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NEW SIPHULIN DERIVATIVES FROM THE LICHEN *SIPHULA CERATITES*

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Key Word Index—*Siphula ceratites*; Usneaceae; siphulin; protosiphulin; oxysiphulin; lichen metabolites; chromenones.

Abstract—From the lichen, *Siphula ceratites*, two new metabolities, protosiphulin and oxysiphulin, were isolated besides the known compound, siphulin. The structures of the two new chromenones were proved by ^{1}H NMR and ^{13}C NMR spectral analysis in comparison with those of siphulin.

The lichen of *Siphula* species are mostly distributed on the Southern hemisphere, and only *Siphula ceratites* (Wahlenb.) Fr. has been found on the northern part of the Scandinavian peninsula and Canada. This lichen is noted chemotaxonomically since it contains a characteristic chromomenone-type compound, siphulin (**1**), which has never been found in any other species of *Siphula* collected on the Southern hemisphere [1, 2].

From acetone extracts of *Siphula ceratites* collected in Canada, 2 new compounds **2** and **3** have been isolated along with siphulin by chromatographic separation. **2**, $C_{24}H_{28}O_8$, was readily converted into siphulin, on teating with methanolic HCl. Therefore, **2** must be a hydrated derivative of siphulin **1**. This assumption was supported by the following NMR spectral comparison of **2** with **1**.

The signal δ 5.74 (1H) assigned to a proton at $C_{(3)}$ of **1** was not observed in the ^{1}H NMR of **2**, whereas signals giving a geminal coupling at δ 3.00 and 3.32 (1H each, *d*, $J = 16$ Hz; CH_2) assigned to protons at $C_{(3)}$ as well as a higher shifted singlet at δ 3.45 (2H) assigned to $C_{(7')}$ were given by **2**.

The ^{13}C NMR spectra of **1** and **2** were also compared (Table 1) with those of flavones and flavanones [3]. The ^{13}C NMR signal assigned to $C_{(4)}$ of flavanone shows a downfield shift in comparison with that of flavone. The same tendency was observed in **2** in

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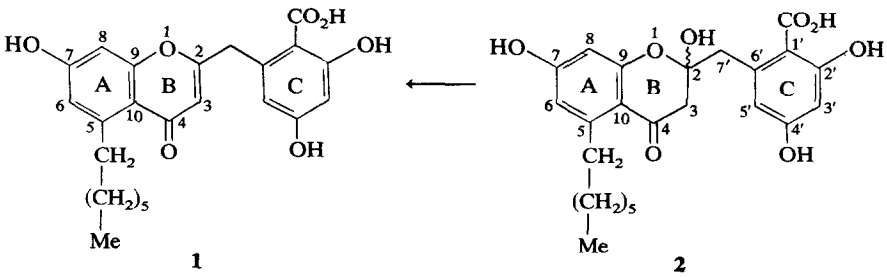

1 **2**

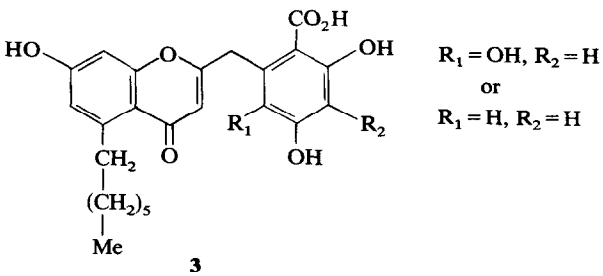

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Table 1. ^{13}C chemical shifts (δ ppm) of acacetin and isosakuranetin in comparison with those of siphulin (**1**) and protosiphulin (**2**)

Compound	Carbon No. $C_{(2)}$	$C_{(3)}$	$C_{(4)}$	$C_{(5)}$	$C_{(6)}$	$C_{(7)}$	$C_{(8)}$	$C_{(9)}$	$C_{(10)}$
Acacetin	168.9	103.9	182.3	157.9	99.4	164.8	94.3	162.2	104.4
(5,7-Dihydroxy 4'-methoxy flavone)									
1		116.9	179.9						
Isosakuranetin	77.8	41.9	196.1	163.4	95.7	166.6	94.8	162.8	101.7
(5,7-Dihydroxy 4'-methoxy flavanone)									
2	100.4	47.9	188.4						

comparison with **1** to show that a double bond is absent from the B ring.

A signal at δ 47.9 in the ^{13}C NMR of **2** which gave a triplet on off-resonance was assigned to $C_{(3)}$, since one of the five doublet signals around 110 ppm on off-resonance of the ^{13}C NMR spectrum of **1** disappeared in that of **2**. The signal at δ 100.4 given by **2** was assigned to the quaternary $C_{(2)}$, since it is the only singlet signal which appeared at a higher field and was not observed in the spectrum of **1**. The singlet signals at δ 104.8 and 115.0 of ^{13}C NMR of **1** and the corresponding signals at δ 105.8 and 112.7 of **2** were assigned to the aromatic carbons attached to carbonyls. A quartet ^{13}C signal which appeared at δ 14.2 for both **1** and **2** was assigned to a terminal methyl of the alkyl side chain, and a triplet at δ 35.7 for both **1** and **2** was assigned to benzyl methylene of the side chain. Other triplets in the region of δ 23.2~37.3 for **1** and δ 23.3~37.3 for **2** were represented by other methylenes of the alkyl side chain. The doublet signals in the region of δ 101.7~115.0 for **1** and δ 102.3~114.1 for **2** accounted for the unsubstituted aromatic ring carbons, and the singlets appeared in the region of δ 140.7~173.2 for **1** and δ 139.8~167.8 for **2** were assigned to other substituted aromatic carbons. Formulation of the structure of **2** is thus complete.

Compound **3**, $C_{24}H_{26}O_8$, gave almost the same ^1H NMR spectrum as **1**, except that there is a singlet at δ 6.72 (1H) instead of at 6.66 (2H) with **1**. This revealed the presence of one more hydroxyl substituted in ring C of **3**. The hydroxyl substitution in **3** was also supported by its greyish-violet colouration with $FeCl_3$ in contrast with the reddish-purple colour given by **1** and **2**. The R_f value of **3** (0.2) on TLC was lower than that of **1** (0.3). The high resolution MS of **3** gave a highest mass peak at 398.1728 (calc. for $C_{23}H_{26}O_6$, $M-CO_2$: 398.1786) and base peak at 327.0867 (calc. for $C_{18}H_{15}O_6$: 327.0852), while **1** gave 382.1754 (calc. for $C_{23}H_{26}O_5$, $M-CO_2$: 382.1778) and 311.0976 (calc. for $C_{18}H_{15}O_5$: 311.0918).

Consequently **3** must have the structure shown, except that conclusive evidence for the position of the hydroxyl, R_1 or R_2, has not been obtained due to the shortage of material.

From the biogenetic viewpoint **2** would be an immediate precursar of siphulin **1**, so that it is designated protosiphulin, while **3** is named oxysiphulin as it is an oxygenated derivtive of siphulin.

EXPERIMENTAL

IR spectra were measured in KBr; ^1H NMR and ^{13}C NMR spectra were recorded in Me_2CO-d_6 with TMS as int. standard.

Extraction and isolation. Lichen material, *Siphula ceratites* (Wahlenb.) Fr. (305 g) collected in British Columbia, Canada, was extracted with Me_2CO. On concn siphulin was precipitated to separate supernatant which was chromatographed over a 0.5 N oxalic acid-impregnated Si gel column eluting with C_6H_6–Me_2CO and then over a Sephadex LH-20 eluted with Me_2CO, siphulin (**1**) (total yield: 6.38 g, 2.1%), protosiphulin (**2**) (yield: 537 mg, 0.17%) and oxysiphulin (**3**) (yield: 18 mg, 0.006%).

Siphulin (**1**). Colourless needles, mp 179–181° (decomp.) (from aq. MeOH); UV and IR as in lit. [2]; ^1H NMR (in Me_2CO-d_6) ppm: δ 0.86 (3H, *m*, $CH_3-(CH_2)_5-CH_2-$), *ca.* 1.3 (10H, *m*, $Me(CH_2)_5-CH_2-$), 3.16 (2H, *tr*, $J=8$ Hz, $Me-(CH_2)_5-CH_2-$), 4.26 (2H, *s*, $-CH_2-$ at 7'), 5.74 (1H, *s*, $C_{(3)}-H$), 6.33 (1H, *d*, $J=2$Hz, $C_{(6\text{ or }8)}-H$), 6.42 (1H, *d*, $J=2$ Hz, $C_{(6\text{ or }8)}-H$), 6.66 (2H, *s*, $C_{(3')}-H$ and $C_{(5')}-H$); ^{13}C NMR (in Me_2CO-d_6) ppm: δ 14.2 ($CH_3-(CH_2)_5-CH_2$), 35.7 ($Me-(CH_2)_5-CH_2-$), 40.4 ($C_{(7')}$), 116.9 ($C_{(3)}$), 148.1 ($C_{(6')}$), 179.9 ($C_{(4)}$). MS: 382.1754 ($M-CO_2$), 339.1246 ($382-Me-CH_2-CH_2$), 325.1069 ($339-CH_2$), 311.0976 ($325-CH_2$) (base peak). Calc. for $C_{23}H_{26}O_5$ ($M-CO_2$): 382.1778, $C_{20}H_{19}O_5$: 339.1231, $C_{19}H_{17}O_5$: 325.1074, $C_{18}H_{15}O_5$: 311.0918.

Protosiphulin (**2**). Colourless needles, mp 179–182° (decomp.) (from Me_2CO–hexane); $[\alpha]_D$ ±0°; UV λ_{max}^{EtOH} nm (log ε): 230 (4.41), 278 (4.41); IR ν_{max}^{KBr} cm^{-1}: 3300, 1663, 1655, 1650, 1635, 1603; ^1H NMR (in Me_2CO-d_6) ppm: δ 0.89 (3H, $CH_3-(CH_2)_5-CH_2-$), *ca* 1.3 (10H, *m*, $Me-(CH_2)_5-CH_2-$), 3.00 (1H, *d*, $J=16$ Hz, $C_{(3)}-H$), 3.1 (2H, *tr*, $J=ca$ 8 Hz, $Me-(CH_2)_5-CH_2-$), 3.32 (1H, *d*, $J=16$ Hz, $C_{(3)}-H$), 3.45 (2H, *s*, CH_2 at 7'), 6.11 (1H, *d*, $J=2$Hz, $C_{(6\text{ or }8)}-H$), 6.28 (1H, *d*, $J=2$ Hz, $C_{(6\text{ or }8)}-H$), 6.40 (1H, *d*, $J=2$ Hz, $C_{(3'\text{ or }5')}-H$, 6.42 (1H, *d*, $J=2$ Hz, $C_{(3'\text{ or }5')}-H$), 9.4 (1H, *s*, OH) 10.80 (1H, *s*, OH); ^{13}C NMR (in Me_2CO-d_6) ppm: δ 14.2 ($CH_3-(CH_2)_5-CH_2-$), 35.6 ($Me-(CH_2)_5-CH_2-$),37.2 ($C_{(7')}$), 47.9 ($C_{(3)}$), 100.4 ($C_{(2)}$), 149.5 ($C_{(6')}$), 188.4 ($C_{(4)}$); MS: 382.1829 ($M-H_2O-CO_2$), 339.1266 ($382-Me-CH_2-CH_2$), 325.1163 ($339-CH_2$),

311.0839 (325 − CH_2) (base peak). Calc. for $C_{23}H_{26}O_5$ (M − H_2O − CO_2): 382.1778, $C_{20}H_{19}O_5$: 339.1231, $C_{19}H_{17}O_5$: 325.1075, $C_{18}H_{15}O_5$: 311.0917. The soln of **2** in MeOH containing a drop of conc HCl was refluxed for 10 min at 100°. The product was purified through Sephadex LH 20 using Me_2CO as the solvent. The product was siphulin (**1**) identified by TLC, IR, NMR and MS comparison.

Oxysiphulin (**3**). Colourless needles, mp 176–178° (decomp.) (from aq. MeCO); UV λ_{max}^{EtOH} nm (log ε): 233 (sh) (4.46), 290 (4.18); ^{1}H NMR (in Me_2CO-d_6) ppm: δ 0.83 (3H, CH_3—$(CH_2)_5$—CH_2), *ca.* 1.3 (10H, *m*, Me—$(CH_2)_5$—CH_2), 3.31 (2H, *tr*, Me—$(CH_2)_5$—CH_2—), 4.42 (2H, *s*, CH_2 at 7'), 5.67 (1H, *s*, $C_{(3)}$—H), 6.30 (1H, *d*, J = 2 Hz, $C_{(6\text{ or }8)}$—H), 6.38 (1H, *d*, J = 2 Hz, $C_{(6\text{ or }8)}$—H), 6.72 (1H, *s*, $C_{(3'\text{ or }5')}$—H). MS: 398.1728 (M − CO_2), 355.1180 (398 − Me − CH_2 − CH_2 −), 341.1033 (355 − CH_2), 327.0867 (341 − CH_2) (base peak), 313.0711 (327 − CH_2). Calc. for $C_{23}H_{26}O_6$(M − CO_2): 398.1786, $C_{20}H_{19}O_6$: 355.1103, $C_{19}H_{17}O_6$: 341.1034, $C_{18}H_{15}O_6$: 327.0852, $C_{17}H_{13}O_6$: 313.0764.

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EIN NEUES SYRINGAALKOHOL-DERIVAT AUS *ERECHTITES HIERACIFOLIA*

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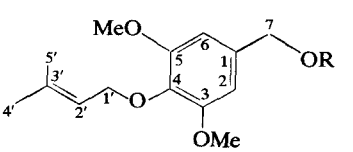
Key Word Index—*Erechtites hieracifolia*; Compositae; new syringyl alcohol derivative.

Aus *E. Hieracifolia* Raf. (Tribus Senecioneae) sind bisher nur Pyrrolizidin-Alkaloide isoliert worden [1], wie sie offenbar für grosse Teile der Tribus Senecioneae charakteristisch sind. Wir haben jetzt die Neutralstoffe näher untersucht. Die Wurzeln enthalten neben β-Farnesen und Bicyclogermacren einen Angelicaester, dem die Konstitution **1** zukommt wie aus den spektroskopischen Daten weitgehend sichergestellt werden kann (s. Tabelle 1). Obwohl biogenetisch die vicinale Anordnung der drei *O*-Funktionen wahrscheinlich war, haben wir diese durch Synthese des entsprechenden Acetats sichergestellt. Durch Alkylierung von Syringaaldehyd (**4**) mit 3,3-Dimethylallylbromid erhält man der Ether **5** und daraus mit Alanat den Alkohol **2**, der mit Acetanhydrid das Acetat **3** liefert. Die ^{1}H-NMR-Daten (s. Tabelle 1) von **3** sind praktisch identisch mit denen von **1**. Lediglich die Lage der CH_2-Gruppe ist wie in ähnlichen Fällen geringfügig verschieden. Bemerkenswert ist eine sehr leicht verlaufende säurekatalysierte Umlagerung von **2**, die zu **6** führt, das ebenfalls als Diacetat (1) isoliert wurde. (^{1}H-NMR-Daten siehe Tabelle 1). Bei der Alanat-Redutkion von **5** ist daher nach Zersetzen mit NH_4Cl Neutralwaschen mit Natriumhydrogencarbonat unerlässlich.



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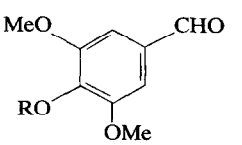
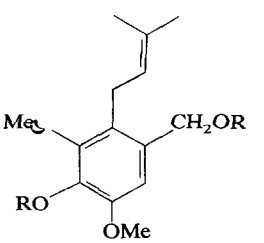
2 R = H
3 R = Ac



4 R = H
5 R = $CH_2CH{=}CMe_2$



6 R = H
7 R = Ac