iron removal[18-21] and the strength of anion binding to transferrin raise this question. In addition, the unusual property of positive cooperativity exhibited in both anion binding and proton dissociation by transferrin poses new questions about this important protein. Further studies are clearly indicated to fully understand the role that anions play in the structure of transferrin, in the thermodynamics of iron binding, and in the mechanism of iron removal.

Acknowledgment. This research was supported by the National Institutes of Health Grant GM 20194 and Grant CHE-7908399 from the National Science Foundation for purchase of the Cary 219 spectrometer. We thank L. P. Rosenberg for interfacing the computer to the EPR spectrometer and for developing the software used in this study, David K. Ryan for assistance in the nonlinear regression analysis, and Dr. W. Rudolf Seitz for helpful discussions.

Registry No. ATP, 56-65-5; AMP, 61-19-8; SCN^-, 302-04-5; ClO_4^-, 14797-73-0; $HP_2O_7^{3-}$, 42499-21-8; Cl^-, 16887-00-6; BF_4^-, 14874-70-5; HPO_4^{2-}, 14066-19-4; F^-, 16984-48-8; SO_4^{2-}, 14808-79-8; HCO_3^-, 71-52-3; Fe, 7439-89-6.

Communications to the Editor

Effects of Wavelength on the Photochemistry of Provitamin D_3[1]

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Received April 12, 1982

Wavelength effects in solution photochemistry can arise from excited-state or ground-state properties.[2] This variant has been studied in the photochemistry of polyenes, and it generally has been found that wavelength-dependent photochemistry arises from a variety of ground-state effects such as a secondary reaction of the primary photoproduct,[3] independent excitation of conformational[4-10] and structural isomers,[11] and excitation of ground-state complexes.[12,13] However, it has been suggested that wavelength dependencies may also result from the involvement of higher excited states or from the involvement of activation barriers in a single excited state. These latter processes permit new vibrational modes for relaxation into new minima on the excited state hypersurfaces.[8,14-16]

Scheme I

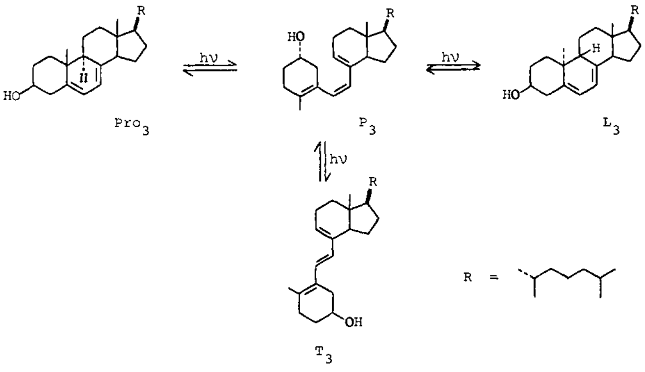

Table I. Relative Quasi-photostationary State Concentrations

λ, nm	Pro_3	P_3	L_3	T_3
295.0	2.0	71	4.0	23
297.5	3.0	70	6.0	21
300.0	5.0	68	8.0	19
302.5	8.0	65	13.0	14
305.0	15.0	50	25.0	10

A detailed study using light of different wavelengths (225–400 nm) for the formation of "potential vitamin D_2" found that 295-nm light was the most effective.[17] More recently, wavelength effects upon the four components in the previtamin D_3 (P_3) photostationary state (Scheme I) have been reported for two wavelengths (254.0 and 302.5 nm)[18] and it was concluded that "it is not yet possible to quantitatively assess the separate contributions of the ground-state and the excited-state properties to the wavelength effects observed". We report results that clearly indicate that excited-state properties are involved in the wavelength effects found in the transformation of P_3 to Pro_3 and L_3.

As an extension of an earlier investigation into the effect of incident irradiation wavelength on the formation of previtamin D_3 (P_3) from 7-dehydrocholesterol (Pro_3),[19] a 1.15×10^{-4} M solution of Pro_3 in anhydrous ether at 0 °C was irradiated with a Chromatix CMX-4 coaxial flash-lamp pumped dye laser.[20] In

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[1] This investigation was supported by PHS Grant 00709, National Institute of Arthritis, Diabetes and Digestive and Kidney Diseases. The laser study was partially supported by the National Science Foundation Grant CHE 78-6484.

[2] For an excellent review of wavelength effects on organic photoreactions in solution, see: Turro, N. J.; Ramamurthy, V.; Cherry, W.; Farneth, W. *Chem. Rev.* **1978**, *78*, 125.

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[18] Jacobs, H. J. C.; Gielen, J. W. J.; Havinga, E. *Tetrahedron Lett.* **1981**, 4013. The conclusion that the quantum yields for the ring-opening reactions are wavelength independent is based upon the findings at 254 and 302.5 nm; however, the conclusion appears to be sound based upon conformational concepts.

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[20] The laser power at each wavelength was as follows: 295 nm, 3.5 mW; 297.5 nm, 4.0 mW; 300 nm, 4.0 mW; 302.5 nm, 3 mW; 305 nm, 5 mW.

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Table II. Ratio of Quantum Yields at Various Wavelengths

λ, nm	$\Phi(P_3 \rightarrow Pro_3)/\Phi(Pro_3 \rightarrow P_3)$	$\Phi(P_3 \rightarrow L_3)/\Phi(L_3 \rightarrow P_3)$	$\Phi(P_3 \rightarrow T_3)/\Phi(T_3 \rightarrow P_3)$
295.0	0.11	0.12	3.86
297.5	0.12	0.16	3.79
300.0	0.11	0.17	3.28
302.5	0.11	0.19	2.43
305.0	0.22	0.32	2.65

Table III. Calculated Quantum Yields

λ, nm	$\Phi(P_3 \rightarrow Pro_3)$	$\Phi(P_3 \rightarrow L_3)$	$\Phi(P_3 \rightarrow T_3)$
254	$(0.014)^a$	$(0.04)^a$	$(0.41)^a$
295.0	0.04	0.06	0.43
297.5	0.04	0.06	0.42
300.0	0.04	0.08	0.36
302.5	$0.04\ (0.02)^a$	$0.09\ (0.09)^a$	$0.27\ (0.29)^a$
305.0	0.08	0.18	0.29

[a] Experimental value; see ref 23, p 27.

view of the reported finding of 295 nm as the most effective wavelength, our attention was focused in the 295–305 nm region. Each irradiation was carried out to the establishment of the quasi-photostationary state consisting of Pro_3, P_3, L_3, and T_3. The results are given in Table I.[21]

The ratio of the quantum yields for the various interconversions, after correction for the molar extinction coefficients at the various wavelengths,[22] are given in Table II. A more quantitative evaluation, given in Table III,[24] for the actual changes in the individual quantum yields of P_3 to Pro_3 and P_3 to L_3 can be obtained by using the conclusion of the Leiden group[18] that the quantum yields for the ring-opening reactions, Pro_3 to P_3 and L_3 to P_3, do not exhibit any wavelength effects. Furthermore, the reported quantum yields for the conversion of P_3 to T_3 at 254 and 302.5 nm,[23] when taken in conjunction with our experimental determination of the quantum yield ratios, indicate that the quantum yield for T_3 to P_3 is similar at the two wavelengths, 0.10 at 254 nm and 0.12 at 302.5 nm. Following the same reasoning used for the ring opening reactions,[18] it can be concluded that the quantum yield for T_3 to P_3 is virtually wavelength independent. The calculated quantum yields for P_3 to T_3 are given in Table III, with an average value of 0.11 for the quantum yield for T_3 to P_3.

The dramatic changes in quantum yields for the ring-closure reactions with the narrow wavelength range of 302.5–305.0 nm do not seem likely to be due to a rapid change in the molar extinction coefficients of the specific conformers of P_3 leading to Pro_3 and L_3, the so-called c(−)Zc and c(+)Zc conformers.[23] A doubling of the coefficient value of both conformers within a 2.5-nm range would be required, and such seems improbable since the molar extinction coefficient of P_3, itself, is decreasing by 29%. Thus, these results indicate that excited-state properties are involved in the wavelength effects found in the photochemical ring closure of previtamin D_3; the nature of this involvement is currently being studied.

On the other hand, the change in the molar extinction coefficient with wavelength of the P_3 conformer that is involved in the isomerization to T_3, i.e., the tZc conformer, could readily account for the changes in the P_3 to T_3 quantum yield, and excited-state properties need not be involved in this isomerization process.

Registry No. P_3, 1173-13-3; Pro_3, 434-16-2; L_3, 5226-01-7; T_3, 17592-07-3.

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[21] The results given are based upon triplicate experiments; the error on the lower quasi-photostationary state concentrations was 10% while the maximum error on the higher concentrations was less than 4%.

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[24] The overall error limits in the calculated quantum yields is 12%.

Bicyclo[2.2.1]heptanes in Organic Synthesis. Total Synthesis of the 16-Membered Ring Macrolide Tylonolide Hemiacetal: Synthesis and Coupling of the C(3)–C(9) and C(11)–C(17) Fragments

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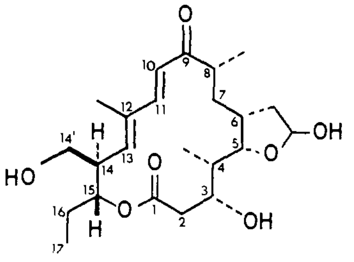
Received May 28, 1982

Tylosin,[1] a structurally complex 16-membered ring macrolide antibiotic that is presently used therapeutically[2] and sold commercially as its tartrate under the name Tylan[3] for the treatment of chronic respiratory disease in chickens, has been the focus of several synthetic investigations.[4] Efforts on the synthetic front have recently culminated in carbohydrate-based total syntheses of *O*-mycinosyltylonolide hemiacetal[4d] and the C(14′) O-tritylated derivative of tylonolide *O*-methylhemiacetal.[4c]

Our strategy for the construction of tylonolide hemiacetal (**1**) centered around the use of the chiral bicyclo[2.2.1]heptenol **4**, whose carbon framework permits elaboration of the seven-carbon C(3)–C(9) fragment **3** and the seven carbon C(11)–C(17) fragment **2**. We detail below the synthesis of the key intermediates **2** and **3** in optically active form and the elaboration of the 16-membered ring of tylonolide hemiacetal.



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The left-hand fragment **2** was prepared as outlined in Scheme I. The known bicyclo[2.2.1]heptane derivative **4**,[5] $[\alpha]_D$ −122.8° (*c* 2.50, $CHCl_3$), was benzylated and subjected to acid-catalyzed removal of the ketal to provide in 87% overall yield ketone **5**. Baeyer–Villiger oxidation of **5** and subsequent treatment of the crude hydroxy acid with boron trifluoride etherate gave rise (89%) to bicyclic lactone **6**, $[\alpha]_D$ +204.8° (*c* 7.11, $CHCl_3$). Sequential reduction of the lactone and the carbon–carbon double bond afforded the corresponding diol whose primary hydroxyl was smoothly transformed[6] (70% overall) to the primary selenide **7** without any complications due to the presence of the secondary hydroxyl. The transformation of selenide **7** into cyclopentanol **8** ($[\alpha]_D$ +47.4° (*c* 1.26, $CHCl_3$), mp 43–44 °C) was achieved in a straightforward fashion in very high yield. Collins oxidation

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