, 746. NMR, \(\delta_1\) (CDCl\(_3\)) 8.54 (1 H, d, J = 13.5 Hz, H-2´), 7.27 (1 H, t, H-6), 7.25 (1 H, d, H-4), 7.04 (1 H, t, H-5), 7.84 (1 H, d, H-7), 5.46 (1 H, d, J = 13.5 Hz, H-1´), 3.67 (2 H, t, CH\(_2\)OH), 3.32 (3 H, s, NCH\(_3\)), 2.85 (2H, t, CH\(_2\)CH\(_2\)CH\(_2\)OH), 1.95 (1 H, bs, OH), 1.85 (2 H, quintet, CH\(_2\)CH\(_2\)OH), 1.65 (6 H, s, gem- CH\(_3\)). \(\delta_C\) (CDCl\(_3\)) 168.4 (s, C-2), 143.6 (s, C-7a), 139.5 (s, C-3a), 139.1 (s, C-3´), 134.8 (d, C-2´), 128.0 (d, C-6), 122.3 (d, C-4), 121.8 (d, C-5), 107.7 (d, C-7), 90.3 (d, C-1´), 61.3 (t, CH\(_2\)OH), 47.3 (s, C-3), 30.4 (t, C-5´), 29.6 (q, NCH\(_3\)), 28.5 (2q, gem- CH\(_3\)), 21.9 (t, C-4´). MS data: 302 (M\(^{+}\), 58), 285 (8), 258 (22), 256 (16), 240 (22), 211 (28), 197 (56), 194 (22), 186 (23), 182 (23), 181 (30), 180 (23), 175 (38), 172 (32), 168 (19), 167 (21), 160 (90), 158 (100), 145 (22), 144 (39), 132 (17), 116 (15), 91 (11), 77 (17).
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References


