

SULFUR AND N-METHYLFORMAMIDE FROM THE MARINE RED ALGA *ERYTHROPHYLLUM DELESSERIOIDES*

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Abstract—Elemental S (0.2% dry wt) and *N*-methylformamide (0.2% dry wt) were isolated from the marine red alga *Erythrophyllum delesserioides*.

Since the late sixties, marine algae have been intensely investigated as a source of bioactive compounds [1,2]. During a general screening for antibiotic and antifungal activity of marine algae from northern California, the lipid-soluble extract of one alga, *Erythrophyllum delesserioides*, (Kallymeniaceae, Cryptonemiales), showed particularly strong activity against the bacteria, *Bacillus subtilis* and *Salmonella typhimurium*, and a fungus, *Cladosporium cucumerinum*. Our interest in this alga also stemmed from field observations concerning its general lack of epibionts.

E. delesserioides, a locally abundant red alga occurring in the littoral and sublittoral zones of the Pacific coast of North America, was collected at Shell Beach, San Luis Obispo County, CA. The air-dried alga (900 g) was ground and Soxhlet extracted successively with hexane and CH_2Cl_2 . Column chromatography of the hexane extract gave a pale yellow crystalline compound (0.2% dry wt) subsequently identified as elemental S (mp, MS). Column chromatography of the CH_2Cl_2 extract yielded a clear viscous oil (0.2% dry wt), which was identified as *N*-methylformamide by comparison (bp, IR, MS, ^1H and ^{13}C NMR) with an authentic sample. The antimicrobial activity of the extract was due entirely to the presence of elemental S. Free S has previously been reported to be the antibiotic component of the organic extract obtained from *Ceramium rubrum* (Ceramiales, Ceramiales) [3]. To our knowledge this is the first report of *N*-methylformamide as a natural product, although it has been reported as a mammalian degradation product of *N,N*-dimethylformamide [4].

EXPERIMENTAL

Isolation of elemental S. *E. delesserioides* was collected at Shell Beach, San Luis Obispo County, CA in July 1976. The air-dried alga (900 g) was ground to 1 mm in a Wiley mill and Soxhlet-extracted with hexane. Removal of the solvent *in vacuo* gave a dark

green oil (5.2 g). Column chromatography (Si gel) of the oil using hexane as the eluent yielded 1.66 g of a pale yellow crystalline compound identified as elemental S.

Isolation of *N*-methylformamide. Soxhlet extraction of the alga with CH_2Cl_2 gave 4.1 g of a crude oil. Chromatography as above using EtOAc as eluant yielded 2 g of a clear oil which was identified as *N*-methylformamide by comparison of its physical and spectral properties with an authentic sample.

Antibiotic assay system [5]. A soln of the extract or S in DMSO (0.1 ml DMSO/mg extract) was added to 5 ml of nutrient agar such that a concn of 2000 ppm was obtained. The agar plates were then streaked with the test organism. Elemental S and the extract completely inhibited the growth of *Bacillus subtilis* and *Salmonella typhimurium*.

Antifungal assay system [6]. About 1 mg of the extract or S was spotted on a precoated (Si gel) TLC plate and the plate developed in CHCl_3 . After evapn of solvent, the plate was sprayed with a thin layer of potato dextrose agar and overlaid with a mist of a H_2O suspension of the spores of the fungus, *Cladosporium cucumerinum*. After 2 days, a zone of inhibition appeared as a white spot on a background of dark spores at R_f 0.6.

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