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# Dihydroflavonols and flavanones from *Lonchocarpus atropurpureus* roots

Aderbal F. Magalhães[a,*], Ana Lucia T.G. Ruiz[a], Ana Maria G.A. Tozzi[b], Eva G. Magalhães[a]

[a]*Organic Chemistry Department of Chemistry Institute, UNICAMP, P.O. Box 6154, 13081-970, Campinas, São Paulo, Brazil*
[b]*Botany Department of Biology Institute, UNICAMP, P.O. Box 6154, 13081-970 Campinas, São Paulo, Brazil*

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## Abstract

From the petroleum extract of *Lonchocarpus atropurpureus* Benth. roots, 5,2′-dihydroxy-3-methoxy-6,7-(2″,2″-dimethylchromene)-8-(3‴,3‴-dimethylallyl)-flavanone and 2′,3,5-trihydroxy-6,7-(2″,2″-dimethylchromene)-8-(3‴,3‴-dimethylallyl)-flavanone were isolated, together with three known flavanoids and a mixture of two pentacyclic triterpenes. Their molecular structures were determined by spectral analyses (UV, IR, MS and 1D- and 2D-NMR experiments). © 1999 Elsevier Science Ltd. All rights reserved.

*Keywords:* Leguminosae; *Lonchocarpus atropurpureus*; Flavonoids; Flavanones; Dihydroflavonols; Minimiflorin; Mundulinol; Mundulin

## 1. Introduction

The genus *Lonchocarpus* belongs to the subfamily Papilionoideae of the Leguminosae. *Lonchocarpus atropurpureus* Benth. is native to Mexico (Pittier, 1917) and is cultivated in the Ecological Park of Campinas State University (UNICAMP). It belongs to *Lonchocarpus* subgenus *Lonchocarpus*, section *Lonchocarpus*.

As part of a chemosystematic study of the genus *Lonchocarpus* (Magalhães, Tozzi, Sales & Magalhães, 1996; Magalhães, Tozzi, Magalhães & Nogueria, 1997) the root extract of *L. atropurpureus* was subjected to a detailed laboratory investigation. We report herein five prenylated flavonoids (**1–5**) and a mixture of two pentacyclic triterpenes (**6**).Two of these compounds (**2** and **3**) are described for the first time.

## 2. Results and discussion

Two flavanones (**1** and **5**), three dihydroflavonols (**2–4**) and a mixture of pentacyclic triterpenes (**6**) (Fig. 1) were isolated through chromatographic fractionation techniques (column, TLC and preparative TLC) from the petroleum extract of *L. atropurpureus* roots.

Compounds **1** ($C_{25}H_{26}O_5$), **4** ($C_{25}H_{26}O_5$) and **5** ($C_{25}H_{26}O_4$) were identified as the known minimiflorin (Mahmoud & Waterman, 1985) mundulinol and mundulin (van Zyl, Rall & Roux, 1979) respectively, by comparison of their spectral data with those previously published. The mixture of pentacyclic triterpenes was analyzed by $^1$H-NMR, $^{13}$C-NMR data (Olea & Roque, 1990; Seo, Tomita & Tori, 1975; Wenkert, Baddeley, Burfitt & Moreno, 1978) and GC/MS (Shannon, 1963; Muccino & Djerassi, 1974) to reveal a mixture of $\beta$-amyrin and lupeol.

Compound **2**, obtained as the major constituent, was deduced as having an elemental formula of $C_{26}H_{28}O_6$ by HREI-MS (observed. $M^{+\cdot} = 436.1886$; required $M^{+\cdot} = 436.1886$). It showed characteristic signals for a dihydroflavonol at $\delta$H 5.43 (1H, *d*, $J$ = 11

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[*] Corresponding author.

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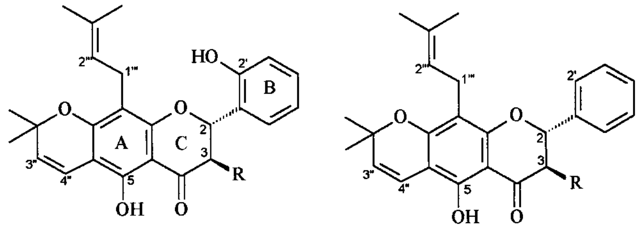
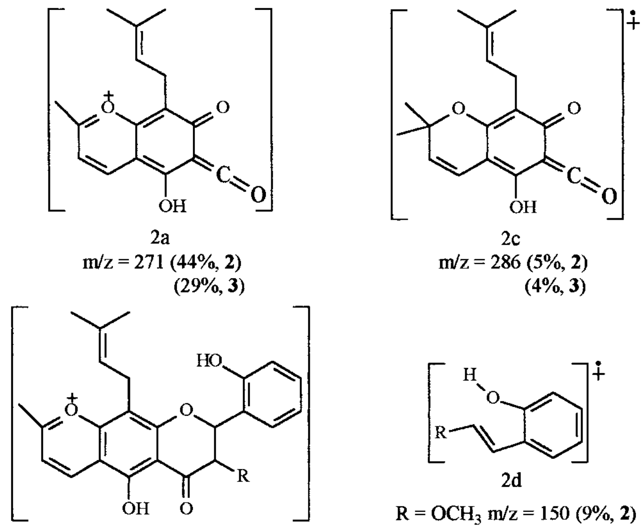


1: R = H
2: R = OCH$_3$
3: R = OH

4: R = OH
5: R = H

Fig. 1. Compounds isolated from *Lonchocarpus atropurpureus* Benth.



2a
m/z = 271 (44%, **2**)
(29%, **3**)

2c
m/z = 286 (5%, **2**)
(4%, **3**)

2b
R = OCH$_3$ m/z = 421 (80%, **2**)
R = OH m/z = 391 (65%, **3**)

2d
R = OCH$_3$ m/z = 150 (9%, **2**)
R = OH m/z = 136 (5%, **3**)

Fig. 2. Most important fragment ions of **2** and **3**.

Hz, H-3) and 4.15 (1H, *d*, $J$ = 11 Hz, H-2) in the $^1$H-NMR spectrum and at $\delta_C$ 81.8 (C-3) and 77.8 (C-2) in the $^{13}$C-NMR spectrum (Agrawal, 1989). This was supported in the UV spectrum by the maximum absorption at 276 nm (benzoyl chromophore). The carbonyl group at C-4 was hydrogen-bonded with the C-5 OH group, as evidenced by a singlet at $\delta_H$ 11.95 in the $^1$H-NMR spectrum. A singlet at $\delta_H$ 3.60 (3H, *s*, OCH$_3$) in the $^1$H-NMR spectrum, correlated with the signal at $\delta_C$ 61.9 (OCH$_3$) in the $^{13}$C-NMR and was compatible with the expected resonance for a 3-methoxy-dihydroflavonol (Agrawal, 1989).

Signals at $\delta_H$ 7.00 (1H, *d*, $J$ = 8 Hz, H-3′), 7.03 (1H, *t*, $J$ = 8 Hz, H-5′), 7.52 (1H, *d*, $J$ = 8 Hz, H-6′) and 7.31 (1H, *t*, $J$ = 8 Hz, H-4′), in the $^1$H-NMR

Table 1
$^1$H-NMR (500 MHz, CDCl$_3$) spectral assignments for compounds **2** and **3**

| | **2** | **3** |
|---|---|---|
| 2 | 5.43 (1H, *d*, $J$ = 11 Hz)[a] | 5.39 (1H, *d*, $J$ = 11 Hz)[a] |
| 3 | 4.15 (1H, *d*, $J$ = 11 Hz)[i] | 4.53 (1H, *d*, $J$ = 11 Hz)[i] |
| 3′ | 7.00 (1H, *dd*, $J$ = 1[c] e 8[j] Hz) | 7.02 (1H, *dl*, $J$ = 7,5 Hz)[j] |
| 4′ | 7.31 (1H, *td*, $J$ = 1[e] e 8[d] Hz) | 7.30 (1H, *tl*, $J$ = 7,5 Hz)[d] |
| 5′ | 7.03 (1H, *td*, $J$ = 1[c] e 8[b] Hz) | 7.05 (1H, *tl*, $J$ = 7,5 Hz)[b] |
| 6′ | 7.52 (1H, *dd*, $J$ = 1[e] e 8[f] Hz) | 7.57 (1H, *dl*, $J$ = 7,5 Hz)[f] |
| CH$_3$-2″ | 1.45[h] (3H, *s*) | 1.46[h] (3H, *s*) |
| CH$_3$-2″ | 1.47[h] (3H, *s*) | 1.47[h] (3H, *s*) |
| 3″ | 5.54 (1H, *d*, $J$ = 10 Hz)[g] | 5.55 (1H, *d*, $J$ = 10 Hz)[g] |
| 4″ | 6.65 (1H, *d*, $J$ = 10 Hz)[g] | 6.64 (1H, *d*, $J$ = 10 Hz)[g] |
| 1‴ | 3.23 (2H, *dd*, $J$ = 6[l] e 10[k] Hz) | 3.23 (2H, *dd*, $J$ = 7[l]e 10[k] Hz) |
| 2‴ | 5.12 (1H, *t*, $J$ = 6 Hz)[l] | 5.12 (1H, *tl*, $J$ = 7 Hz)[l] |
| 4‴ | 1.66 (3H, *s*) | 1.66 (6H, *s*) |
| 5″′ | 1.67 (3H, *s*) | – |
| C-3–OR | 3.60 (3H, *s*, O–CH$_3$=R) | 4.18 (1H, *sl*, OH=R) |
| C-5–O<u>H</u> | 11.95 (1H, *s*) | 11.29 (1H, *s*) |
| C-2′–O<u>H</u> | 6.73 (1H, *s*) | 6.86 (1H, *sl*) |

[a] $J_{2,3}$.
[b] $J_{5'-4'} = J_{5'-6'}$.
[c] $J_{5'-3'}$, $J_{3'-5'}$.
[d] $J_{4'-5'} = J_{4'-3'}$.
[e] $J_{4'-6'} = J_{6'-4'}$.
[f] $J_{6'-5'}$.
[g] $J_{3''-4''}$.
[h] interchangeable.
[i] $J_{3,2}$.
[j] $J_{3',4'}$.
[k] $J_{1'''a-1'''b}$.
[l] $J_{1'''-2'''}$.

Table 2
$^{13}$C-NMR ($CDCl_3$) spectral assignments for compounds **2** and **3**

| C | **2**[a] | **3**[b] |
|---|---|---|
| $CH_3$-4‴ | 17.8 | 17.9 |
| $CH_2$-1‴ | 21.3 | 21.3 |
| $CH_3$-5‴ | 25.7 | 25.8 |
| $CH_3$-2″ | 28.3 | 28.4 |
| $CH_3$-2″ | 28.4 | 28.4 |
| $CH_3$–O-3 | 61.9 | – |
| CH-2 | 77.8 | 78.6 |
| $C_0$-2″ | 78.5 | 78.0 |
| C-3 | 81.8 (CH) | 73.2 (CH) |
| $C_0$-10 | 101.3 | 100.1 |
| $C_0$-6 | 103.5 | 103.5 |
| $C_0$-8 | 109.1 | 109.6 |
| CH-3″ | 115.4 | 115.3 |
| CH-3′ | 117.8 | 118.1 |
| CH-5′ | 121.1 | 121.3 |
| CH-2‴ | 122.2 | 122.0 |
| $C_0$-1′ | 124.2 | 124.2 |
| CH-6′ | 126.3 | 126.5 |
| CH-4″ | 127.1 | 126.8 |
| CH-4′ | 129.9 | 129.9 |
| $C_0$-3‴ | 131.6 | 131.7 |
| $C_0$-2′ | 154.0 | 153.9 |
| $C_0$-5 | 156.7 | 156.0 |
| $C_0$-7 | 158.3 | 158.9 |
| $C_0$-9 | 160.3 | 161.0 |
| $C_0$-4 | 195.7 | 195.0 |

[a] 125 MHz.
[b] 75 MHz.

Table 4
Observed correlation in HSQC (vicinal C–H) and in HMBC (long-range C–H) spectra ($CDCl^3$, 11 Tesla) of **3**

| H ($\delta$) | C ($\delta$, $J^1$) | C ($\delta$, $J^n$) |
|---|---|---|
| 2 (5.39) | 2 (78.6) | – |
| 3 (4.53) | 3 (73.2) | – |
| $\underline{H}$O-3 (4.17) | – | – |
| $\underline{H}$O-5 (11.29) | – | – |
| 3′ (7.02) | 3′ (118.1) | – |
| 4′ (7.30) | 4′ (129.9) | – |
| 5′ (7.05) | 5′ (121.3) | – |
| 6′ (7.57) | 6′(126.5) | 2′ (153.9) |
| $C\underline{H}_3$-2″a (1.46) | $\underline{C}$H3-2″a (28.4) | 2″ (78.7), 4″ (126.8) |
| $C\underline{H}_3$-2″b (1.47) | $\underline{C}$H3-2″b (28.4) | 2″ (78.7), 4″ (126.8) |
| 3″ (5.55) | 3″ (115.3) | 6 (103.5), 2″ (78.7) |
| 4″ (6.64) | 4″ (126.8) | 7 (158.9), 2″ (78.7) |
| 1‴ (3.23) | 1‴ (21.3) | 8 (109.6), 9 (161.0), 3‴ (131.7) |
| 2‴ (5.12) | 2‴ (122.0) | – |
| 4‴ (1.66) | 4‴ (17.9) | 3″ (131.7), 2″ (122.0) |
| 5‴ (1.66) | 5‴ (25,8) | 3″ (131.7), 2″ (122.0) |

spectrum, which exhibited $^1J$-coupling with the $^{13}$C-NMR resonances at $\delta_C$ 117.8 (C-3′), 121.1 (C-5′), 126.3 (C-6′) and 129.9 (C-4′), respectively, in the $^1$H-$^{13}$C HSQC NMR spectrum, gave evidence for a 2′-hydroxy B-ring, which is not a very frequent substitution position (Iinuma & Mizuno, 1989). A 3,3-dimethylallyl and a 2,2-dimethylchromene substituent were apparent from observed $^1$H- and $^{13}$C-NMR signals (Tables 1 and 2). Since the B-ring was identified as 2′-hydroxy, both 2,2-dimethylchromene and 3,3-dimethylallyl groups were connected to the A-ring, which was confirmed by the fragment ion at $m/z = 271$ (**2a**) in its mass spectrum (Fig. 2).

An HMBC NMR experiment was used to confirm the position of the 2,2-dimethylchromene and 3,3-dimethylallyl groups. The correlation of H-1‴ ($\delta_H$ 3.23) with carbons C-8 ($\delta_C$ 109.1) and C-9 ($\delta_C$ 160.3),

Table 3
Observed correlation in HSQC (vicinal C–H) and in HMBC (long-range C–H) spectra ($CDCl_3$, 11 Tesla) of **2**

| H ($\delta$) | C ($\delta$, $J^1$) | C ($\delta$, $J^n$) |
|---|---|---|
| 2 (5.45) | 2 (77.8) | 3 (81.8), 4 (195.7), 2′(154.0), 6′(126.3) |
| 3 (4.16) | 3 (81.8) | 2 (77.8), 3-$OCH_3$ (61.9), 4 (195.7), 1′(124.2) |
| $\underline{H_3}$CO-3 (3.60) | 3-$OCH_3$ (61.9) | – |
| $\underline{H}$O-5 (11.95) | – | 5 (156.7), 6 (103.5), 7 (158.3), 10 (101.3) |
| $\underline{H}$O-2′ (6.76) | – | 3′ (117.8) |
| 3′ (7.00) | 3′ (117.8) | 5′ (121.1) |
| 4′ (7.31) | 4′ (129.9) | 2′(154.0), 3′ (117.8), 6′(126.3) |
| 5′ (7.04) | 5′ (121.1) | 1′(124.2), 2′(154.0), 3′ (117.8) |
| 6′ (7.51) | 6′(126.3) | 2′(154.0), 4′ (129.9) |
| $C\underline{H_3}$-2″a (1.45) | $\underline{C}H_3$-2″a (28.3) | 2″ (78.5), 3″ (115.4), 4″ (127.1) |
| $C\underline{H_3}$-2″b (1.47) | $\underline{C}H_3$-2″b (28.4) | 2″ (78.5), 3″ (115.4), 4″ (127.1) |
| 3″ (5.54) | 3″ (115.4) | 6 (103.5), 2″ (78.5), 4″ (127.1) |
| 4″ (6.65) | 4″ (127.1) | 5 (156.7), 7 (158.3), 2″ (78.5) |
| 1‴ (3.23) | 1‴ (21.3) | 8 (109.1), 9 (160.3), 2‴ (122.2), 3‴ (131.6) |
| 2‴ (5.13) | 2‴ (122,2) | 4‴ (17.8), 5‴ (25.7) |
| 4‴ (1.67) | 4‴ (17.8) | 3‴ (131.6), 5‴ (25.7) |
| 5‴ (1.67) | 5‴ (25.7) | 3‴ (131.6), 4‴ (17.8) |

and those of H-4″ ($\delta_H$ 6.65) with carbons C-5 ($\delta_C$ 156.7) and C-7 ($\delta_C$ 158.3) required that the 2,2-dimethylchromene group was linearly connected to the A-ring with the 3,3-dimethylallyl group at C-8. In the EIMS spectrum, the fragment ion at $m/z = 421$ (**2b**) must be the molecular ion losing a methyl group; a fragmentation by retro Diels-Alder (RDA) could explain fragment ions at $m/z = 271$ (**2a**), $m/z = 286$ (**2c**) and $m/z = 150$ (**2d**) (Fig. 2). The higher abundance of the fragment 2a ($m/z = 271$) suggested that C-ring RDA cleavage occurs preferentially from the fragment ion $m/z = 421$, which was further confirmed by an MS/MS experiment. All $^1$H- and $^{13}$C-NMR assignments for **2** were performed using appropriate HSQC and HMBC NMR experiments (Table 3).

The molecular formula of compound **3** was established in turn as $C_{25}H_{26}O_6$ by HREI mass spectrometry (observed $M^{+\cdot} = 422.1729$, required $M^{+\cdot} = 422.1729$). Analysis of its $^1$H-NMR (Table 1), $^{13}$C-NMR (Table 2) and mass spectral data (Fig. 2) indicated that **3** was very closely related with compound **2**, but this time was the corresponding dihydroflavonol. All $^1$H- and $^{13}$C-NMR assignments for **3** were performed using appropriate HSQC and HMBC NMR experiments (Table 4).

## 3. Experimental

IR: film or KBr; $^1$H- and $^{13}$C-NMR: in $CDCl_3$, at 7 or 11 Tesla instruments with TMS as int. standard; EIMS: 70 eV, direct probe; GC-MS: programmed 50–290° at 15°/min$^{-1}$, injector at 290°, interface with detector EI (70 eV) at 285°, column DB-5.

### 3.1. Plant material

Roots of *L. atropurpureus* Benth. were collected at the UNICAMP Ecological Park in Campinas, Brazil in March 1997, and were identified by one of the authors (A.M.G.A.T.). A voucher specimen (AMGA Tozzi 98-04) has been deposited in the Herbarium of the Biology Institute (UNICAMP).

### 3.2. Extraction and isolation

Dry, milled roots (130 g) were successively extracted in a Soxhlet apparatus for 154 hour with petrol, dichloromethane and methanol. After solvent evaporation, the petrol extract gave a yellow oil (2.2 g), part of which (100 mg) was fractionated by preparative TLC (silicagel 60 $GF_{254}$) run with $CH_2Cl_2$. This furnished six fractions which were numbered according to increasing polarity. The fifth fraction (20 mg) was further fractionated by preparatory TLC (hereafter, prep. TLC) continuously eluted with Hex–$CH_2Cl_2$–EtOAc (30 : 10 : 4) during 100 min to afford **3** (7.1 mg). Fr. 3 (30 mg) was submitted to the same method, but with a longer development time (150 min), furnishing **1** (8 mg) and **2** (11 mg).

Another part of the petrol extract (2.0 g) was subjected to *flash* CC over silica gel (Still, Kahn & Mitra, 1978); eluted with dichloromethane with increasing eluent polarity from the gradual addition of methanol until reaching 100% methanol, furnishing 325 fractions (30 ml) which were reduced to 20 groups after TLC. The second group (459.5 mg, fr. 6–23) was fractionated by prep. TLC continuously run with Hex–EtOAc (9 : 1) during 100 min to afford **4** (30.3 mg) and **5** (5.3 mg), which were then submitted to prep. TLC run with Hex–EtOAc (9 : 1) (three developments) and Hex–$CH_2Cl_2$–EtOAc (30 : 10 : 4) (two developments), respectively. Group 3 (75.1 mg, fr. 24–30), after prep. TLC run with Hex–EtOAc (9 : 1) and $CH_2Cl_2$, furnished a mixture **6** and **7** (lupeol + $\beta$-amirin, 16.7 mg).

### 3.3. Minimiflorin (*1*)

Viscous yellowish oil, $[\alpha]_D^{20}$, UV, IR, $^1$H-NMR, $^{13}$C-NMR and EIMS data (Mahmoud & Waterman, 1985).

### 3.4. 5,2′-dihydroxy-3-methoxy-6, 7-(2″,2″-dimethylchromene)-8-(3‴, 3‴-dimethylallyl)-flavanone (*2*)

Pale yellow crystals (methanol), mp 128.8–129.2°. $[\alpha]_D^{20}$-12.69° ($CH_2Cl_2$, $c$ 0.670). UV $\lambda_{max}^{MeOH}$ nm (log $\varepsilon$): 276 (4.52), 318 (4.06), 374 (3.29). IR $\nu_{max}^{CH_2Cl_2}$ cm$^{-1}$ (KBr): 3368, 2966, 2924, 1643, 1620, 1583, 1500, 1457, 1381, 1338, 1290, 1266, 1233, 1188, 1138, 1127, 1094, 1027, 983, 947, 750, 727. $^1$H-NMR (500 MHz, $CDCl_3$/TMS) (see Table 1). $^{13}$C-NMR (125 MHz, $CDCl_3$) (see Table 2). EIMS (70 eV), $m/z$ (rel. int): 436 $[M]^+$ (100), 421 (80), 403 (6), 389 (16), 285 (10), 271 (44), 243 (27), 231 (21), 215 (42), 150 (9), 107 (11), 91 (12), 77 (10), 69 (14). HR-EIMS $m/z$: found 436.18856 $[M^+]$ ($C_{26}H_{28}O_6$ requires 436.18859).

### 3.5. 2′,3,5-trihydroxy-6,7-(2″,2″-dimethylchromene)-8-(3‴,3‴- dimethylallyl)-flavanone (*3*)

Viscous yellowish oil, $[\alpha]_D^{20}$-54.43° ($CH_2Cl_2$, $c$ 0.625). UV $\lambda_{max}^{MeOH}$ nm (log $\varepsilon$): 276 (4.80), 316 (4.35), 372 (3.81). IR $\nu_{max}^{CH_2Cl_2}$ cm$^{-1}$ (KBr): 3406, 2966, 2923, 1644, 1627, 1460, 1381, 1290, 1233, 1188, 1022, 938, 905, 844, 748. $^1$H-NMR (500 MHz, $CDCl_3$/TMS) (see Table 1). $^{13}$C-NMR (75 MHz, $CDCl_3$) (see Table 2). EIMS (70 eV), $m/z$ (rel. int): 422 $[M]^+$ (100), 407 (65), 405 (13), 404 (17), 389 (26), 285 (7), 271 (29), 243 (17), 231 (29), 215

(32), 107 (15), 91 (7), 77 (7). HR-EIMS *m/z*: found 422.17292 [$M^+$] ($C_{25}H_{26}O_6$ requires 422.17294).

### 3.6. Mundulinol (**4**)

Viscous yellowish oil, $[\alpha]_D^{20}$, UV, IR, $^1$H-NMR, $^{13}$C-NMR and HR-EIMS data (van Zyl et al., 1979). EIMS (70 eV), *m/z* (rel.int): 406 $[M]^+$ (81), 391 (100), 363 (7), 285 (8), 271 (24), 243 (14), 231 (11), 215 (13), 189 (10), 91 (14).

### 3.7. Mundulin (**5**)

Viscous yellowish oil. $[\alpha]_D^{20}$, UV, IR, $^1$H-NMR, $^{13}$C-NMR and HR-EIMS data (van Zyl et al., 1979).

### 3.8. β-Amyrin and lupeol

$^1$H-NMR, $^{13}$C-NMR and MS data (Olea & Roque, 1990; Seo et al., 1975; Wenkert et al., 1978; Shannon, 1963; Muccino & Djerassi, 1974).

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