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NEW 8-HYDROXYFLAVONOIDS FROM *SOLANUM* SECTION *ANDROCERAS*

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Key Word Index—*Solanum* section *Androceras*; Solanaceae; 8-hydroxyflavones; 8-hydroxyflavonols.

Abstract—Five new 8-hydroxyflavonoids have been identified from leaves of *Solanum* section *Androceras*: 8-methoxymyricetin 3,7,4′-trimethyl ether; 8-hydroxymyricetin 3,7,4′-trimethyl ether; 8-hydroxymyricetin 8-*O*-glucosylxyloside 3,7,4′-trimethyl ether; 8-hydroxychrysoeriol 7-methyl ether; 8-hydroxychrysoeriol 7-*O*-glucoside.

INTRODUCTION

Most studies of flavonoids from *Solanum* (Solanaceae) have concerned section *Tuberarium* (the potatoes), members of which afforded flavonol 3-*O*- and 3,7-*O*-glycosides and their acylated derivatives [1, 2]. No 8-hydroxyflavonoids have been previously reported from the Solanaceae.

Structures of foliar flavonoid constituents of *Solanum* section *Androceras*, which includes twelve non-cultivated herb species of Mexico and the southwestern United States, were determined as part of a taxonomic survey [3]. Flavonols were found to predominate, but flavones were more widespread and diverse in section *Androceras* than in other previously examined Solanaceae.

RESULTS AND DISCUSSION

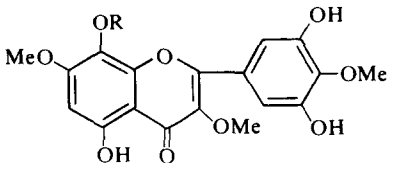
Among the flavonoids isolated and identified from members of section *Androceras* are three new 8-hydroxyflavonols (**1**, **2**, **3**) and two new 8-hydroxyflavones (**4**, **5**).

The new 8-hydroxyflavonoids were isolated from the following species: *S. citrullifolium* A. Br. (**1**–**3**); *S. grayi* Rose (**4** and **5**); *S. heterodoxum* Dun. (**1** and **3**); *S. tenuipes* Bartl. (**1**–**3**).

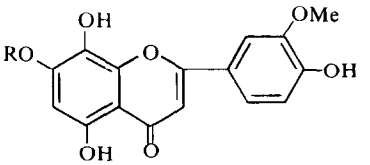
The MS of **1** exhibited a molecular ion at *m/e* 390 indicating it was a tetramethoxytrihydroxyflavone ($C_{19}H_{18}O_9$), and an $[M - CH_3]^+$ ion at *m/e* 375 (78%), typical for the loss of a methyl group from a methoxyl function at C-6 or C-8 [4]. An NMR spectrum of **1** in CCl_4 displayed two singlets at δ 3.88 (6 protons) and δ 3.97 (6 protons) for four methoxyl groups and a singlet at δ 6.32 for an isolated C-6 proton. The 2′ and 6′ protons appeared as a singlet at δ 7.42, typical for a symmetrically substituted myricetin type B-ring. Band I of the UV spectrum of **1** in MeOH was at 357 nm as expected for a 3-*O*-substituted flavonol. The dark purple color of the compound on paper in UV light was further evidence for 3-*O*-substitution and indicated a free 5-hydroxyl. The presence of the latter group, as well as an oxygen function at C-8 [5], was confirmed by a Band-I shift of 63 nm in $AlCl_3$/HCl relative to the MeOH spectrum. Since Band II did not give a bathochromic shift in NaOAc, substitution of the 7-hydroxyl group was indicated. Substitution of the 4′-hydroxyl group was shown by the dark color of the compound on paper in UV light + NH_3 and the small magnitude of the Band I bathochromic shift in NaOMe.

The above data for **1** were in accord with a 3,5,7,8,3′,4′,-5′-oxygenation pattern with methoxyl groups at 3, 7 and 4′. The fourth methoxyl function was known to be located at C-8 since the C-5 hydroxyl group was free and the B-ring symmetrically substituted (from the NMR data). Compound **1** is therefore 8-methoxymyricetin 3,7,4′-trimethyl ether.

The UV spectra of **2** were essentially identical with those of **1**, indicating equivalent oxygenation and substitution patterns. Compound **2** was a glycoside, however, and upon acid hydrolysis, yielded an aglycone and two sugars which were identified by PC as xylose and glucose. The aglycone from the hydrolysis of **2** exhibited UV spectral and color properties expected



1 R = Me
2 R = Xyl-*O*-Glc
3 R = H



4 R = Me
5 R = Glc

for a 3,7,4′-substituted 8-hydroxymyricetin. Its MS displayed a molecular ion as the base peak at *m/e* 376, corresponding to trimethoxy-tetrahydroxyflavone ($C_{18}H_{16}O_9$). The low intensity of the $[M - CH_3]^+$ ion (14%) confirmed the absence of a C-8 methoxyl substituent [4], while the prominent $[M - H]^+$ fragment (55%) was consistent with the expected loss of a proton from a C-8 hydroxyl group. When **2** was subjected to β-glucosidase hydrolysis it afforded a monoglycoside with UV spectral properties identical to those of **2**; it gave only xylose upon hydrolysis with acid. Compound **2** thus contains an *O*-glucosylxylosyl moiety and must be 8-hydroxymyricetin 8-*O*-glycosylxyloside 3,7,4′-trimethyl ether.

The chromatographic, UV and MS properties of **3** established that it was identical with 8-hydroxymyricetin 3,7,4′-trimethyl ether, the aglycone obtained upon acid hydrolysis of **2**.

A molecular ion at *m/e* 330 appeared as the base peak in the MS of **4** in accord with a trihydroxydimethoxyflavone, $C_{17}H_{14}O_7$. Band I of the UV spectrum of **4** in MeOH appeared at 342 nm, in the range for flavones. A 3′,4′-dioxygenation pattern in the B-ring was indicated by the two peaks at 254 and 272 nm. The large bathochromic shift of Band I (60 nm) with an increase in its intensity in NaOMe relative to MeOH signified the presence of an unsubstituted hydroxyl group at C-4′, as did the color change from purple to yellow observed when the compound on paper was fumed with ammonia in UV light. The complete acid stability of the $AlCl_3$ complex showed that the B-ring lacked an *o*-dihydroxyl group and thus that a methoxyl function must be located at C-3′. The $AlCl_3$/HCl spectrum also indicated the presence of a free hydroxyl group at C-5. Substitution of the C-7 hydroxyl group was demonstrated by the failure of Band II to show a bathochromic shift in NaOAc relative to MeOH. The magnitude of the Band I shift in $AlCl_3$/HCl relative to MeOH (59 nm compared to 33 nm for luteolin 7,3′dimethyl ether [6]) supported the assignment of the remaining free hydroxyl group to C-8 [5]. These data establish that **4** is 8-hydroxychrysoeriol 7-methyl ether.

The UV spectra of **5** were identical with those of **4**, indicating equivalent oxygenation and substitution patterns; however, **5** was a glycoside and yielded glucose upon acid hydrolysis. The R_f values of **5** were in the range expected for a 7-*O*-monoglycoside and it is tentatively assigned an 8-hydroxychrysoeriol 7-*O*-glucoside structure.

EXPERIMENTAL

Vouchers are on deposit in the University of Texas Lundell Herbarium: *S. citrullifolium*, MDW 42; *S. grayi*, MDW 184; *S. heterodoxum*, MDW 80; *S. tenuipes*, MDW 218.

Extraction and purification. Air-dried and ground plant material (*ca* 70 g) was extracted in 1000 ml of 85% aq. MeOH. The filtered extract was evapd to 75 ml, removing essentially all the MeOH. The resulting aq. syrup was extracted with $CHCl_3$ (×3) and then with EtOAc (×8). Both the organic fractions were evapd to small vols and applied to 4 cm polyamide columns, which were eluted with $CHCl_3$–MeOH (2:1). Flavonoid-containing bands were collected from the columns, concentrated and applied in narrow strips to sheets of Whatman 3MM paper. The paper chromatograms were developed by descent in 15% HOAc, and the resulting bands were cut out and eluted. Flavonoid solns thus obtained were filtered, concentrated and passed through small polyamide columns, eluted with MeOH. Most aglycones were obtained from the $CHCl_3$ fraction of the initial extract, while glycosides were recovered from the EtOAc fraction.

Sugar-analysis of O-glycosides. Acid hydrolyses were carried out in 2 N HCl at 100° for 1 hr. Flavonoid aglycones were removed from the resulting sugar-flavonoid mixtures by extraction with EtOAc. The sugar-containing aq. fractions were chromatographed by ascent with standard sugars on Whatman 3MM paper. Chromatograms were developed twice in EtOAc–Py–H_2O (12:5:4). Sugar spots were detected with alkaline $AgNO_3$ [7]. NMR spectra were measured at 60 MHz with $SiMe_4$ as internal standard.

8-*Methoxymyricetin* 3,7,4′-*trimethyl ether* (**1**): MS (*m/e*) 390.0940 (calc. for $C_{19}H_{18}O_9$ 390.0950) (M^+), 375 ($M - CH_3$)$^+$; colors on paper, purple-green with UV, unchanged with UV/NH_3; R_fs, 0.88 (TBA), 0.38 (15% HOAc). UV data λ_{max} (nm): MeOH 274, 308sh, 323, 357; NaOMe 266, 305, 336sh, 374; $AlCl_3$ 283, 312, 351, 421; $AlCl_3$–HCl 283, 312, 350, 420; NaOAc 268, 308sh, 326, 360; NaOAc–H_3BO_3 273, 308sh, 324, 356. NMR data for TMS ether (ppm): in CCl_4 δ 3.88 (6H), 3.97 (6H), 6.32 (1H), 7.42 (2H); in C_6D_6 δ 3.21 (3H), 3.80 (9H), 6.30 (1H), 7.82 (2H).

8-*Hydroxymyricetin* 8-*O-glucosylxyloside* 3,7,4′-*trimethyl ether* (**2**): colors on paper, purple-green (with UV), unchanged with UV/NH_3; R_fs 0.48 (TBA), 0.62 (15% HOAc). UV data λ_{max}(nm): MeOH 273, 308sh, 324, 357; NaOMe 267, 306, 338sh, 388; $AlCl_3$ 281, 310, 350, 416, $AlCl_3$–HCl 281, 309, 349, 415; NaOAc 268, 306sh, 327, 366; NaOAc–H_3BO_3 272, 305sh, 324, 357. Glucosidase hydrolysate: colors on paper, purple-green (with UV), unchanged with UV/NH_3; R_fs, 0.51 (TBA), 0.33 (15% HOAc). Acid hydrolysate (aglycone): see compound **3**.

8-*Hydroxymyricetin* 3,7,4′-*trimethyl ether* (**3**): MS (*m/e*) 376 (M^+); colors on paper purple-green (with UV), unchanged with UV/NH_3; R_fs 0.76 (TBA), 0.35 (15% HOAc). UV data λ_{max} (nm): MeOH 278, 302, 328sh, 372sh; NaOMe 342 (decomposes); $AlCl_3$ 288, 320, 352, 443; $AlCl_3$–HCl 288, 320, 352, 438; NaOAc 280, 304, 326sh, 375sh; NaOAc–H_3BO_3 278, 302, 329sh, 372sh.

8-*Hydroxychrysoeriol* 7-*methyl ether* (**4**): MS (*m/e*) 330 (M^+); colors on paper purple-green (with UV), yellow-green (with UV/NH_3); R_fs 0.85 (TBA), 0.38 (15% HOAc). UV data λ_{max} (nm): MeOH 254, 272, 292 sh, 342; NaOMe 266, 303 sh, 402; $AlCl_3$ 266sh, 279, 305, 358, 402; $AlCl_3$–HCl 266sh, 279, 304, 356, 401; NaOAc 260, 266sh, 295sh, 410; NaOAc–H_3BO_3 252sh, 271, 292sh, 349.

8-*Hydroxychrysoeriol* 7-*O-glucoside* (**5**): colors on paper, purple-green (with UV), yellow-green (with UV/NH_3); R_fs 0.45 (TBA), 0.22 (15% HOAc). UV data λ_{max} (nm): MeOH 254, 272, 293sh, 343; NaOMe 249sh, 264, 302sh, 406; $AlCl_3$ 266sh, 279, 304, 358, 402; $AlCl_3$–HCl 266sh, 279, 304, 357, 402; NaOAc 260, 266sh, 297sh, 409; NaOAc–H_3BO_3 253sh, 271, 292sh, 349. Acid hydrolysate (aglycone): colors on paper, purple-green (with UV), yellow-green (with UV/NH_3); R_fs 0.77 (TBA), 0.06 (15% HOAc).

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