addition, the iodopurine is capable of a slow, dark substitution reaction[15] of low yield (22%) which apparently is of the $S_{RN}1$ type as evidenced by radical anion inhibition.

We have extended these investigations to a variety of other ketone enolates (Table I). For example, cyclopentanone enolate reacts with **1** to give crystalline 6-(2-cyclopentanoyl)-9-ethylpurine (**4**) (65% yield) which exists largely (80%) in the enolic form. Cyclohexanone behaves similarly. When 2-methylcyclohexanone was treated with **1** under the same conditions, both the thermodynamic (major) and kinetic (minor) products **6a** and **6b** were formed. The thermodynamic product **6a** exists exclusively in the keto form as evidenced by ^1H and ^{13}C NMR and FTIR data. The lower yield of the products in this case results apparently from a significant (30%) competing side reaction, i.e., formation of 9-ethylpurine through hydrogen abstraction. Photolysis of the enolate of α-tetralone with **1** gave an excellent yield of the aralicylic substituted product **7**. The aralkyl ketone acetophenone also underwent a smooth photochemical $S_{RN}1$ reaction with the iodopurine **1**. The conversion product **8** exists almost exclusively in the enol form. We have discovered that purines can be modified at the 6-position with acylated heteroaromatic systems. Of particular interest to us was the furan derivative **9** because of the close structural resemblance to plant growth regulators called cytokinins.[16] We are currently extending this methodology to the synthesis of some biologically active highly functionalized nucleosides.

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Supplementary Material Available: NMR (^1H and ^{13}C), UV, and mass spectral data for all adducts (8 pages). Ordering information is given on any current masthead page.

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Extraordinary Micellar Enantioselectivity Coupled to Altered Aggregate Structure

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The diasteroselectivity exhibited in the thiolysis of (e.g) L,L- and D,L-(*Z*)-Trp-Pro *p*-nitrophenyl esters by long-chain thiocholine surfactants not only requires micellar surfactant, but a "second form" of the micellar aggregate is actually the stereoselective agent. These latter micelles are characterized by an apparent critical concentration about 5 times above the nominal cmc, and considerably larger hydrodynamic diameters as determined by dynamic light scattering (dls).[3] Now we report that the extraordinary enantioselectivity observed[4] in the cleavage of L or D-*N*-dodecanoylphenylalanine *p*-nitrophenyl esters (**1**) by the tripeptide histidine catalyst (*Z*)-L-Phe-L-His-L-Leu (**2**) in *coaggregates* of the single-chain surfactant cetyltrimethylammonium bromide (CTAB) and the double-chain surfactant ditetradecyldimethylammonium bromide ($2C_{14}$) appears to be coupled to a systematic variation of coaggregate structure that can be monitored by dls.

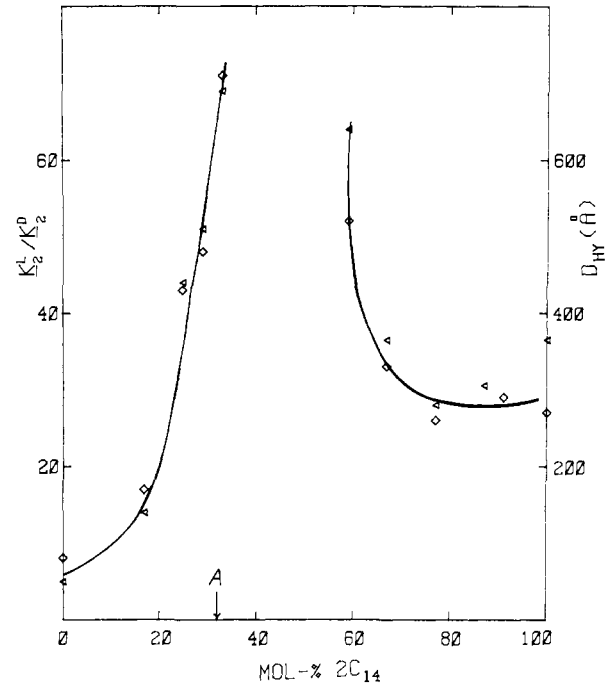
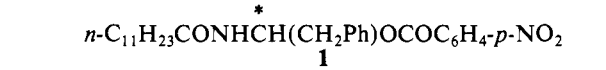


Figure 1. Enantioselectivity (k_2^L/k_2^D) for the coaggregate catalyzed cleavage of L- or D-*N*-dodecanoylphenyalanine *p*-nitrophenyl ester by (*Z*)-L-Phe-L-His-L-Leu (◊) left-hand ordinate) and apparent hydrodynamic diameters of the coaggregates (Δ, d_{hy}, Å, right-hand ordinate) versus coaggregate composition (mol-% $2C_{14}$ in mixtures of $2C_{14}$ and CTAB, abscissa). Point A designates a composition of 33% $2C_{14}$ and 67% CTAB, where maxima are found for k_2^L/k_2^D and d_{hy}.



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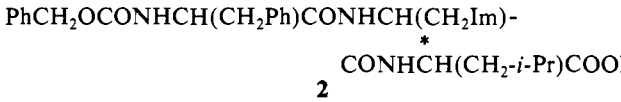

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L- or D-**1** were cleaved by His peptide **2** in pure CTAB micelles, pure $2C_{14}$ vesicles, or coaggregates formed by cosonication of CTAB and $2C_{14}$.[5] Second-order cleavage rate constants (k_2, M^{-1} s^{-1}) ranged from 1700 (L-**1**) or 63 (D-**1**) in vesicular $2C_{14}$ to 270 (L-**1**) or 34 (D-**1**) in micellar CTAB. In Figure 1, we plot the enantioselectivity of the cleavage (k_2^L/k_2^D) on the left-hand ordinate vs. the coaggregate composition ($[2C_{14}]/([2C_{14}] + [CTAB])$) on the abscissa. These experiments were carried out at 25 °C, where maximum enantioselectivity is observed.[6] In response to the admixture of $2C_{14}$, the enantioselectivity rises sharply from ~8.0 in CTAB micelles to ~71 in coaggregates containing 67 mol % CTAB and 33 mol % $2C_{14}$ ("composition A"). Further addition of $2C_{14}$ leads to patent inhomogeneity until ~41% CTAB/59% $2C_{14}$, whereupon clear coaggregate solutions are again obtained. Here, the enantioselectivity is ~52, and it decreases with further addition of $2C_{14}$ before leveling off at ~30. Enantioselectivity is ~27 in unadulterated $2C_{14}$ vesicles.

On the right-hand ordinate of Figure 1, we plot the *apparent* mean hydrodynamic diameter (d_{hy}, Å) of the various aggregates as determined by dls.[7] The remarkable similarity in the de-

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(5) Conditions: 0.083 M aqueous Tris buffer, 0.083 M added KCl, pH 7.6, 3 vol % CH_3CN, 25 °C; [**1**] = 1.0×10^{-5} M, [**2**] = 5×10^{-5} M, $[2C_{14}] = 1.0 \times 10^{-3}$ M. The concentration of CTAB was varied as required to obtain the mole percent compositions shown in Figure 1. Sonication was carried out with a Bransonic 12 unit at 80 W, 50 °C, 1 h.
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pendence of *both* d_{hy} and enantioselectivity on coaggregate composition is immediately apparent. Enantioselectivity responds directly and sensitively to variations in coaggregate structure that can be monitored by dls.

Separate experiments demonstrated that the maximum value of d_{hy} (690 ± 10 Å) observed at composition A, where enantioselectivity is also maximized, is not greatly affected (≤10%) by the addition of appropriate quantities of L- or D-**1**, catalyst **2**, or their reaction products. The properties of the $2C_{14}$/CTAB coaggregates are therefore innate, and not induced by addends as is the case in the diastereoselective thiolyses of dipeptide esters.[3]

What is the structure of the coaggregates and how do they exert control over enantioselectivity? These questions cannot now be answered definitively, but informed speculation is possible. Stopped-flow fluorescence experiments were carried out with $2C_{14}$/CTAB coaggregates and 1-anilino-8-naphthalene sulfonate.[8] $\tau_{1/2}$ for ANS permeation decreased from 720 ms in pure $2C_{14}$ vesicles, to 150 ms at 23 mol % CTAB, to 27 ms at 33% CTAB. At higher CTAB, specifically at composition A, "instantaneous" development of ANS fluorescence (i.e., binding without measurable permeation) was observed. Our interpretation is that $2C_{14}$/CTAB coaggregates lose vesicular structure somewhere above 33% CTAB, a conclusion supported by the inability of differential scanning calorimetry to detect a critical temperature for a phase change in coaggregates richer than 23% in CTAB.

The coaggregates were also examined by monitoring the fluorescence of 5×10^{-5} M solubilized pyrene.[5,8,9] From the near constancy (0.70 ± 0.02) of the fluorescence intensity ratio at 385 nm, relative to that at 375 nm, the micropolarity[9a] of the coaggregates appears to be independent of composition all across the abscissa of Figure 1. On the other hand, the microviscosity, as reflected by the intensity of pyrene excimer (475 nm) relative to pyrene monomer (393 nm) fluorescence,[9b] shows a maximum in the region of 67–83% CTAB (I_{475}/I_{393} = 0.21–0.11) when compared to either other coaggregate compositions or to pure $2C_{14}$ or CTAB (I ratios 0.43 or 0.42). Similar conclusions follow from fluorescence polarization studies using solubilized 1,6-diphenyl-1,3,5-hexatriene.[4]

Variable-angle (45–135°) dls reveals the coaggregates of composition A to be markedly nonspherical. They are characterized by a strong dependence of d_{hy} on scattering angle, whereas coaggregates containing 83%, 75%, 41%, 33%, 13%, or 0% CTAB exhibit little or no angular dependence of d_{hy} and are presumably spherical or nearly spherical micelles or vesicles.

Taking the evidence together, we suggest that upon admixture of $2C_{14}$, CTAB micelles undergo successive transitions to large rodlike or cylindrical micelles,[10] then to extended lamellae, and finally to spherical vesicles when $2C_{14} \geq 70\%$.[11] We suggest that the highly enantioselectivity-supportive coaggregates at composition A are rodlike micelles.[10] It would be conceptually attractive if the crystalline coaggregate (66–42% CTAB) lay between rod micelles at composition A and lamellae at <42% CTAB.

Crucially, *both* enantioselectivity and d_{hy} peak just before the coaggregate composition crosses an obvious phase boundary. Near this boundary, i.e., at composition A, d_{hy} does not reflect the hydrodynamic diameter of spherical particles, but more probably the correlation range of large extended aggregates.[12] Moreover, we suggest that the increasingly correlated, extended molecular alignment within coaggregates on the verge of phase separation may impose ordered relative arrangements on solubilized host molecules (such as substrate **1** and catalyst **2**) that engender highly amplified enantioselectivities.

An important implication of this hypothesis is that various types of selectivity (stereo, regio, or even chemo) expressed by reactions occuring in micelles or vesicles might be augmented in coaggregates held at compositions close to phase boundaries. We are investigating these possibilities.

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(7) We used a Nicomp TC-100 computing autocorrelator, an argon laser light source (488 nm), and a Hazeltine microcomputer fitted with the cumulant program. This directly afforded a nominal value of d_{hy} based on the *assumption* of a spherical aggregate. Data were collected at a 90° scattering angle unless otherwise specified, and d_{hy} was reproducible to better than ±10% in duplicate preparations.

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Oxidative Cleavage of 1-Phenyl-1,2-ethanediol by 4-Cyano-*N*,*N*-dimethylaniline *N*-Oxide and Chloro(5,10,15,20-tetraphenylporphinato)-chromium(III): A Model for Cholesterol Side-Chain Cleavage by Cytochrome P-450$_{SCC}$[1]

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Exogenous oxidant supported substrate oxidations by metalloporphyrins have been used extensively as simplified model systems for the corresponding enzyme-catalyzed oxidations by cytochrome P-450. Documented reactivities include epoxidations,[2-4] hydroxylations,[2-5] N-demethylation.[6] and oxidation of alcohols and ethers to aldehydes or ketones.[7] In this paper we report the oxidative cleavage of 1-phenyl-1,2-ethanediol (PED) by chloro(5,10,15,20-tetraphenylporphinato)chromium(III) (Cr(TPP)Cl) and the exogenous oxidant 4-cyano-*N*,*N*-dimethylaniline-*N*-oxide (CN-DMANO),[8] stoichiometrically producing benzaldehyde.[9] This carbon–carbon lyase reaction is analogous to the third step in the removal of the side chain of

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(8) Nee, M. W.; Bruice, T. C. *J. Am. Chem. Soc.* **1982**, *104*, 6123–6125. In preliminary experiments iodosobenzene was chosen as the exogenous oxidant for the cleavage reaction. In this case, however, it was demonstrated that iodosobenzene was active in oxidative cleavage of PED in the absence of porphyrin catalyst (Egeberg and Sligar, unpublished observation). Initial reaction rates were 70 μM product min^{-1} for iodosobenzene and 4 μM product min^{-1} with 100 μM Cr(TPP)Cl and CN-DMANO as oxygen donor. With the *N*-oxide as exogenous oxidant, no detectable reaction was found in the absence of catalyst.

(9) We have found that cleavage of the 3°,3° glycol, 1,1,2,2-tetraphenyl-1,2-ethanediol, produced 2 equiv of benzophenone for each CN-DMANO consumed, thus confirming the overall stoichioimetry of the reaction.

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