seems to indicate that biphenylene is formed in vibrationally-excited states. Nonetheless, persistence of the absorption maximum at about 240 mμ for times up to 200 μsec., together with the fact that the long-wave-length bands of biphenylene are exceedingly weak at times when absorption in regions (1) and (2) is quite strong, indicates to us that the transient spectrum is not from excited biphenylene.

Drawing an analogy with the pyridine spectrum, one can make a speculative assignment of bands consistent with the benzyne structure. Regions (1) and (2) would be assigned to n → π* excitation, the band being broad (rather than sharp as in pyridine) because such a transition in benzyne would be accompanied by a large change in equilibrium nuclear configuration. Absorption in the 240 mμ region could be assigned to a π → π* transition, like that of pyridine in the 245–270 region.

Further work will be directed principally toward studying other spectral regions more closely and obtaining a detailed theoretical interpretation of the structure and spectrum of the transient intermediate.

We are grateful to Mr. Roy G. Miller for preparing the benzenediazonium-2-carboxylate, and to Mr. Wayne G. Warren for his part in constructing the apparatus. This work was supported in part by a contract with the United States Air Force Office of Scientific Research.

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RECEIVED AUGUST 24, 1960

THE STABILITY OF INTERPEPTIDE HYDROGEN BONDS IN AQUEOUS SOLUTION

Sir:

X-ray diffraction and infrared spectra provide direct evidence for interpeptide hydrogen bonds[1] for substances (model peptides or proteins) in the solid state where the bond strength is high. In aqueous solution, however, where water provides competing groups, the stabilizing effect of such bonds is much more uncertain. The intrinsic stability of the N–H·O═C bond in water actually never has been measured despite the fact that it is a fundamental quantity in any analysis of the configuration of proteins in aqueous solution. An attempt to estimate its free energy of formation was made by Schellman,[2] based on an analysis of literature data for the thermodynamic behavior of urea solutions, but this computation is based on the risky assumption that deviations from ideal behavior may be attributed to the formation of aggregated species of urea.

This note provides direct experimental information on the stability in water of a model interamide hydrogen bond. Of the several approaches tried, the successful one was an examination of the infrared spectra[3] of concentrated aqueous solutions of N-methylacetamide in the region of 1.4–1.7 μ (Fig. 1). In this range glass vessels can be used, and optical densities are not too intense, so concentrated solutions can be examined in cells with precisely matched thicknesses. The absorptions of N–H and O–H groups still overlap, however, and hence the absorption of water must be compensated for. This was accomplished by the use of reference cuvettes which contained aqueous dimethylacetamide solutions at concentrations carefully selected to place the same amount of water in the light path as was present in the sample cuvette containing aqueous monomethylacetamide. Liquid dimethylacetamide is essentially transparent in the range 1.45–1.60 μ and shows peaks very comparable to those of monomethylacetamide on both flanks of this range.

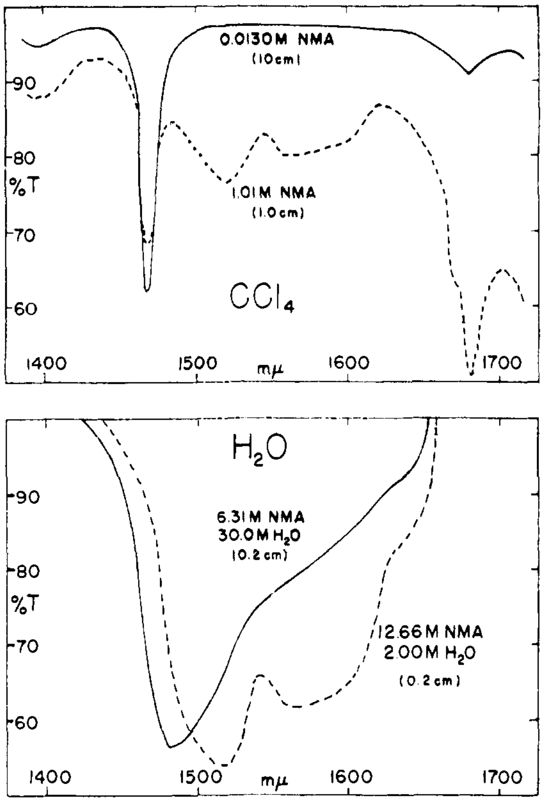
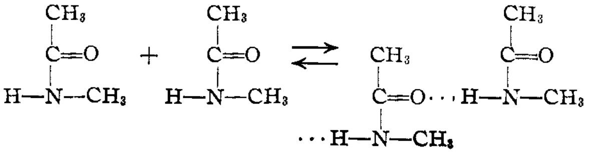


Fig. 1.—Near infrared absorption spectra of N-methylacetamide in carbon tetrachloride and in water. Water solutions contain dimethylacetamide in reference cell to balance all absorption except that of N–H of methylacetamide. Cell thickness is marked for each solution.

In Fig. 1 are illustrated spectra in relatively dilute and concentrated solutions, respectively, in each of two solvents. In carbon tetrachloride, N-methylacetamide exists as a monomer in dilute solution (~0.01 *M*) and as such shows a sharp peak at 1.47 μ (6800 cm.$^{-1}$). In more concentrated solutions aggregation sets in



$$\begin{array}{c}CH_3\\|\\C{=}O\\|\\H{-}N{-}CH_3\end{array} + \begin{array}{c}CH_3\\|\\C{=}O\\|\\H{-}N{-}CH_3\end{array} \rightleftarrows \begin{array}{lcl}CH_3 & & CH_3\\| & & |\\C{=}O & \cdots & H{-}N{-}CH_3\\| & & \\\cdots H{-}N{-}CH_3 & & \end{array}$$

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[1] G. Pimentel and A. L. McClellan, "The Hydrogen Bond," W. H. Freeman and Co., San Francisco, 1960.

[2] J. A. Schellman, *Compt. rend. trav. lab. Carlsberg, Ser. Chim.*, **29**, 223 (1955).

[3] Compare J. Hermans, Jr., and H. A. Scheraga, THIS JOURNAL, **82**, 5156 (1960), for another application of near infrared spectra to problems of protein structure.

as is evident from the appearance of a twin peak between 1.5–1.6 μ (6600–6300 cm.$^{-1}$) and the decrease in intensity of the 1.47 μ monomer peak. Corresponding behavior is observed in aqueous solutions (Fig. 1) except that the concentration near which aggregation becomes significant is exceedingly high. N-Methylacetamide in water shows a single absorption peak at 1.48 μ (6760 cm.$^{-1}$) with an optical density proportional to concentration until the solute becomes nearly 7–8 *M*. At this point the ratio of H_2O/amide is down to about 3. In more concentrated solutions, the 1.48 μ peak decreases in intensity and a twin peak appears in the 1.5–1.6 μ range.

A preliminary rough computation of the equilibrium constant for dimer formation by N-methylacetamide in water has been made from changes in absorption at 1.48 μ, and a $K \simeq 0.008$ obtained. From this value, as well as the spectra in Fig. 1, it is apparent that the inter-peptide hydrogen bond of small molecules in aqueous solution is exceedingly unstable. For model amides, at least, aggregation through hydrogen bonding is essentially nonexistent as long as enough water molecules are available to occupy the N–H and C=O groups.

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[4] This investigation was assisted by a research grant (H-2910) from the National Heart Institute, United States Public Health Service.

[5] Postdoctoral Fellow, United States Public Health Service.

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RECEIVED AUGUST 3, 1960

CARBOMETHOXY DERIVATIVES OF 1,2-DIMETHYLENEBENZOCYCLOBUTENE AND 1-KETO-2-METHYLENEBENZOCYCLOBUTENE

Sir:

We wish to report the synthesis of some simple derivatives of the unknown systems 1,2-dimethylenebenzocyclobutene (I) and 1-keto-2-methylenebenzocyclobutene (II). Molecular orbital calculations[1] have shown that the resonance energies of both molecules are almost identical with that of the known, stable benzocyclobutenedione (III).[2] The syntheses of 1,2-dicarbomethoxymethylenebenzocyclobutene (IV) and of 1-keto-2-carbomethoxymethylenebenzocyclobutene (VI) were achieved by the reaction of diketone III with triphenylphosphinecarbomethoxymethylene.[3]

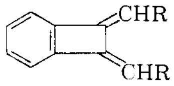
Allowing a solution of diketone III and two equivalents of triphenylphosphinecarbomethoxymethylene in methylene chloride to stand overnight at room temperature gave, in 85% yield, IV, m.p. 122–123.[4] *Anal.* Calcd. for $C_{14}H_{12}O_4$: C, 68.84; H, 4.95. Found: C, 69.01; H, 4.95. Ultraviolet spectrum: $\lambda_{\max}^{\mathrm{EtOH}}$ 256 mμ (log *E* 4.64), 290 mμ (log *E* 4.46), 305 mμ (log *E* 3.98) and 333 mμ (log *E* 3.98).

On catalytic hydrogenation, IV absorbed two moles of hydrogen to give 1,2-benzocyclobutenediacetic acid dimethyl ester (V). *Anal.* Calcd. for $C_{14}H_{16}O_4$: C, 67.75; H, 6.50. Found: C, 67.61; H, 6.70. The ultraviolet spectrum of V was identical with that of benzocyclobutene.[5] Significantly no reaction occurred when IV was refluxed with tetracyanoethylene[6] in toluene for twenty-four hours, and 93% of the starting material was recovered.

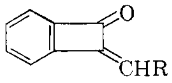
Addition of one equivalent of triphenylphosphinecarbomethoxymethylene in methylene chloride to diketone III in methylene chloride over a period of eight hours gave, in 93% yield, VI, m.p. 86–87°. *Anal.* Calcd. for $C_{11}H_8O_3$: C, 70.21; H, 4.29. Found: C, 69.91; H, 4.65. Ultraviolet spectrum: $\lambda_{\max}^{\mathrm{EtOH}}$ 246 mμ (log *E* 4.55), 330 mμ (log *E* 4.00). The 2,4-dinitrophenylhydrazone of VI, m.p. 235° (dec.) formed readily. *Anal.* Calcd. for $C_{17}H_{12}O_6N_4$: C, 53.93; H, 3.40; N, 15.73. Found: C, 53.89; H, 3.13; N, 15.22.

A solution of VI with one mole of triphenylphosphinecarbomethoxymethylene in methylene chloride on standing overnight gave IV in 75% yield.

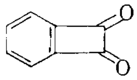
A closer study of this series of compounds is now in progress.



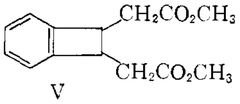
I, (R = H)
IV, (R = CO_2CH_3)



II, (R = H)
VI, (R = CO_2CH_3)



III



V

We gratefully acknowledge a grant by the National Science Foundation in support of this work.

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[1] S. L. Manatt and J. D. Roberts, *J. Org. Chem.*, **24**, 1336 (1959).

[2] M. P. Cava and D. R. Napier, THIS JOURNAL, **79**, 3606 (1957).

[3] O. Isler *et al.*, *Helv. Chim. Acta*, **40**, 1242 (1957).

[4] All melting points are uncorrected.

[5] M. P. Cava and D. R. Napier, THIS JOURNAL, **80**, 2256 (1958).

[6] The somewhat related 3,4-diphenyl-1,2-dimethylenecyclobutene reacts under milder conditions, a spiran rather than a cyclobutadiene being formed: A. T. Blomquist and Y. C. Meinwald, *ibid.*, **81**, 667 (1959).

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RECEIVED AUGUST 10, 1960

THE NON-CLASSICAL PENTAMETHYLCYCLOPENTADIENYL-CARBINYL CATION

Sir:

In considering the nature of the intensely magenta colored species obtained from hexamethylcyclopentadiene,[1] the possibility arose that the pentamethylcyclopentadienyl-carbinyl cation would have a highly stabilized non-classical structure, such as A.[2]

This was convincingly borne out by examination of the solvolysis behavior of the corresponding arenesulfonate. These are obtainable from 1,2,3,4,5-pentamethylcyclopentadienylcarbinol(I)[3] at −10°.

Rate studies show that the *p*-toluenesulfonate acetolyses with remarkably high anchimeric acceleration and with SN1 kinetics.[4]

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[1] To be published in a subsequent issue of THIS JOURNAL.

[2] This was suggested to the author by Prof. S. Winstein.

[3] L. de Vries, *J. Org. Chem.*, in press.

[4] Private communication from S. Winstein and M. Battiste.