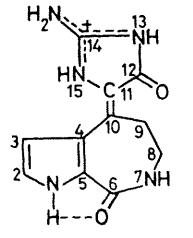
Characterization of a Yellow Compound Isolated from the Marine Sponge *Phakellia flabellata*

By GURDIAL M. SHARMA,* JEFFREY S. BUYER, and MARK W. POMERANTZ
(*New York Ocean Science Laboratory, Montauk, New York* 11954)

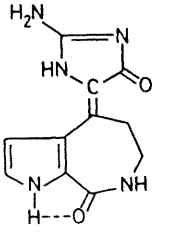
Summary A new yellow compound isolated from the Great Barrier Reef sponge *Phakellia flabellata* is shown to have structure (**1**).

THE Great Barrier Reef sponge *Phakellia flabellata* produces a wide variety of natural products some of which possess antimicrobial activities while others are complex molecules unique to the marine environment.[1] The structures of one class of compounds, called phakellins, isolated from this sponge have been reported in a previous publication.[2] In this communication we describe the characterization of a yellow compound obtained by chromatography of the aqueous extract of the sponge over a Sephadex G-10 column. Although the yellow compound did not turn out to be the antibacterial constituent of the sponge, its elemental composition suggested that this compound and phakellins may have a common biosynthetic progenitor.

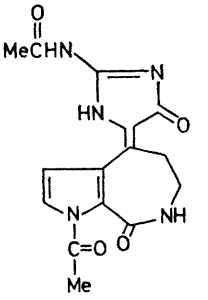
The optically inactive yellow compound is a hydrochloride having molecular formula $C_{11}H_{11}N_5O_2.HCl$, m.p. 230—235 °C (decomp.). Treatment of the yellow compound with sodium carbonate liberated the free base which crystallized from water as a dihydrate, $C_{11}H_{11}N_5O_2.2H_2O$, m.p. 220—225 °C (decomp.). Reaction of the free base with acetic anhydride at 100 °C for 30 min produced the diacetyl derivative, $C_{15}H_{15}N_4O_4$, m.p. 230 °C.



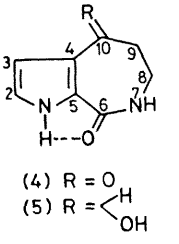
(1)



(2)



(3)



(4) R = O
(5) R =

Potassium permanganate oxidation of the free base in water at room temperature gave guanidine and a new compound having molecular formula $C_8H_8N_2O_2$, m p 275—277 °C. The ^1H and ^{13}C n m r spectra of the C_8 compound† showed that it contained two adjacent ring methylenes, an $\alpha\beta$-disubstituted pyrrole ring, one amide group, and one carbonyl function Its u v spectrum showed three absorption maxima at 298, 247, and 218 nm, assigned to a chromophore consisting of a pyrrole nucleus having carbonyl functions at both the α- and β-positions This interpretation was verified when sodium borohydride reduction of the C_8 compound gave an alcohol, $C_8H_{10}N_2O_2$, m p 166—168 °C, whose u v spectrum [λ_{max} (MeOH) 266 and 218 nm] was typical of pyrroles having a carbonyl function at the α-position [2,3] Based on these data structure (**4**) is assigned to the C_8 compound and it is presumed that its sodium borohydride reduction product will have the structure (**5**).

Except for one oxygen and two carbon atoms, all other atoms present in the molecular formula of the yellow compound are accounted for by the guanidine unit and the structural unit (**4**) The ^1H and ^{13}C n m r spectra of the yellow compound‡ revealed that the remaining atoms are present as a =C–CONH unit in the structure of the natural product; this compound should, therefore, be represented by the formula (**1**) The 11 peaks in the ^{13}C n m r spectrum of the yellow compound were assigned by reference to n m r data for pyrroles, caprolactam, the degradation product (**4**), and creatine [4,5] The shifts (*i e* $\Delta\delta$ values) observed in the resonances upon going from the free base (**2**) to the hydrochloride (**1**)‡ verified the assignments These protonation shifts are in good agreement with those observed in the case of creatine and amiloride [5]

The three absorption maxima at 348 (ϵ 17,400), 260 (9500), and 228 nm (11,700) in the u v spectrum of the yellow compound corroborate conjugation of the pyrrole ring at the α- and β-positions with >CONH– and >C=C–CONH– functions, respectively It is noteworthy that the bands at 348 and 260 nm shift to 365 and 272 nm when the spectrum of the yellow compound is measured in 5% NaOH solution These bands were also found to have shifted to the red in the u v spectrum of the diacetyl derivative (**3**) which showed absorption maxima in MeOH at 376 (ϵ 19,513), 281 (8321), and 235 nm (16,158)

In structure (**1**) there is a possibility of geometrical isomerism at the 10,11 double bond The yellow compound was considered to be the isomer (**1**) because the large downfield shift of 9-methylene protons in the ^1H n m r spectrum of the sponge product may then be attributed to the anistropy of the amide carbonyl at position 12 The 9-methylene protons of (**1**) were found to absorb at δ 3·2, rather than in the region δ 1·2—2 2, the usual range for the allylic protons or the γ-protons of an $\alpha\beta$-unsaturated ketone The pronounced downfield shift of the pyrrole N–H resonance in the ^1H n m r spectra of (**1**), (**2**), (**4**), and (**5**) [δ 11·8—12] is presumed to be due to the intramolecular H-bonding[6] shown in the structural formulae of these molecules

This work was supported by grants from Suffolk and Nassau Counties

(*Received, 3rd January* 1980, *Com* 006)

† ^1H n m r [$(CD_3)_2SO$] δ 2 7 (m, 9-CH_2), 3 4 (m, 8-CH_2), 6 6 (t, 3-H), 7 0 (t, 2-H), 8 1 (br, CONH), and 11 95 (br, pyrrole NH), triplets at δ 6 6 and 7 0 become doublets and signals at δ 8 1 and 11 95 disappear after D_2O addition ^{13}C N m r [$(CD_3)_2SO$] δ 36 52 (C-9), 43 44 (C-8), 103 14 (C-3), 109 45 (C-4), 122 25 (C-5), 123 53 (C-2), 168 18 (C-6), and 194 27 (C-10) p p m

‡ Compound (**1**) ^1H n m r [$(CD_3)_2SO$] δ 3 3 (br s 8-CH_2 and 9-CH_2), 6 6 [t 3-H] 7 2 [t, 2-H] 8 0 (br, CONH), 8 9 [br, 14-NH_2 and N(15)-H], 8-9 [br, N(13)-H], and 11 82 (br, pyrrole NH) triplets at δ 6 6 and 7 2 become doublets and the peaks in the region 8—11 82 disappear after D_2O exchange ^{13}C N m r [$(CD_3)_2SO$] δ 31 2 (C-9), 39 2 (C-8), 109 6 (C-3), 119 9 (C-4), 120 4 (C-11) 123 2 (C-2) 126 8 (C-5), 130 4 (C-10), 155 2 (C-14) 163 3 (C-6), and 164 0 (C-12) p p m Free base (**2**) ^{13}C n m r [$(CD_3)_2SO$] δ 30 07 (C-9) 40 15 (C-8), 111 07 (C-3), 122 73 (C-4), 122 97 (C-2), 126 2 (C-11), 126 39 (C-5), 126 63 (C-10), 159 7 (C-6), 163 99 (C-14), and 171 37 (C-12) p p m

[1] G M Sharma, G F Schem, and A T Pastore, Proceedings of the Drugs and Foods from the Sea Conference, University of Oklahoma Press, 1978, pp 199—202

[2] G M Sharma and M B Fairchild, *J Org Chem*, 1977, **42**, 4118

[3] A I Scott, in 'Interpretation of the Ultraviolet Spectra of Natural Products,' Pergamon–Macmillan, New York, 1964, p 165

[4] G C Levy and G L Nelson, 'Carbon-13 Nuclear Magnetic Resonance for Organic Chemists,' Wiley-Interscience, New York, 1972, p 97, LeR F Johnson and W C Jankowski, in 'Carbon-13 NMR Spectra,' Wiley-Interscience, New York, 1972, spectrum no 185

[5] R L Smith, D W Cochran, P Gund, and E J Crajoe, Jr, *J Am Chem Soc*, 1979, **101**, 191

[6] F A Bovery, in 'Nuclear Magnetic Resonance Spectroscopy,' Academic Press, New York and London, 1969, pp 82—85