Our preliminary results for aryl coupling indicate that Ph(*p*-tolyl)Cu(CN)Li$_2$ affords a 1:2:1 ratio of PhPh, *p*-tolylPh, and bis(*p*-tolyl) when treated with *o*-dinitrobenzene. If phenyl cuprates are trimeric in solution, as they are in the solid state,[3b] then either there is no *intra*molecular exchange and only vicinal coupling or else there is *inter*molecular exchange.

The necessity for a cluster in the case of BuPeCuLi is confirmed by experiments in which 1 and 2 equiv of 12-crown-4 were included in the reaction mixtures. While 1 equiv had a negligible effect, 2 equiv afforded significantly less coupling. Our interpretation is that the first equivalent complexes Li$^+$ (either the counterion for a halide or for an anionic cluster[3b]), and the second equivalent disrupts the cuprate cluster by excising Li from it to yield monomeric cuprates, as characterized by Power.[9]

The exact nature of the involvement of CN in the cyanocuprate clusters is still open to debate. We observe only small amounts (~1%) of BuCN or PeCN in the oxidation of "BuPeCu(CN)Li$_2$" with *o*-dinitrobenzene. This does not preclude the presence of CN ligands in the clusters, since it might be expected that the CN would be bound more tightly to the metal cluster core than alkyl groups owing to the participation of the CN π (including π^*) orbitals.

In summary, the oxidation of organocuprates with nitroarenes such as nitrobenzene and the dinitrobenzenes can be used as a probe of organocuprate structure and, in favorable cases, can give useful yields of cross-coupled products. Using this new structure probe, it has been determined that dialkyl cyanocuprates such as BuPeCu(CN)Li$_2$ (and by implication Bu$_2$Cu(CN)Li$_2$ and Pe$_2$Cu(CN)Li$_2$) are dimeric in THF solution[10] and that they differ significantly in their structures or ligand exchange rates (or both) from the corresponding cuprates prepared from CuI.

Supplementary Material Available: Table of predicted product distributions from oxidation of various cuprate structures (1 page). Ordering information is given on any current masthead page.

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[9] Hope, H.; Olmstead, M. M.; Power, P. P.; Sandell, J.; Xu, X. *J. Am. Chem. Soc.* **1985**, *107*, 4337.

[10] Vapor pressure depression experiments (cf. ref 3a) have failed in this case (Lipshutz, B. H., personal communication).

Imbricatine, an Unusual Benzyltetrahydroisoquinoline Alkaloid Isolated from the Starfish *Dermasterias imbricata*

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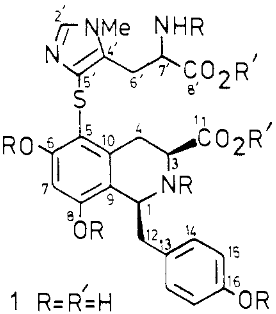
Sea anemones are common sessile marine invertebrates that normally respond to tactile stimulation by contracting and covering their oral disc with a portion of their body column. Biologists long ago discovered that a northeastern Pacific anemone, *Stomphia coccinea*, responds to contact with the starfish *Dermasterias imbricata* in a "striking and extraordinary manner: the anemone releases its basal disc from the substratum, and then propels itself through the water by means of a series of whip like motions".[1] It was subsequently shown that a single chemical substance was responsible for eliciting the "swimming" response.[1,2]

Table I. ^{1}H NMR Assignments

carbon	1^a	3^a	4
1	4.67 (dd, 8.4, 4.5)	4.57 (dd, 8, 4)	
3	3.76 (dd, 12.5, 5)	3.20 (dd, 12, 4)	
4	4.03 (dd, 16, 5)	2.90 (dd, 16, 4)	
	2.71 (dd, 12.5, 16)	2.71 (dd, 12, 16)	
5		6.08 (d, 2)	
7	6.42 (s)	6.22 (d, 2)	
12	3.22 (dd, 13.9, 4.5)	3.12 (dd, 14, 4)	
	2.85 (dd, 13.9, 8.4)	2.80 (dd, 14, 8)	
14	7.04 (d, 8)	7.01 (d, 8)	
15	6.71 (d, 8)	6.70 (d, 8)	
2′	7.73 (s): 8.73 (s)^b		8.95 (s)^b
6′	3.30 (dd, 15, 9)		3.44 (d, 7.5, 2 H)^b
	3.02 (dd, 15, 5): 3.34 (d, 8, 2 H)^b		
7′	3.60 (dd, 5, 9): 4.31 (t, 8)^b		4.29 (t, 7.5)^b
9′	3.66 (s): 3.87 (s)^b		3.94 (s)^b

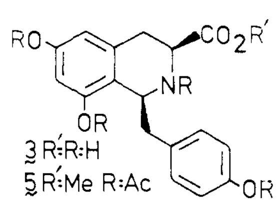
^{a}Spectra run in MeSO-d_6. ^{b}Chemical shifts in D$_2$O.

We now wish to report the structure of imbricatine (**1**), a novel benzyltetrahydroisoquinoline alkaloid that is capable of inducing *S. coccinea* "swimming" behavior at very low concentrations.[3] Imbricatine also displays significant activity in the L1210 (ED$_{50}$ < 1 μg/mL)[4a] and P388 (T/C 139 at 0.5 mg/kg) antineoplastic assays.[4b]



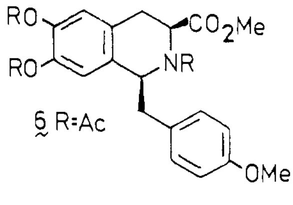
1 R=R′=H

2 R=Ac R′=Me

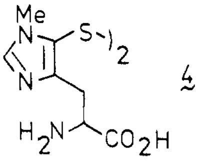


3 R′=R=H

5 R′=Me R=Ac



6 R=Ac



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A bioassay-guided fractionation of the methanol extract of *D. imbricata*, making use of XAD-4, Biogel P2 (1% HOAc/H$_2$O), and Sephadex LH 20 (80% MeOH/H$_2$O) chromatographies, gave pure imbricatine (6–7 mg/animal) as a water-soluble, white amorphous solid.[2b] The molecular formula of imbricatine, C$_{24}$H$_{26}$N$_4$O$_7$S, was determined from the mass spectra of the parent compound (FABMS M$^+$ + H 515) and the dimethylpentaacetyl derivative **2** (FABMS M$^+$ + H 753; HREIMS M$^+$ − OAcbenzyl, obsd 603.1756, required for C$_{27}$H$_{31}$N$_4$O$_{10}$S 603.1761) prepared from **1** by esterification (MeOH/HCl) and acetylation (Ac$_2$O/pyridine).

An *N*-methyl-5-thiohistidine fragment in **1** could be identified by comparing ^{1}H and ^{13}C NMR resonances in the spectrum of imbricatine to the values reported for the symmetrical disulfide **4** (Tables I and II) isolated from echinoderm eggs.[5] Reduction of imbricatine (**1**) with Ra-Ni (MeOH/reflux, 3 h) cleaved the thioether to give the tetrahydroisoquinoline **3** and methylhistidine which was shown to be identical with 3-methylhistidine and

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[1] (a) Ward, J. A. *J. Exp. Zool.* **1965**, *158*, 357. (b) Ross, D. M.; Sutton, L. *J. Exp. Biol.* **1964**, *41*, 751.

[2] (a) Ayer, W. A.; Ross, D. University of Alberta, personal communication, 1982. (b) Singer, P. Ph.D. Thesis, Chemistry Department, University of Alberta, 1975.

[3] The "swimming" behavior is very difficult to quantify; however, application of one to two drops of a 1 mg/mL solution of **1** in seawater to the tentacles of a partially submerged *S. coccinea* consistently elicits the response.

[4] Carried out by (a) Allen, T. Department of Pharmacology, University of Alberta and (b) Bristol Myers Ltd.

[5] Palumbo, A.; Misuraca, G.; D'Ischia, M.; Donaudy, F.; Prota, G. *Comp. Biochem. Physiol. B*: *Comp. Biochem.* **1984**, *78B*, 81.

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Table II. ^{13}C NMR Assignments

carbon	1^a	3^a	4^b
1	52.9	53.0	
3	54.9	55.5	
4	27.2	30.0	
5	110.0	106.0	
6	159.7	157.0	
7	104.0	100.9	
8	155.8	154.7	
9	112.7	110.8	
10	137.7	136.0	
11	169.7	169.2	
12	37.3	37.8	
13	126.5	126.9	
14	130.5	130.2	
15	115.3	115.0	
16	156.4	156.0	
2′	137.8		141.1
4′	126.8		130.0
5′	131.1		134.8
6′	25.1		25.5
7′	52.3		54.5
8′	170.5		173.3
9′	32.3		34.0

^{a}Spectra run in Me$_2$SO-d_6. ^{b}Spectra run in D$_2$O.

different from 1-methylhistidine by TLC comparison. The CI mass spectrum of **3** showed a parent ion at m/z 316 daltons (M$^+$ + H) and fragment ions at 270 (M$^+$ - CO$_2$H), 242 (M$^+$ - NH═CHCO$_2$H via retro Dields-Alder), 208 (M$^+$ - OHbenzyl), and 164 (M$^+$ - (OHbenzyl + CO$_2$)) daltons typical of benzyltetrahydroisoquinolines.[6] ^{1}H NMR resonances at 6.70 (d, J = 8 Hz, 2 H) and 7.01 (d, J = 8 Hz, 2 H) required that the benzyl residue in **3** contain a para hydroxyl substituent. Additional ^{1}H NMR resonances at 6.08 (d, J = 2 Hz) and 6.22 (d, J = 2 Hz) in the spectrum of **3** were assigned to meta protons on the aromatic ring of the isoquinoline moiety, requiring that the two hydroxyl substituents on this ring also be meta disposed. Imbricatine (**1**) has only a single proton on the isoquinoline aromatic ring (6.42 ppm, s). the other nonphenolic position being occupied by the thioether linkage.

Model compound **6** and its trans isomer were prepared according to literature procedures.[7] Comparison of the ^{1}H NMR spectra of the model compounds (**6**: (CDCl$_3$) 1.87 (s, CH$_3$CON); 2.88 (dd, J = 14, 8 Hz, H12); 3.21 (m, H4a and H4e); 3.28 (dd, J = 14, 6 *Hz*, H12′); 4.49 (t, J = 10 Hz, H3a); 4.73 (dd, J = 8, 6 Hz, H1a)) to that of derivative **5** ((CDCl$_3$) 1.80 (s, C*H$_3$*CON); 2.88 (dd, J = 14, 8 Hz, H12); 3.24 (m, H4a and H4e); 3.30 (dd, J = 14, 6 Hz, H12′); 4.48 (t, J = 10 Hz, H3a); 5.04 (dd, J = 8, 6 Hz, H1a)) confirmed the benzyltetrahydroisoquinoline nature of **3** and indicated that the C1 and C3 substituents were cis as shown.

The H4e and H3a resonances are both strongly deshielded in imbricatine (**1**) relative to the resonances for the corresponding protons in the Ra-Ni reduction product **3** (Table I). The difference in chemical shifts observed for these two protons in **1** and **3** can best be explained if the thioether linkage in imbricatine is attached to C5 of the isoquinoline nucleus, which in turn requires that there be a proton meta to it at C7 and hydroxyl substituents at C6 and C8. A pair of INAPT experiments,[8] one of which showed three bond couplings between H1 and carbons 8 and 10, and another which showed two and three bond couplings between H7 and carbons 5, 6, 8, and 9 of imbricatine (**1**), confirmed this assignment.

Imbricatine (**1**) represents the first example of a benzyltetrahydroisoquinoline alkaloid from a marine organism, and it is apparently the first example from a nonplant source. The C3 carboxyl substituent, the C6/C8 hydroxylation pattern, and the thioether linkage to a histidine substituent represent structural features not previously encountered in this family of alkaloids.

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Alloy Clusters: The Encapsulation of Transition Metals (Mn, Fe, Co, Ni) within Cluster Halides of Zirconium and the Rare-Earth Metals

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We have recently reported that numerous zirconium analogues of the long-known (Nb,Ta)$_6$X$_{12}{}^{n+}$ clusters (X = Cl, Br, and some I, n = 2, 3, 4)[1,2] may be stabilized by the inclusion of an interstitial atom Be, B, C, N, Al, Si, or P, the last three only in iodides so far.[3-6] The interstitial atom Z contributes both additional electrons and strong Zr–Z bonds. Similar strategies have allowed the synthesis of different scandium and lanthanide cluster phases[7,8] and condensed cluster compounds[8-10] but only with Z = B, C, C$_2$, or N.[11] To this profusion there is now even more; we here report the synthesis and structural classification of a wide variety of remarkable rare-earth-metal and zirconium cluster compounds (Table I) in which a 3d transition metal (Mn, Fe, Co, or Ni so far) is ensconced. The zirconium phases were made by allowing stoichiometric proportions of MI$_2$, ZrI$_4$, Zr powder (or excess Zr strips), and CsI where appropriate to react in sealed Ta tubing between 700 and 925 °C for 2–4 weeks. The rare-earth-metal compounds were similarly obtained using MI$_3$, M = Sc, Y, Pr, Gd, and a 20% excess of the appropriate metal (as strips). The black microcrystalline powders or blue-black gemlike crystals are usually obtained as single-phase products (>95% yield) as judged by Guinier powder diffraction. This technique also shows that the phases occur in the same structure types as reported earlier for analogous phases stabilized by interstitial carbon, etc.[3,4,8,9] Single-crystal X-ray structure determinations have also been performed on Cs$_{0.63}$Zr$_6$I$_{14}$Fe, CsZr$_6$I$_{14}$Mn, and Sc$_7$I$_{12}$Co.

The principal structural points of interest involve the bonding within the clusters. The Zr$_6$ cluster in Cs$_{0.63}$Zr$_6$I$_{14}$Fe is expanded to give a mean Zr–Zr distance of 3.51 Å while the average Sc–Sc distance in Sc$_7$I$_{12}$Co is 3.44 Å. These distances are to be compared with 3.28 and 3.26 Å in the corresponding iodide carbides. Relatively short Zr–Fe and Sc–Co distances of 2.48 and 2.43 Å, respectively, are also found. In the series of M$_6$X$_{12}$Z-type cluster compounds, these new examples are near the terminus where

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