^{13}C Nuclear Magnetic Resonance Studies of Azide-containing C_{18} Fatty Ester Derivatives

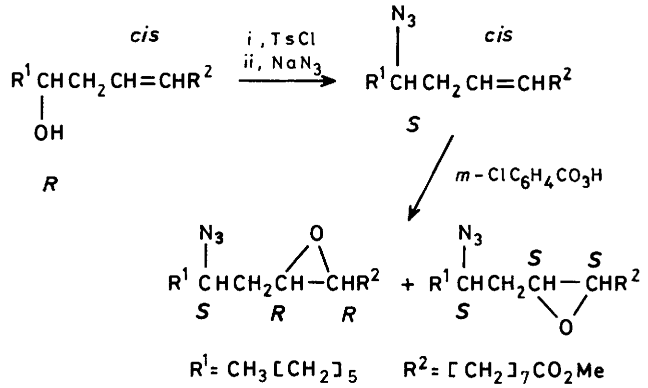
Marcel S. F. Lie Ken Jie* and H. B. Lao
Department of Chemistry, University of Hong Kong, Pokfulam Road, Hong Kong

The ^{13}C n.m.r. spectra of mono-, di-, and tri-azido C_{18} fatty esters, and seven other C_{18} derivatives containing an azido and another functional group (acetate, bromo, ethylene, epoxy, hydroxy, methoxy, or tosyl) are reported. The azido group exerts a deshielding effect on the α- and β-carbon atoms. The carbon atom at the γ-position is shielded. The ^{13}C chemical non-equivalence caused by diastereoisomers in some of the derivatives studied is reflected in the different shifts for these asymmetric carbon nuclei.

The synthesis and some physical properties of a series of C_{18} methyl esters containing azido groups (mono-, di-, and tri-azides) and other functional groups (acetate, bromo, ethylene, epoxy, hydroxy, methoxy, or tosyl) have been reported elsewhere.[1] A ^{13}C n.m.r. spectral analysis of these derivatives has been conducted to study the shielding and deshielding effects of the azido group towards the adjacent carbon atoms.

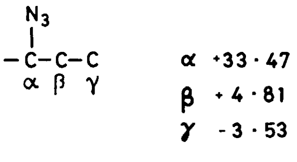
Results and Discussion

The chemical shifts of the various carbon nuclei of the ten C_{18} azido fatty ester derivatives are given in the Table. With the exception of compound (**2**), prepared from methyl oleate, the derivatives were obtained from methyl ricinoleate. During the chemical transformation of methyl ricinoleate, the configuration at C-12 was inverted to yield an (*S*)-azido stereoisomer by an S_N2 reaction. Reactions involving the *cis*-ethylenic bond of the substrate also gave rise to mixtures of diastereoisomers (see Scheme 1).



Scheme 1.

From the ^{13}C n.m.r. spectrum of compound (**1**), the substituent increments (in p.p.m.) due to the azido group (at C-12 of the alkyl chain) were deduced for the α-, β-, and γ-carbon atoms (Scheme 2). The increments were derived by subtracting 29.7 p.p.m. from the observed chemical shift values for compound (**1**) in accordance with the Grant–Paul relation.[2,3] By making further use of the empirical increments of substituents listed by Breitmaier and Bauer,[4] the chemical shifts for the carbon atoms between C-8 and C-13 in each derivative could be readily calculated. On the basis of these estimated chemical shifts, assignments of the signals were made (Table). The combined α- and β-effects on C-9 and C-10 caused the signals for these nuclei to shift to 65.87 p.p.m. in compound (**2**). As the γ-effect caused shielding effect, the signals for the methylene carbon above on either side of the two azido groups were shifted to 30.05 p.p.m. Compound (**3**) provided the facility to observe the combined α-, β-, and γ-effects in operation on the various carbon atoms from C-7 to C-14. The most downfield signal for α-carbon attached to an azido group was assigned to C-9 (65.88 p.p.m.), followed further upfield by C-10 (62.09 p.p.m.) and C-12 (60.19 p.p.m.); the last was influenced solely by the γ-effect from the azido group at C-10. The shift for C-10 was influenced by a combination of β- and γ-effects from azido groups at C-9 and C-12, respectively. The C-9 signal was identified as the further downfield signal of those of the azido-substituted carbon atoms, as both α- and β-effects contributed to its deshielding. The chemical shifts for C-7, C-8, C-11, C-13, and C-14 of the same derivative (**3**) agreed to within ±0.7 p.p.m. with those calculated.



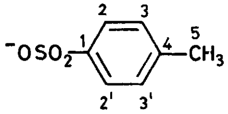
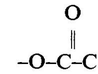
Scheme 2.

Compound (**3**) also showed an additional signal (66.09 p.p.m., assigned to C-9), probably due to the chemical non-equivalence arising from the presence of two diastereoisomers. No reasonable assignment was apparent for a minor signal at 59.81 p.p.m.; this was tentatively assigned to C-12.

The shielding γ-effect on the ethylenic system in compound (**4**) shifted the C-10 signal upfield to 124.65 p.p.m.; that of C-9 appeared at 133.05 p.p.m. The chemical shifts of the carbon atoms between C-7 and C-14 in compounds (**5**), (**6**), (**8**), and (**9**) were assigned without much difficulty. Of great interest were two additional signals assigned to C-9 and C-10 in each case. These signals were the probable result of the chemical non-equivalence of the asymmetric C-9 and C-10, arising from the presence of diastereoisomers. However, in compound (**7**) additional signals were not observed for C-9 and C-10, but the chemical shifts of the *ortho*- and *para*-aromatic carbon atoms in the tosyl groups produced two signals each (144.8/144.9 and 145.1/145.2 p.p.m.). In compound (**8**), the acetate carbonyl signal also appeared as two distinct peaks at 170.43 and 170.27 p.p.m.

Treatment of compound (**5**) with acidified methanol could have given either of two possible positional isomers (**10a**) and (**10b**). A careful analysis of the spectrum of the product showed the presence of both and allowed the assignments of the various carbon atom shifts (see Table), by use of the various empirical increments due to the azido, hydroxy, and methoxy substituents. The methoxy signals appeared at 59.75 and 60.51 p.p.m., respectively.

Table. ^{13}C Chemical shifts (p.p.m.) of methyl azido octadecanoate derivatives

Compd.	Substituents	C-1	C-2	C-3	C-4	C-5	C-6	C-7	C-8	C-9	C-10	C-11	C-12	C-13	C-14	C-15	C-16	C-17	C-18	Me
(1)	12-Azido	174.11	34.13	25.03	29.02	29.20	29.52	29.74	29.52	29.20	26.17	34.51	63.17	34.51	26.17	29.74	31.80	22.64	14.03	51.30
(2)	9,10-Diazido	174.06	34.08	24.92	29.20	29.36	29.03	26.33	30.05	65.87	65.87	30.05	26.33	29.20	29.03	29.74	31.85	22.64	14.03	51.36
(3)	9,10,12-Triazido	174.12	34.08	24.92	29.04	29.04	29.04	25.90	30.93	65.88 (66.09)[a]	62.09	35.05	60.19 (59.81)[a]	34.83	26.02	29.04	31.69	22.59	14.03	51.41
(4)	12-Azido-*cis*-9-ene	174.06	34.07	24.94	29.14	29.14	29.14	29.14	27.41	133.05	124.65	32.34	62.95	34.07	26.12	29.52	31.80	22.59	14.08	51.24
(5)	12-Azido-*cis*-9,10-epoxy	173.14	33.48	24.32	28.65	28.65	28.76	28.87	32.83	(56.55)[a] 55.85	53.57 (53.09)[a]	34.40	60.78	33.80	25.67	28.65	31.31	22.15	13.54	50.65
(6)	12-Azido-*cis*-9,10-diol	174.44	34.13	24.97	29.47	29.09	29.09	25.95	35.21	(74.92) 74.59	73.19 (71.34)[a]	35.54	61.43 (60.02)	34.40	26.16	29.09	31.85	22.59	14.08	51.46
(7)	12-Azido-*cis*-9,10-ditosyl	174.11	34.08	24.87	28.93	28.93	29.36	29.36	29.69	83.32	76.76	34.35	58.24	34.94	25.73	29.09	31.69	22.54	14.03	51.41
												C-1 C-2,2′ C-3,3′	144.8, 144.9 129.75 128.07			C-4 C-5	145.1, 145.2 21.63			
(8)	12-Azido-*cis*-9,10-diacetyl	174.11	34.02	24.87	28.98	28.98	28.98	28.76	29.90	(74.06)[a] 73.79	(71.78)[a] 71.62	35.10	(59.97)[a] 59.48	33.59	25.41	28.98	31.64	22.54	13.98	51.36
										 $-O-\overset{\overset{O}{\parallel}}{C}-CH_3$ 170.48 170.27	20.19									
(9)	12-Azido-*trans*-9,10-dibromo	174.17	34.08	24.92	29.74	29.04	28.66	27.68	35.32 (35.81)[a]	59.32 (58.29)[a]	56.29 (54.34)[a]	40.47 (40.31)[a]	60.84 (60.46)[a]	34.78	25.95	29.04	31.69	22.59	14.03	51.41
(10a)	12-Azido-10-hydroxy-9-methoxy								29.09	84.57	69.45 (70.10)[a]	38.57	59.92							
		174.17	34.08	24.97	29.09	29.09	29.47	29.74						35.38	26.11	29.09	31.69	22.59	14.03	51.36
(10b)	12-Azido-9-hydroxy-10-methoxy								33.59	72.31	81.26	34.08	58.08							
										OCH_3	59.75, 60.51									

[a] Signal of lower intensity in parentheses.

This study revealed that the inductive effect of the azido group caused deshielding at the α- and β-carbon atoms, but significant shielding at the γ-carbon atom.

Experimental

^{13}C N.m.r. spectra were obtained with a JEOL FX90 instrument operating at 22.62 MHz with proton noise decoupling. The spectra (7 000 to 10 000 accumulations; 27° pulse; 30 °C) were obtained from solutions in $CDCl_3$ (0.2—0.3 mol l^{-1}), which also served as an internal deuterium lock. All spectra were calibrated against $SiMe_4$ as internal standard.

Acknowledgements

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References

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