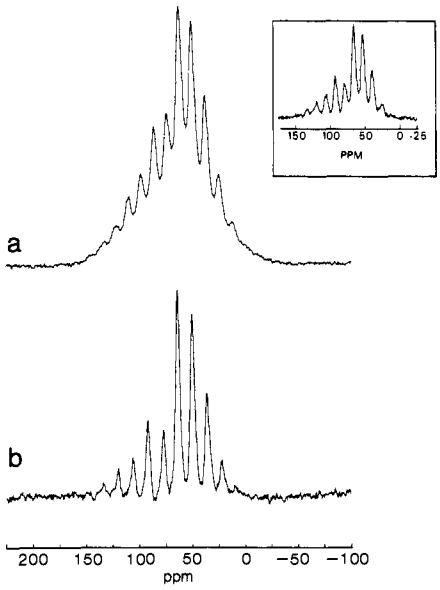

Figure 3. ^{19}F MAS-NMR spectra at 282.3 MHz of hydroxyapatite exposed to fluoride, aged 14 (a) and 10 (b) months after preparation: (a) 155.3 mM (2950 ppm) final fluoride concentration, total fluoride uptake = 2.2%, spinning rate = 3.80 kHz, 45° pulses at 1-s intervals; Insert shows spectrum of same sample obtained using Hahn spin–echo (90_x–263 μs–180_y–263 μs–acquire), 90° pulse = 3.2 μs; the delay time must be set to an integral multiple of the sample rotation period to obtain a good spectrum.[24] (b) 9.7 mM (184 ppm) final fluoride concentration, total fluoride uptake = 0.68%, spinning rate = 3.84 kHz, 45° pulses at 1-s intervals. Center peak of fluoroapatite component in both samples is at 63.3 ppm.

probably due to diffusion of the ions over the surface of the crystallites, rather than to any bulk-phase transformation.

The effect of the aqueous fluoride concentration on samples aged for many months after isolation is shown in Figure 3, a and b. The ^{19}F MAS-NMR spectrum of the lower concentration sample (Figure 3b) shows the presence of only fluoroapatite (cf. Figure 1b). In marked contrast, the sample exposed to the higher fluoride concentration exhibits sharp peaks characteristic of apatitic fluoride superimposed upon a broad peak (Figure 3a). We assign the broad component to calcium fluoride on the basis of its chemical shift position and large line width. Furthermore, calcium fluoride is the only non-apatitic form of fluoride that is known to form at higher fluoride concentrations.[2,4,5,9]

Identification and quantitation of the apatitic component in a spectrum such as that in Figure 3a is hindered by the substantial broad peak arising from calcium fluoride. It is possible to eliminate the calcium fluoride signal from the spectrum by taking advantage of the fact that the spin–spin relaxation time T_2 of calcium fluoride is 2 orders of magnitude smaller than that of fluoroapatite.[11] The insert in Figure 3a shows a ^{19}F MAS-NMR spectrum of the same sample obtained by using a Hahn spin–echo pulse sequence.[20] All of the signal from calcium fluoride has decayed, leaving only the signal from the apatitic component, whose chemical shift and sideband intensities are indicative of fluoroapatite. The use of the Hahn spin–echo enables one to obtain good spectra of the apatitic component alone in these surface samples, and should make possible more accurate quantitation of the relative amounts of calcium fluoride and fluoroapatite. These data provide spectroscopic evidence for the onset of calcium fluoride formation at high concentrations[2,4,5,9] and reveal as well that fluoroapatite coexists with the calcium fluoride. It is significant that an apatitic form of fluoride has been detected in all of the numerous samples we have investigated. This observation suggests that the surface fluoride ion occupies its normal position in the apatitic lattice[16] and is surrounded by a triangle of three calcium atoms as in the bulk solid. No evidence for a second site of incorporation has been seen.

In summary, high-field ^{19}F MAS-NMR is a powerful method for investigating the fluoridated surface of hydroxyapatite. It selectively probes *only* the fluoride environment and quantitatively detects *all* the fluoride present, whether crystalline, amorphous, or adsorbed.[21] The spectral appearance is very sensitive to the form of fluoride, and many NMR parameters can be used to characterize the samples. Low levels of fluoride (<0.1%) can be detected, making possible the study of biological calcified tissue. Applications to the study of fluoride in other minerals, either on surfaces or in the bulk, should also prove very fruitful.

Acknowledgment. We thank Rex Wolfgang and Robert Faller for invaluable technical assistance.

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(21) Integration of the fluoride signal obtained under nonsaturating conditions yields fluoride concentrations in agreement with those determined from chemical analysis.

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Thioether Trans-Cross-Linking Reaction of Phalloidin[1]

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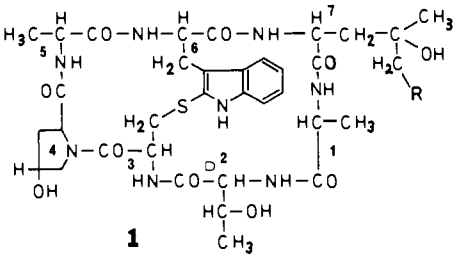
Phalloidin (**1a**), one of the toxic components of the poisonous



1

1a, R = OH
1b, R = OTos

fungus *Amanita phalloides*,[3] is a *bicyclic* heptapeptide cross-linked by a sulfur atom between the 2-position of the indole ring of a tryptophan and the methylene of a cysteine residue.[4] Its positive helicity of the (inherently) unsymmetric thioether chromophore gives rise to the positive Cotton effects (around 240 and 300 nm, Figure 1) in the CD spectrum.[5]

The likewise toxic virotoxins from *Amanita virosa* are *monocyclic* heptapeptides containing a methylsulfonyl group instead of the thioether cross-link.[6] Attempts were made to transform **1a** to viroidin by cleaving this bridge. However, methylation of the sulfur and β-elimination of the desired methylsulfonium ion failed. Hence, it was intriguing to find an intramolecular alkylation of the thioehter as the first step of a trans cross-linking in the bicyclic system.

(1) Dedicated to Dr. Ulrich Weiss, National Institutes of Health, Bethesda, MD, on the occasion of his 75th birthday.
(2) Miura, Tamiko, visiting student, 1980–1981. Present address: Science University of Tokyo, Department of Chemistry, Kagurazaka, Shinyuku-ku Tokyo, Japan.

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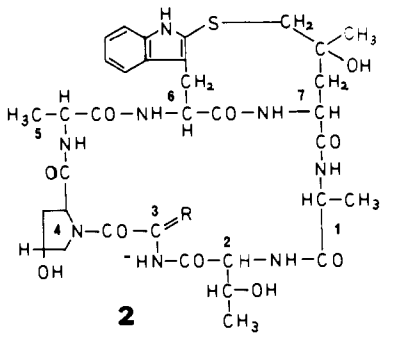
Table I. Chemical Shifts (ppm; $Me_4Si = 0$) of the Proton Signals of Phalloidin (1a) and Product 2a in Me_2SO-d_6 (Aromatic Protons Are Omitted)

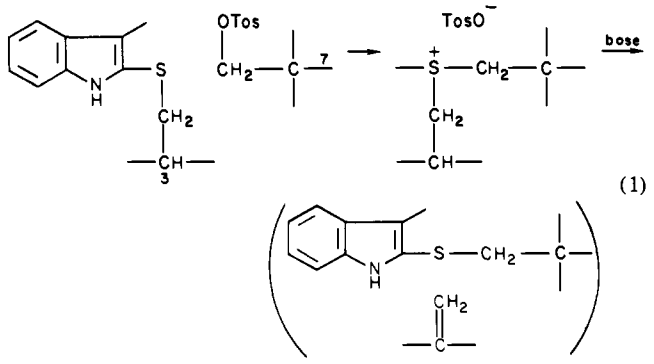
Aa	N-H	α-H	β-H	γ-H	δ-H	CH_3	OH
Ala-1 1a	7.48	4.51				1.22	
2a	7.87	4.33				1.23	
Thr-2 1a	8.34	3.98				1.08	4.58
2a	7.60	4.43				0.98	4.82
Aa-3 1a	7.64	4.74	3.54, ~3.50				
2a	9.80		5.12, 4.80				
Hyp-4 1a		4.15	2.31, 1.85	4.35	3.77, 3.54		5.39
2a		4.39	2.22, 2.03	4.26	3.63, 3.31		4.98
Ala-5 1a	7.62	3.92				0.79	
2a	7.72	4.59				1.26	
Trp-6 1a	7.23	4.74	3.40, ~3.20				
2a	8.75	3.77	3.25, 3.02				
Aa-7 1a	8.18	4.04	1.76, 1.81		~3.3 (2 H)	1.03	4.46, 4.48
2a	8.43	3.93	2.76, 1.91		3.34, 2.43	1.15	4.81

The primary δ-hydroxyl group of **1a** can be tosylated.[7] $O^{7\delta}$-Tosylphalloidin (**1b**), which exhibits identical positive Cotton effects as **1a**, is transformed on exposure for several hours to strong bases to a new compound, which has a greater R_f and shows the blue reaction with cinnamaldehyde/HCl characteristic of 2-indolyl thioethers.[8] If methoxide ions are employed as a base an additional product is formed in a minor amount, which has an even greater R_f than the main product and also gives a positive blue reaction. The products were separated by repeated chromatography on Sephadex LH-20 in methanol. They differ from **1a** by their (identical) CD spectra, which in the long wave length range appear like slighly shifted mirror images of the positive spectra of **1a** and **1b** (Figure 1). This points to an inversion of the helicity of the thioether chromophore in **2a** and **2b** from positive (**1a** and **1b**) to negative (**2a** and **2b**). We ascribe structure **2a** to the main product of transformation of **1b** by bases. Intramolecular alkylation of the sulfur by the tosylate and subsequent β-elimination of the sulfonium ion would generate **2a**, the first step being a trans cross-linking of the original thioether (eq 1).



2

2a, R = CH_2
2b, R = CH_3 + OCH_3
2c, R = $CH_2SCH_2CH(NH_2)CO_2H$ + H
2d, R = $CH_2SCH_2CH_2NH_2$ + H



(1)

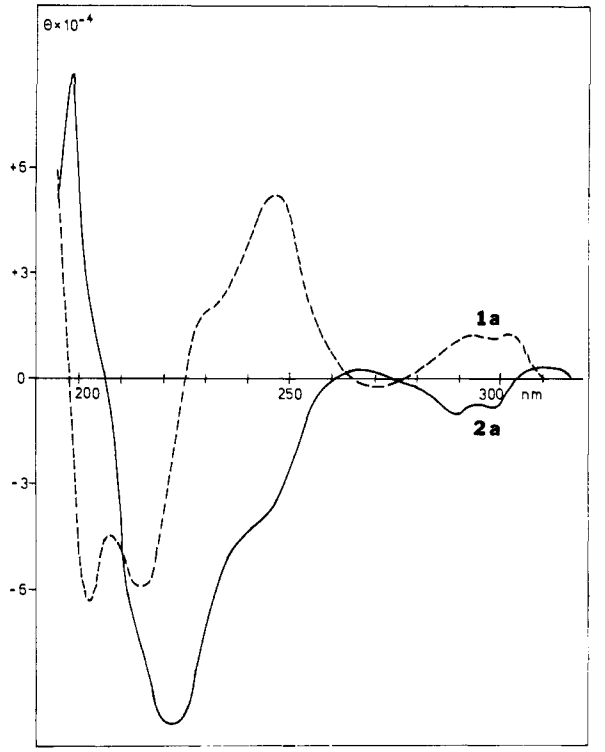


Figure 1. Circular dichroism spectra in methanol of phalloidin (1a) and the rearrangement product **2a** of tosylate **1b**.

The byproduct formed by methoxide in methanol could then arise from addition of methanol to the exo double bond in position 3 of **2a**. Proof of these suggestions has been given (I) by (FAB) mass spectrometry, (II) by NMR studies, and (III) by chemical evidence.

(I) Mass Spectrometry. The mass spectrogram (FAB) of **2a** shows exclusively the base peak m/z 771 (770 + H^+), which arises after TosOH elimination of **1b**. In the mass spectrum of **2b** two prominent peaks are visible, the base peak with m/z 803 (equivalent to 771 + CH_3OH) and the other one with m/z 771.

(II) Proton NMR Studies (360 MHz, Me_2SO-d_6). As Table I shows in the spectrum of **2a** the signals of almost all the protons of phalloidin (**1a**) are present except those of C-α of cysteine 3 and of the OH group in the amino acid no. 7 (Aa-7). The main difference is the downfield shift of the C-β protons in **2a** compared to those in **1a**; this indicates an olefinic system ($J < 0.5$ Hz). A geminal arrangement of these protons has been proved by NOE measurements.

(III) Chemical Evidence. The main product, **2a**, gives a positive blue reaction with cinnamaldehyde/HCl for 2-indolyl thioethers. It does not give a positive ninhydrin reaction, i.e., it is most probably a cyclic peptide.

As a proof of the proposed dehydroalanine side chain in position 3, **2a** reacts with cysteine or cysteamine at room temperature

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yielding two products (**1c** and **1d**). These derivatives give a positive ninhydrin reaction and with cinnamaldehyde/HCl, blue products. On hydrolysis **1c** and **1d** yield, among the known amino acids, lanthionine and *S*-(β-aminoethyl)cysteine (thialysine), respectively, as identified by TLC.

On standing in a methanolic solution of $NaOCH_3$ (8-fold excess) at room temperature for 5–10 h **2a** is converted into **2b** and several minor products. The addition of methoxide to the α-carbon atom of Aa-3 is proved unambiguously by H NMR spectrometry: while almost all proton signals of **2b** coincide with those of **2a** (Table I), the singlets from the β-protons of Aa-3 at 4.80 and 5.12 ppm (olefinic protons) are missing. Instead, two new methyl singlets appear at 1.47 (CCH_3) and 3.16 OCH_3).

Three-dimensional models of the suggested structure **2** can be built without strain. They exhibit negative helicity of the thioether moiety in accordance with the negative Cotton effects in CD spectra as shown in Figure 1.[9]

Acknowledgment. We are indebted to Prof. W. König, Universität Hamburg, for the FAB mass spectra and to Prof. J. Dabrowski, Abteilung Organische Chemie of this institute, for providing high-resolution NMR data of phalloidin. The study was supported by the Deutsche Forschungsgemeinschaft.

(9) Compound **2a**, accordingly, is cyclic(L-alanyl-D-threonyldehydroalanyl-*cis*-4-hydroxy-L-propyl-L-alanyl-2-mercapto-L-tryptophyl-4-hydroxy-5-mercapto-L-leucyl) cyclic(6–7)-sulfide. The name of **2b** is cyclic(L-alanyl-D-threonyl-2-methoxyalanyl-*cis*-4-hydroxy-L-prolyl-L-alanyl-2-mercapto-L-tryptophyl-4-hydroxy-5-mercapto-L-leucyl) cyclic(6–7)-sulfide.

Additions and Corrections

Elimination Reactions of *N*-(2-*p*-Nitrophenyl)ethyl)alkylammonium Ions by an E1cB Mechanism [*J. Am. Chem. Soc.* **1983**, *105*, 265–279]. JAMES R. KEEFFE* and WILLIAM P. JENCKS

Page 275, Table VII: The value of $10^3k_{OH^-}$ for 1,2-dibromo-1-(*p*-nitrophenyl)ethane should be 385 M^{-1} s^{-1}.

Boronic Ester Homologation with 99% Chiral Selectivity and Its Use in Syntheses of the Insect Pheromones (3*S*,4*S*)-4-Methyl-3-heptanol and *exo*-Brevicomin [*J. Am. Chem. Soc.* **1983**, *105*, 2077–2078]. DONALD S. MATTESON* and KIZHAKETHIL M. SADHU

Page 2077: To identify the compounds, Scheme I should have the following legend:

R: a, Pr; b,  ; c, Me; d, Bu; e, *i*-Bu; f, $PhCH_2$

R': a, Me; b, Et

Double Isotope Fractionation: Test for Concertedness and for Transition State Dominance [*J. Am. Chem. Soc.* **1983**, *105*, 2475]. JOEL G. BELASCO, W. JOHN ALBERY, and JEREMY R. KNOWLES*

Page 2476, eq 1 should read:

$$\xi = \frac{(\phi'_{1,2})_{H''}}{(\phi'_{1,2})_{D''}} - 1 = \frac{(\phi''_1 - \phi''_2)(\phi'_1 - \phi'_2)}{(\kappa^{-1}\phi''_2 + \phi''_1)(\phi'_2 + \kappa\phi'_1)}$$

Detection of Free Radicals from Low-Temperature Ozone–Olefin Reactions by ESR Spin Trapping: Evidence That the Radical Precursor Is a Trioxide [*J. Am. Chem. Soc.* **1983**, *105*, 2883]. WILLIAM A. PRYOR,* DONALD G. PRIER, and DANIEL F. CHURCH

Page 2888: Footnote 29a omitted the numerical value for the heat of homolysis. The second line of this footnote should read: ...split to give ROO· and HO· by 10 kcal/mol....

*Book Reviews**

The Theory of Vibrational Spectroscopy and its Application to Polymeric Materials. By Paul C. Painter and Michael M. Coleman (Pennsylvania State University) and Jack L. Koenig (Case Western Reserve University). John Wiley & Sons, New York. 1982. XVII + 530 pp. $60.00.

This book is both unusually honest in its definition of scope and clear in its presentation of material. It sets out to do nothing more or less than provide the reader with a concise, systematic exposition of the application of elementary vibrational spectroscopy theory to the determination of polymer structures. As the authors point out in their Preface and Chapter 1, several classic monographs are available which treat the fundamentals of nuclear vibrations in "ordinary" (monomeric) molecules. But, in spite of the extensive series of research articles and review papers by Krimm, Schactschneider, Snyder, Zerbi, and others, there is as yet no single book where the infrared spectroscopy of polymers is treated "from beginning to end". Painter, Coleman, and Koenig do so in the present text with a commendable degree of modesty, simplicity and thoroughness.

Chapters 1 through 9 present the standard theory of: internal vs. symmetry coordinates; group theory techniques; molecular force field representations; computer methods for solving secular equations; and infrared and Raman intensities. While all of these topics are discussed in many already-published texts, their present exposition is especially well-written and provides a self-contained introduction to the rest of the book. In Chapters 10 through 12 the reader is treated to a brief but comprehensive discussion of lattice dynamics and symmetry analysis of infinite (extended) systems, topics which are usually only found scattered throughout solid state physics monographs. Then, in Chapters 13 through 15, the authors "get down to business" and outline in detail the vibrational analysis of polymer crystals (mostly polyethylene) taking into account the following successively: intrachain force fields, interchain interactions, defects, chain-end effects, and local modes. Finally, no fewer than the last 150 pages of the book are devoted to exposing the nitty-gritty details of the infrared spectroscopy/molecular structure of important selected examples (polyolefins, haloethylenes, polydienes and alkenylenes, polymers containing aromatic rings, and polyamides, peptides, and proteins).

William M. Gelbart, *University of California, Los Angeles*

The Gamma Rays of the Radionuclides. By Gerhard Erdtmann and Werner Soyka (Nuclear Research Establishment Julich). Verlag Chemie, Weinheim. 1979. xv + 862 pp. $160.00.

The subtitle of this volume, "Tables for Applied Gamma Ray Spectroscopy", implies the audience to which it is intended. The book, the seventh in the series "Topical Presentations in Nuclear Chemistry", is an expanded (by 50%) and up-dated version of tables issued in 1973

*Unsigned bood reviews are by the Book Review Editor.