hydroxy amide **15b** was obtained from 25 g of **14**, 133 mmol of *sec*-BuLi (hexane), and 14.5 g of *m*-tolualdehyde.

Treatment of a similar mixture (13.2 g) with 7.9 g of *p*-toluenesulfonic acid in toluene as in the case of **15a** gave, after purification, 3.19 g of **16b**: mp 90 °C; ^{1}H NMR (CDCl$_3$) δ 2.35 (3 H, s), 3.9 (3 H, s), 6.40 (1 H, s), 6.8 (1 H, br s), 7.15–7.35 (5 H, m), 8.05 (1 H, d, $J = 6$). Anal. Calcd for $C_{16}H_{14}O_3$: C, 75.57; H, 5.54. Found: C, 75.61; H, 5.61.

4-Methoxy-2-[(3-methylphenyl)methyl]benzoic Acid (17b). Hydrogenolysis of 1.0 g of **16b** by using the procedure for the conversion of **16a** to **17a** gave acid **17b**: mp 85–86 °C; 99% yield; ^{1}H NMR (CDCl$_3$) δ 2.35 (3 H, s), 3.85 (3 H, s), 4.45 (2 H, s), 6.75 (1 H, s), 6.9–7.25 (5 H, m), 8.15 (1 H, d, $J = 9$), 9.15 (1 H, br s). Acid **17b** so obtained was sufficiently pure to use directly in the next reaction.

2-Methoxy-7-methyl-9,10-anthraquinone (13). Conversion of **17b** to **13** via anthranol **18b** was effected by a procedure identical with that used for the preparation of **12** from **17a**. Anthraquinone **13** (mp 162–163 °C) was obtained in 39% overall yield from acid **17b**: ^{1}H NMR (CDCl$_3$, 80 MHz) δ 2.52 (3 H, s), 3.98 (3 H, s), 7.24 (1 H, dd, $J = 8.3, 2.8$), 7.58 (1 H, br d, $J = 8$), 7.72 (1 H, d, $J = 2.5$), 8.08 (1 H, br s), 8.19 (1 H, d, $J = 8$), 8.25 (1 H, d, $J = 8.5$). ^{13}C NMR (CDCl$_3$) δ 183.31, 181.84, 164.12, 144.54, 135.58, 134.77, 133.43, 131.38, 129.50, 127.28, 127.21, 120.86, 109.88, 55.98, 21.67. Two resonances are apparently superimposed. Anal. Calcd for $C_{16}H_{12}O_3$: C, 76.17; H, 4.80. Found: C, 76.01; H, 4.87.

Acknowledgment. Support of this work by the National Cancer Institute (Grants CA-00040 and CA-17631) is gratefully acknowledged. We are particularily indebted to Dr. Wayne Manning[11,12] for carrying out the analyses reported in Table II. We thank Drs. V. Snieckus[10] and R. K. Boeckman, Jr.,[18] for helpful information and J. Vaya and S. Dasgupta for recording the ^{13}C NMR and 270-MHz ^{1}H NMR spectra.

Registry No. 2, 5196-28-1; **6a**, 4923-53-9; **6b**, 29263-68-1; **6c**, 71186-88-4; **7**, 73451-87-3; **10**, 83312-50-9; **11**, 83312-51-0; **12**, 83312-52-1; **13**, 83333-48-6; **14**, 7465-86-3; **15a**, 83312-53-2; **16a**, 83312-54-3; **16b**, 83312-56-5; **17a**, 83312-55-4; **17b**, 83312-57-6; **21**, 68963-23-5; **22**, 68963-22-4.

Notes

Conformation of 1,2-Adducts of *N*-Halo Amides and *tert*-Butylethylene by High-Field Proton Nuclear Magnetic Resonance Spectroscopy

Jean Lessard* and Jacques Tuaillon[1]

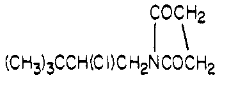
Département de Chimie, Université de Sherbrooke, Sherbrooke, Québec, Canada J1K 2R1

Received August 17, 1981

Conformational preference and potential barriers for rotation about single bonds in open-chain fragments is a field of continued interest.[2,3] We report herein the ^{1}H NMR data at 400 MHz of *N*-(2-halo-3,3-dimethylbutyl) amides **1** and *N*-(2-chloro-3,3-dimethylbutyl)succinimide (**2**) which show a strong preference for one conformation about the C_1–C_2 and C_1–N single bonds in CDCl$_3$.

$(CH_3)_3CCH(X)CH_2NHCOZ$

1a, X = Cl; Z = CH_3
b, X = Cl; Z = CH_2Cl
c, X = Cl; Z = CCl_3
d, X = Cl; Z = CF_3
e, X = Cl; Z = OCH_2CH_3
f, X = Br; Z = CCl_3



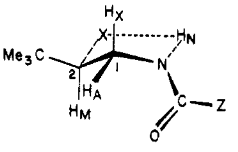
$(CH_3)_3CCH(Cl)CH_2\overset{COCH_2}{N}COCH_2$

2

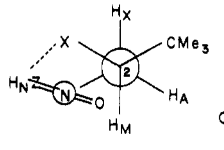
Compounds **1** were obtained by the photochemical addition of *N*-halo amides (ZCONHX) to *tert*-butylethylene in the course of a study of the influence of Z on the quantum yield of the reaction.[4] The preparation of **2** by the photochemical addition of *N*-chlorosuccinimide to *tert*-butylethylene has been reported.[5]

Table I lists the ^{1}H NMR data for compounds **1** at ca. 27 °C. The two methylenic protons at C-1 (H_A and H_X) and the halomethine proton at C-2 (H_M) form an AMX system. The methylenic protons are further coupled with the proton on nitrogen (H_N), and each of them appears as a doublet of doublets of doublets which becomes a double doublet upon irradiating the NH. The large chemical shift difference between the two methylenic protons is noteworthy (from 0.8 ppm in **1f** to 1.2 ppm in **1a**): proton H_A absorbs at a lower field and proton H_X at a higher field than the halomethine proton H_M. The attribution of the coupling constants was confirmed by spin-decoupling experiments: $J_{AX} = J_{gem} = 14.0$–14.2 Hz; $J_{AM} = 2.4$–2.6 Hz; $J_{MX} = 10.5$–10.7 Hz; $J_{AN} = 7.8$–8.3 Hz; $J_{XN} = 3.5$–3.9 Hz. All the protons of the bromo derivative **1f** are more deshielded than the corresponding protons of the chloro analogue **1c**: H_N by 0.13 ppm, H_A by 0.04 ppm, H_M by 0.11 ppm, H_X by 0.16 ppm, and the *tert*-butyl group by 0.15 ppm.

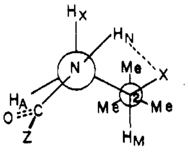
The preferred conformation of compounds **1** is shown in the three-dimensional formula A[6] and the corresponding Newman projections B (along the C_1–C_2 bond), and C (along the N–C_1 bond). This conformation follows from



A



B



C

---

(1) NATO Visiting Scientist (1980–1981) from the Faculté des Sciences, Besançon, France.

(2) Inter alia, see the following reviews and references therein: (a) Zefirov, N. S. *Tetrahedron* **1977**, *33*, 3193. (b) Ōki, M. *Angew Chem., Int. Ed. Engl.* **1976**, *15*, 87. (c) Sternhell, S. "Dynamic Nuclear Magnetic Resonance Spectroscopy"; Jackman, L. M., Cotton, F. A., Eds; Academic Press: New York, 1975. (d) Dale, J. *Tetrahedron* **1974**, *30*, 1683. (e) Wolfe, S. *Acc. Chem. Res.* **1972**, *5*, 102.

(3) For some recent articles with references therein see: (a) Thompson, H. B.; Opdycke, W. N. *J. Org. Chem.* **1981**, 46, 1786. (b) Abe, A. *Macromolecules* **1980**, *13*, 541. (c) Exner, O.; Engberts, J. B. F. N. *Collect. Czech. Chem. Commun.* **1979**, *44*, 3378. (d) Wang, C. Y.; Bushweller, C. H. *J. Am. Chem. Soc.* **1977**, *99*, 313.

(4) Lessard, J.; Tuaillon, J., unpublished results.

(5) Day, J. C.; Katsaros, M. G.; Kocher, W. D.; Scott, A. E.; Skell, P. S. *J. Am. Chem. Soc.* **1978**, *100*, 1950.

(6) Carboxamides are known to have a trans arrangement of the N substituent with respect to Z.[7]

(7) Robin, M. B.; Bovey, F. A.; Basch, H. "The Chemistry of Amides"; Zabicky, J., Ed; Wiley: New York, 1979; pp 19–22. Stewart, W. E.; Siddall, T. H., III. *Chem. Rev.* **1970**, *70*, 517.

0022-3263/82/1947-5013$01.25/0

Table I. ^{1}H NMR Chemical Shifts (ppm)[a] and J Values (Hertz)[b] for Compounds 1a–f

	chemical shift					
		methylene protons at C-1		halomethine proton at C-2 (H_M)		
compd	NH (H_N)	H_A	H_X		protons of Z	t-C_4H_9
1a	5.85 (m)	4.15 (ddd, J = 14.1, 8.1, 2.6)	2.96 (ddd, J = 14.1, 10.7, 3.5)	3.80 (dd, J = 10.7, 2.6)	2.00 (s, 3 H)	1.05 (s)
1b	7.01 (m)	4.14 (ddd, J = 14.0, 7.9, 2.4)	3.14 (ddd, J = 14.0, 10.7, 3.6)	3.82 (dd, J = 10.7, 2.4)	4.07 (s, 2 H)	1.08 (s)
1c	7.14 (m)	4.11 (ddd, J = 14.1, 7.8, 2.6)	3.25 (ddd, J = 14.1, 10.6, 3.8)	3.89 (dd, J = 10.6, 2.6)		1.09 (s)
1d	6.78 (m)	4.15 (ddd, J = 14.1, 7.9, 2.4)	3.19 (ddd, J = 14.1, 10.7, 3.7)	3.83 (dd, J = 10.7, 2.4)		1.09 (s)
1e	5.13 (m)	3.92 (br dd,[c] J = 14.2, 8.3)	3.03 (ddd, J = 14.2, 10.5, 3.7)	3.81 (br d,[c] J = 10.5)	4.13 (2 H),[d] 1.25 (t, J = 7.0, 3 H)	1.06 (s)
1f	7.27 (m)	4.15 (ddd, J = 14.2, 7.8, 2.6)	3.36 (ddd, J = 14.2, 10.6, 3.9)	4.05 (dd, J = 10.6, 2.6)		1.14 (s)

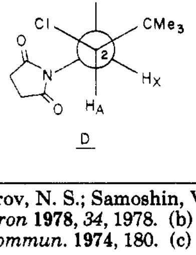
[a] The spectra were obtained at 400 MHz in $CDCl_3$ solutions. [b] ±0.2 Hz. [c] The smallest coupling was not resolved: width at half-height of the individual peaks was ≤ 5 Hz. [d] AB part of an ABX_3 system.

the strong deshielding of one (H_A) of the methylenic protons—which must be not only close to the carbonyl but also in its deshielding region, that is near the plane of the amide group—and from the values of the vicinal coupling constants given above which would correspond to the following approximate dihedral angles: $\phi_{AM} \simeq 60°$, $\phi_{XM} \simeq 180°$, $\phi_{AN} \simeq 170°$, $\phi_{XN} \simeq 50°$.

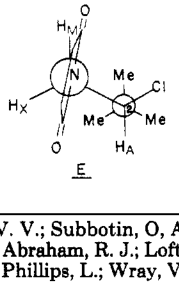
No noticeable change in coupling constants was observed by cooling **1a** to −50 °C. The peaks were broadened due to an increase of the solvent viscosity. Heating **1a** to 97 °C causes only slight changes in the 60-MHz spectrum (where the AMS system observed at 400 MHz has changed to an ABX system: H_M = part B): decrease of J_{XM} from 10 to 9 Hz, increase of J_{AM} from 2 to 2.5 Hz, decrease of J_{XN} from 3.5 to 3 Hz, and apparently no detectable change of $J_{AN} \simeq 7.5$ Hz.

Two factors can play a role in the conformational preference about the C_1–C_2 bond. Steric repulsion between the bulky *tert*-butyl group and the amido group is most probably the main factor. The other factor could be an attractive dominant gauche interaction (gauche effect)[2d–e,3b–d,8] between the halogen at C-2 and the nitrogen of the amido group. As for the conformational preference about the C_1–N bond, the oxygen of the amido group and the halogen at C-2 should tend to be as far apart as possible (see A and Newman projection C) both for steric and electrostatic reasons; such a conformation could then be stabilized by hydrogen bonding between the halogen and the proton on nitrogen.

In compound **2**, the protons at C-1 and the proton at C-2 also form an AMX system, but the most deshielded proton (H_A) is now the halomethine proton at 4.16 ppm, the two methylenic protons absorbing at 3.93 (H_M) and 3.72 ppm (H_X), respectively. The attribution of the coupling constants confirmed by spin decoupling, gives $J_{MX} = J_{gem}$ = 13.7 Hz, J_{AX} = 2.4 Hz, and J_{AM} = 11.4 Hz. Thus the conformation about the C_1–C_2 bond must be nearly the same as in compounds **1** and is shown in Newman projection D. This is to be expected since the succinimido group is bulkier than a ZCONH group (steric effect) and more electronegative (gauche effect). For the conformation about the C_1–N bond, we propose the one shown in Newman projection E. With conformation D about the C_1–C_2 bond, conformation E is the sole conformation about the C_1–N bond that can be easily constructed with space-filling models (CPK models), thus showing that rotation about that bond must be fairly restricted. Furthermore, conformation E agrees with the chemical shifts of H_A, H_M, and H_X: H_M is more deshielded than H_X because H_M is in the deshielding region of one of the carbonyls of the succinimido group, and H_A is the most deshielded proton not only because it is on the carbon bearing the chlorine but also because it is close to the other carbonyl of the succinimido group.



D



E

Finally, in the case of the carbamate **1e**, the protons of the ethyl group appear as an ABX_3 system which means that the methylenic protons are nonequivalent or diastereotopic even if six bonds separate them from the asymmetric center at C-2.[9]

Experimental Section

The ^{1}H NMR spectra at 400 MHz were obtained in a 5-mm spinning tube from solutions of approximately 10 mg of compound in 1 mL of $CDCl_3$ with Me_4Si as an internal reference. The instrument employed was a Bruker WH-400 spectrometer. The higher temperature experiments were carried out at 60 MHz with a Bruker WP-60 instrument. Mass spectra were determined on a ZAB-1F double–focusing mass spectrometer. IR spectra were recorded on a Perkin-Elmer 257 spectrometer.

Compounds 1 and 2 were prepared by irradiating a deoxygenated solution (argon) of the *N*-halo derivative (5 mmol) and *tert*-butylethylene (7.6 mmol, passed through alumina) in freshly distilled (over P_2O_5) methylene chloride (25 mL) in a RPR-100 Rayonnet reactor as described for the photochemical addition of *N*-halo amides to olefins.[11] The yields, physical constants, and characteristic IR absorptions together with the analytical and high-resolution mass spectral data are reported below.

***N*-(2-Chloro-3,3-dimethylbutyl)acetamide (1a)**: 72%; mp 109–110 °C; IR ($CHCl_3$) 3450, 1675, 1520 cm^{-1}; exact mass calcd for $C_8H_{16}ClNO$ 177.0920, found 177.0923. Anal. Calcd C, 54.08; H, 9.08; N, 7.88; Cl, 19.95. Found: C, 54.25; H, 9.33; N, 8.03; Cl, 19.91.

---

[8] (a) Zefirov, N. S.; Samoshin, V. V.; Subbotin, O, A.; Baranenkov, V. I. *Tetrahedron* **1978**, *34*, 1978. (b) Abraham, R. J.; Loftus, P. *J. Chem. Soc., Chem. Commun.* **1974**, 180. (c) Phillips, L.; Wray, V. *Ibid.* **1973**, 90.

[9] Nonequivalence of the methylenic protons of carbethoxy groups has been observed at 60 MHz but with two protons being five bonds away from the asymmetric center; they become equivalent upon removing the asymmetric center.[10]

[10] Robert, J. F.; Koch, J.; Panouse, J. J. *Spectrochim. Acta, Part A* **1979**, *35*, 131.

[11] Lessard, J.; Mondon, M.; Touchard, D. *Can. J. Chem.* **1981**, *59*, 431.

***N*-(2-Chloro-3,3-dimethylbutyl)chloroacetamide (1b)**: 83%; mp 84 °C; IR ($CHCl_3$) 3420, 1680, 1535 cm^{-1}; exact mass calcd for $C_8H_{15}Cl_2NO$ 211.0522, found 211.0525. Anal. Calcd C, 45.29; H, 7.13; N, 6.60; Cl, 33.42. Found: C, 45.50; H, 7.18; N, 6.49; Cl, 34.02.

***N*-(2-Chloro-3,3-dimethylbutyl)trichloroacetamide (1c)**: 95%; mp 85 °C; IR ($CHCl_3$) 3425, 1720, 1515 cm^{-1}; exact mass calcd for $C_8H_{13}Cl_4NO$ 278.9751, found 278.9755. Anal. Calcd C, 34.19; H, 4.66; N, 4.98; Cl, 50.46. Found: C, 34.95; H, 4.85; N, 4.87; Cl, 49.10.

***N*-(2-Chloro-3,3-dimethylbutyl)trifluoroacetamide (1d)**: 98%: mp 65 °C; IR ($CHCl_3$) 3440, 1735, 1550 cm^{-1}; exact mass calcd for $C_4H_5F_3ClNO$ ($M^+ - C_4H_8$[12]) 175.0012, found 175.0016. Anal. Calcd for $C_8H_{13}F_3ClNO$: C, 41.48; H, 5.66; N, 6.04; Cl, 15.30. Found: C, 41.27; H, 5.90; N, 5.92; Cl, 15.08.

Ethyl *N*-(2-Chloro-3,3-dimethylbutyl)carbamate (1e): 75%; mp 69 °C; IR ($CHCl_3$) 3450, 1720, 1520 cm^{-1}; exact mass calcd for $C_9H_{18}ClNO_2$ 207.1022, found 207.1022. Anal. Calcd C, 52.04; H, 8.73; N, 6.79; Cl, 17.07. Found: C, 51.87; H, 8.73; N, 6.91; Cl, 17.30.

***N*-(2-Bromo-3,3-dimethylbutyl)trichloroacetamide (1f)**: 98%; mp 83 °C; IR ($CHCl_3$) 3440, 1720, 1518 cm^{-1}; exact mass calcd for $C_8H_{13}Cl_3BrNO$ 322.9246, found 322.9246. Anal. Calcd C, 29.52; H, 4.03; N, 4.30. Found: C, 29.61; H, 4.19; N, 4.18.

***N*-(2-Chloro-3,3-dimethylbutyl)succinimide (2)**: 48%;[13] mp 92 °C; IR ($CHCl_3$) 1785, 1720 cm^{-1}; ^1H NMR ($CDCl_3$) 1.07 (s, t-C_4H_9), 2.75 (s, succinimid group), 3.72 (dd, J = 13.4, 2.4 Hz, H_X), 3.93 (dd, J = 13.7, 11.4 Hz, H_M), 4.16 ppm (dd, J = 11.4, 2.4 Hz, H_A); exact mass calcd for $C_{10}H_{16}ClNO_2$ 217.0869, found 217.0867. Anal. Calcd C, 55.17; H, 7.40; N, 6.43; Cl, 16.28. Found: C, 54.94; H, 7.55; N, 6.30; Cl, 16.41.

Acknowledgment. We thank the "Ministère de l'Education du Québec" and the Natural Sciences and Engineering Council of Canada for financial support.

Registry No. 1a, 83269-99-2; **1b**, 83270-00-2; **1c**, 83270-01-3; **1d**, 83270-02-4; **1e**, 15044-22-1; **1f**, 83270-03-5; **2**, 83270-04-6.

---

[12] The molecular ion could not be detected. In the mass spectra of all the other compounds, the base peak did correspond to the facile loss of C_4H_8 (M^+ − 56 fragment).

[13] A yield of 50% is reported in ref 5, but no physical, spectroscopic, and analytical data are given.

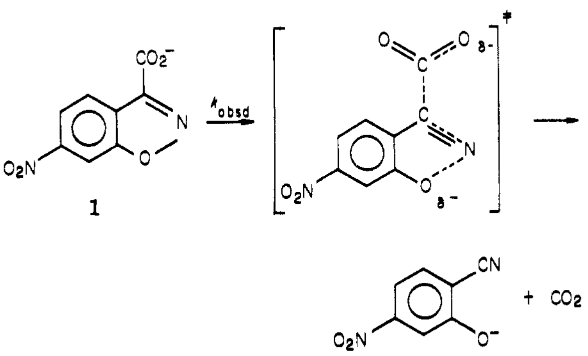
Salt Effects on the Decarboxylation of 6-Nitrobenzisoxazole-3-carboxylate Catalyzed by 1-Methyl-4-dodecylpyridinium Iodide Micelles. Effect of Microenvironment vs. Ion Exchange

Leo A. M. Rupert and Jan B. F. N. Engberts*

Department of Organic Chemistry, University of Groningen, Nijenborgh 16, 9747 AG Groningen, The Netherlands

Received April 2, 1982

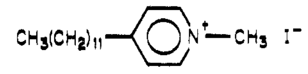
Micellar catalysis of unimolecular reactions is determined by two factors, the binding of the substrate to the micelle and the nature of the reaction medium at the binding sites. These binding sites are usually located in the Stern layer of the micelle.[1,2] One particularly popular and useful model reaction to probe microenvironmental effects is the intermediateless decarboxylation of 6-nitrobenzisoxazole-3-carboxylate (1; eq 1).[3] This reaction is remarkably sensitive to solvent effects.[4] Important solvation factors are hydrogen bonding interactions involving the carboxylate group of the substrate and dispersion interactions of the polarizable transition state.



1

(1)

The microenvironment in the Stern layer of micelles has been studied by using a variety of techniques including solubilization of extrinsic micropolarity reporter probes.[5] It is generally found that the local polarity is reduced with respect to bulk water. For ionic amphiphiles this result reflects the presence of the ionic head groups, the counterions, and the nearness of the first part of the hydrocarbon chain. Recent investigations involved 1-methyl-4-dodecylpyridinium iodide (2), an amphiphile carrying an *intrinsic* polarity reporter group.[6] From the position of the first long-wavelength intramolecular charge-transfer (CT) absorption band of the head group in the micelle, it could be deduced that the micropolarity in the Stern layer is rather similar to that in ethanol as expressed in Kosower's Z value (Z = 80.6). In the presence of a series of electrolytes, the micropolarity is still further reduced.[6]



2

In the present study we have employed the decarboxylation of 1 as a kinetic probe for the micropolarity in the Stern layer of micelles formed from 2. Interestingly, in the presence of NaCl, NaBr, and NaI a competition occurs between surface polarity effects and ion exchange.

Results and Discussion

A plot of the first-order rate constants (k_{obsd}, 30 °C) for decarboxylation of 1 as a function of the concentration of the amphiphile 2 is shown in Figure 1. When the concentration of 2 is increased, the value of k_{obsd} gradually reaches a limiting value which is the usual behavior for a micellar-catalyzed unimolecular reaction.[1] Analysis of this plot in terms of the enzyme model for micellar catalysis[7] provides values for the rate constant in the micelle ($k_m = 3.42 \times 10^{-4}\ s^{-1}$) and for the binding constant of 1 to the micelle ($K_S = 1160\ M^{-1}$). As expected on the basis of the reduced micropolarity in the Stern layer, the rate constant is increased as compared with that in water ($k_w = 2.1 \times 10^{-6}\ s^{-1}$; k_m/k_w is ca. 160). The rate constant at the micellar surface is of the same order of magnitude as that for decarboxylation in ethanol ($k_{EtOH} = 10 \times 10^{-4}\ s^{-1}$)[4]. This result is in agreement with the respective Z values (vide supra). In addition, the micellar catalysis is of the same

---

[1] Fendler, J. H.; Fendler, E. J. "Catalysis in Micellar and Macromolecular Systems"; Academic Press: New York, 1975.

[2] Bunton, C. A. *Catal. Rev. Sci. Eng.* **1979**, *20*, 1.

[3] (a) Bunton, C. A.; Minch, M. J. *Tetrahedron Lett.* **1970**, 3881. (b) Bunton, C. A.; Minch, M. J.; Sepulveda, L. *J. Phys. Chem.* **1971**, *75*, 2707. (c) Bunton, C. A.; Minch, M. J.; Hidalgo, J.; Sepulveda, L. *J. Am. Chem. Soc.* **1973**, *95*, 3262. (d) Bunton, C. A.; Kamego, A. A.; Minch, M. J.; Wright, J. L. *J. Org. Chem.* **1975**, *40*, 1321. (e) Kunitake, T.; Okahata, Y.; Ando, R.; Shinkai, S.; Hirakawa, S.-I. *J. Am. Chem. Soc.* **1980**, *102*, 7877.

[4] (a) Kemp, D. S.; Paul, K. G. *J. Am. Chem. Soc.* **1975**, *97*, 7305. (b) Kemp, D. S.; Cox, D. D.; Paul, K. G. *Ibid.* **1975**, *97*, 7312.

[5] For a recent review, see: Lindman, B.; Wennerström, H. *Top. Curr. Chem.* **1980**, *87*, 1.

[6] Sudhölter, E. J. R.; Engberts, J. B. F. N. *J. Phys. Chem.* **1979**, *83*, 1854.

[7] Menger, F. M.; Portnoy, C. E. *J. Am. Chem. Soc.* **1967**, *89*, 4698.

0022-3263/82/1947-5015$01.25/0