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ROTAMER POPULATIONS WITHIN THE STERN LAYER OF MICELLES

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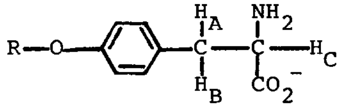
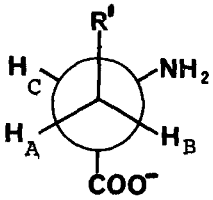
We have applied the methodology of conformational analysis to a subject of intense current interest, micelles. The union stems from a desire to understand the relationship between conformation and aggregation. How does a molecule fold and twist within an assemblage relative to the isolated state? Only one previous article addresses this question specifically: a group of Japanese workers have shown that micelles stabilize the trans configuration of N-acyl sarcosinates.[1] In the present communication we describe an ^1H NMR study of O-alkyl-D,L-tyrosines (0.10 M in D_2O, pD = 13.1, 33°):

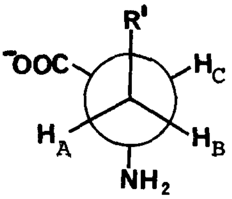


These compounds were prepared by adding an alkyl bromide to a solution of tyrosine and NaOH in aqueous dimethyl sulfoxide and heating at 80° for 2 hours.[2] The amino acids are monomeric in water when R is short-chained. When R = $\underline{n}$-C_6H_{13} and $\underline{n}$-C_8H_{17}, the molecules agglutinate in water above a critical micelles concentration (2.2×10^{-2} M and 6.5×10^{-3} M, respectively, as determined by the dye method[3]). Coupling constants J_{AC} and J_{BC}, secured by computer-assisted analysis of the ABC multiplet, permitted us to probe the conformations about the methylene-methine bond. Rotamer populations about this bond should respond to environmental factors within the Stern layer of the micelles (the Stern layer being defined as the outer surface of the micelle containing the ionic head groups, their counterions, and water of solvation).

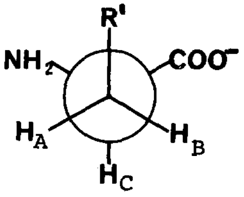
We make the usual assumption that 3 conformations (of fractional abundance a, b, and c) suffice to describe the amino acid system:[4,5,6,7]



a



b



c

We further assume the validity of the following equations (where J_t = 13.6 Hz and J_g = 2.6 Hz represent the trans and gauche coupling constants, respectively[4]):

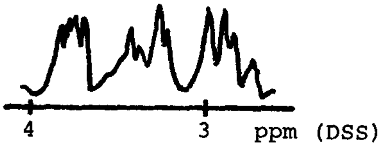
$$a + b + c = 1$$

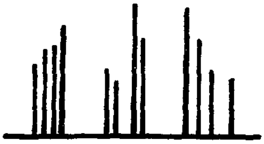
$$J_{AC} = aJ_g + bJ_t + cJ_g$$

$$J_{BC} = aJ_t + bJ_g + cJ_g$$

Neither of these assumptions is, of course, strictly correct; their impact is lessened by the fact that we focus primarily on changes in conformer populations upon micellization rather than on absolute numbers.

Shown below is the ABC portion of a 100 MHz NMR spectrum of O-hexyl-D,L-tyrosine above its critical micelle concentration. Adjacent to it is a simulated spectrum from which we obtained J_{AC} and J_{BC}. The two parameters in





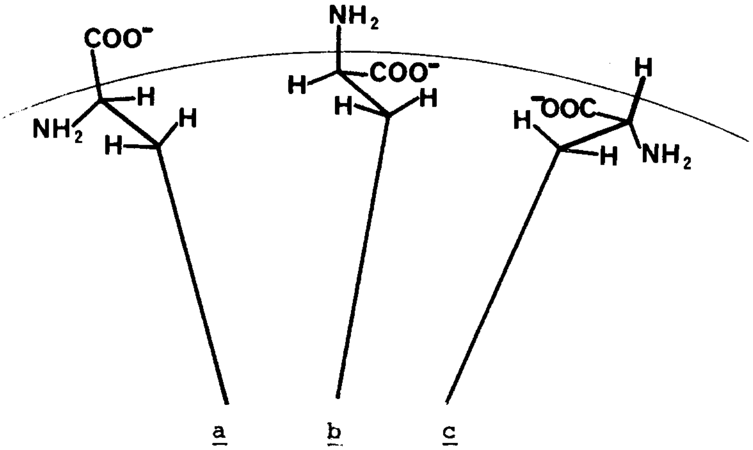
conjunction with the three equations lead to values of a, b, and c presented in Table I.[8]

Table I. Fractional Rotamer Populations for O-Alkylated Tyrosines in Basic Aqueous Solutions at 33°

Compound	Aggregation State	*a*	*b*	*c*
L-Tyrosine	Monomeric	0.48	0.23	0.29
O-Methyl-L-tyrosine	Monomeric	0.52	0.24	0.24
O-Hexyl-D,L-tyrosine*	Micellar	0.67	0.12	0.21
O-Octyl-D,L-tyrosine	Micellar	0.65	0.05	0.30

* No difference was detected between L and D,L compounds.

Aggregation markedly enhances the population of conformer *a* at the expense of conformer *b*. Conformer *c* remains virtually unchanged in relative abundance. These results are readily understood by noting that only conformer *a* possesses a carboxylate and a hydrocarbon "tail" in a *trans* coplanar arrangement:



Consequently, the carboxylate in *a* achieves maximum exposure to the external water. On the other hand, the carboxylates of rotamers *b* and *c* are directed laterally where they must endure unfavorable electrostatic interactions with each other in the densely packed Stern layer. We presume that micellization renders *b* more unstable than *c* because *b* lacks laterally oriented amino groups which may help solvate the carboxylates of micellar *c*.

Acknowledgment

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References and Notes

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8. Kainosho and Ajisaka (ref. 5) assigned the two prochiral methylene protons of tyrosine by means of stereoselective deuteration. We assumed that the relative chemical shifts of the protons in the tyrosine derivatives did not change.
9. Solubility problems precluded our studying micelles composed of cationic and zwitterionic species at lower pH values.