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ALIPHATIC NITRO-COMPOUNDS—LIII*

NITRO DERIVATIVES OF DIOXABORACYCLOHEXANE†

H. PIOTROWSKA, B. SERAFIN and T. URBAŃSKI
Department of Organic Technology, Institute of Technology Warsaw, Poland

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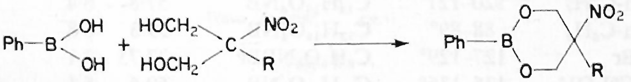
Abstract—A series of new derivatives of 2-phenyl-5-nitro-1,3-dioxa-2-boracyclohexane have been prepared. The properties and I.R. spectra of these compounds are compared with 1,3-dioxane derivatives.

THE reaction of phenylboronic acid with polyhydroxyalcohols yields cyclic esters. Compounds of a similar structure were first obtained by Kuivila *et al.*,[1] from sorbite and mannite etc. By a similar reaction Wolfram and Solms[2] prepared from pentose and 6-desoxyhexose products which are easily hydrolysed in water.

The condensation of phenylboronic acid with 1,2-, 1,3- and 1,4-butanediols yields five- six- and seven-membered ring systems respectively, the reaction of 1,3-butanediol giving the best yield.[3]

According to Salzberg and Signaigo,[4] polymers obtained from polyvinyl alcohol and alkylboronic acid possess the basic structure of borodioxacyclohexane. In 1960 the first boro-organic drug, Clarmil, with tranquilizing activity[5,6] was introduced by the Russel laboratory. Following earlier investigations on reactions of 2-nitro-1,3-propanediol derivatives[7] and aryloboron compounds,[8] we prepared a series of cyclic esters (I) of phenyloboronic acid with 2-nitropropanediol-1,3 and its derivatives.



I

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* Previous papers of this series are:
Part LI: H. Piotrowska, T. Urbański, *J. Chem. Soc.* In press.
Part LII: Z. Eckstein, P. Gluziński, E. Grochowski, M. Mordarski, T. Urbański, *Bull. Acad. Polon. Sci.* In press.

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[1] G. Kuivila, A. H. Keough and E. J. Soboczeński, *J. Org. Chem.* **19**, 780 (1954).

[2] M. L. Wolfram and J. Solms, *J. Org. Chem.* **21**, 815 (1956).

[3] J. M. Sugikava and C. M. Browman, *J. Amer. Chem. Soc.* **80**, 2443 (1958).

[4] P. L. Salzberg and F. K. Signaigo, U.S. Pat. 2,457.603 (1948).

[5] P. Boislambert and G. Wangen, *Archives Hospitalieres* **4**, (1960).

[6] J. M. Farthouat, *Bull. Soc. Chim.* In press.

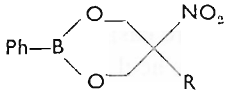
[7] T. Urbański, *Bull. Soc. Chim.* 1475 (1961).

[8] B. Serafinowa, M. Makosza and A. Jośkiewicz, *Roczn Chem.* **36**, 531 (1962); B. Serafinowa, M. Makosza and M. Szretter, *Ibid.* **35**, 489 (1961).

The compounds I are crystalline and are obtained almost quantitatively by heating the starting materials in acetone solution for a short time. With the exception of If (R = Br), they are stable in aqueous solution at normal and elevated temperatures, they are not hydrolysed by diluted acids and alkalis or by conc. hydrochloric acid at room temperature. Boiling with a 20% solution of sodium hydroxide causes decomposition with formation of phenylboronic acid and formaldehyde. As the compounds I are more stable than other acyclic and cyclic phenylboronic esters,[3,4] this probably indicates that the 1,3-dioxa-2-boracyclohexane ring is stabilized by phenyl and nitro substituents in the 2 and 5 positions respectively. 2-Phenyl-5-nitro-5-alkyl-1,3-dioxa-2-boracyclohexanes (Ib,Ic,Id and Ie) are also obtained in lower yields (ca. 50%) by heating phenyloboronic acid with an alcoholic solution of formaldehyde and the respective nitroparaffin.

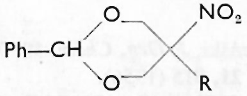
All the derivatives of dioxaboracyclohexane I were identified by elementary analysis and I.R. spectra (strong band characteristic for B—O and NO_2 and lack of bands in the OH region). The properties of the compounds (I) are listed in Table 1.

TABLE 1



				Analysis			
Compounds	R	M.p.	Formula	Required		Found	
				%C	%H	%C	%H
Ia	H	151–152°	$C_9H_{10}O_4NB$	52·2	4·8	53·0	5·1
Ib	CH_3	148–150°	$C_{10}H_{12}O_4NB$	54·3	5·4	53·9	5·2
Ic	C_2H_5	130–131°	$C_{11}H_{14}O_4NB$	56·2	5·95	56·0	5·9
Id	n-C_3H_7	120–121°	$C_{12}H_{16}O_4NB$	57·8	6·4	57·4	6·2
Ie	n-C_4H_9	88–89°	$C_{13}H_{18}O_4NB$	59·3	6·8	59·3	6·9
If	Br	127–129°	$C_9H_9O_4NBBr$	37·75	3·1	38·0	3·3
Ig	CH_2OH	135–136°	$C_{10}H_{12}O_5NB$	50·6	5·1	51·3	5·1
Ih	C_6H_5	133–135°	$C_{15}H_{14}O_4NB$	63·6	5·00	64·2	4·8

In order to compare the properties of I with the compounds which do not contain boron, a series of derivatives of 2-phenyl-5-nitro-1,3-dioxane (II) were prepared by condensation of benzaldehyde with the corresponding 2-nitropropanediol-1,3, the reaction being carried out according to Senkus.[9]

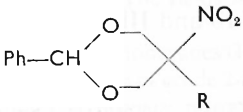


II

Compound IIa was also obtained by treating IIg with sodium methoxide. All the compounds II are crystalline and may be hydrolysed with formation of benzaldehyde. The properties are listed in Table 2.

[9] M. Senkus, *J. Amer. Chem. Soc.* 63, 2635 (1941).

TABLE 2.



Compounds	R	M.p.	Formula	Analysis					
				Required			Found		
				%C	%H	%N	%C	%H	%N
IIa	H	69–70°	$C_{10}H_{11}O_4N$	57·5	5·3	6·7	57·6	5·55	6·85
IIb	CH_3[9]	121–122°							
IIc	C_2H_5	74–75°	$C_{12}H_{15}O_4N$	60·8	6·4	5·9	61·05	6·6	6·1
IId	n-C_3H_7	103–104°	$C_{13}H_{17}O_4N$	62·2	6·8	5·6	62·3	6·75	5·8
IIe	n-C_4H_9	62–63°	$C_{14}H_{19}O_4N$	63·45	7·2	5·2	63·6	7·4	5·4
IIf	Br[10]	87–88°							
IIg	CH_2OH	130–131°	$C_{11}H_{13}O_5N$	55·3	5·5	5·9	55·4	5·4	6·0

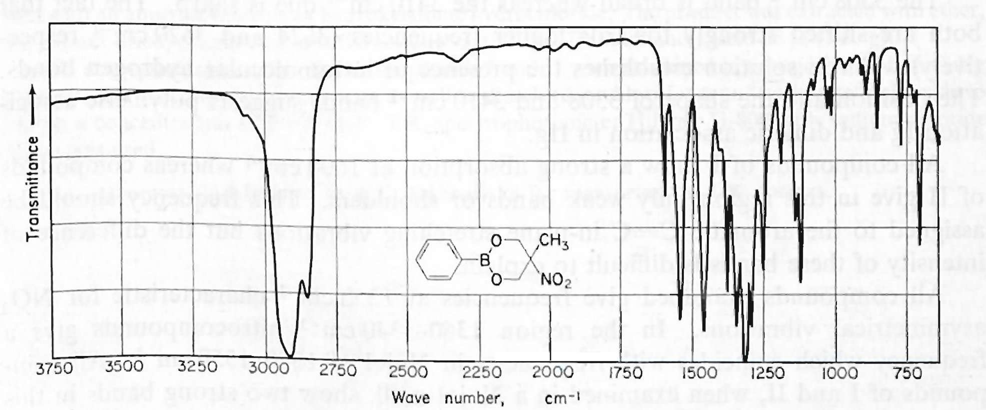


Fig. 1

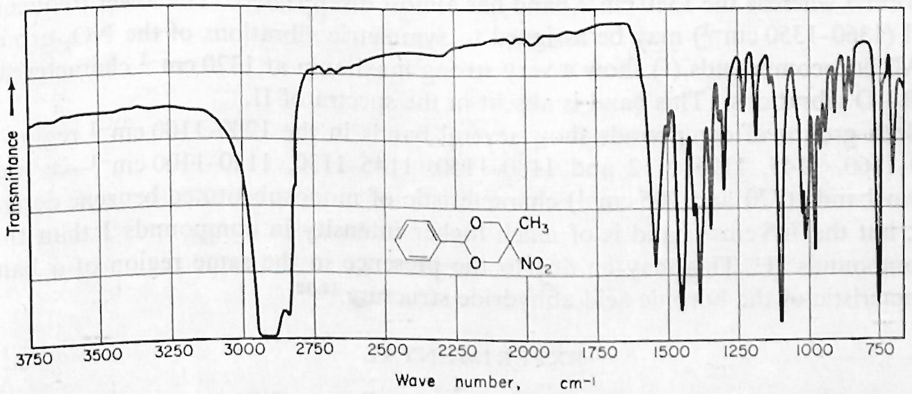


Fig. 2

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[10] Z. Eckstein, *Roczn. Chem.* 27, 246 (1953).

Typical absorption spectra of the compounds I and II are given on Figs 1 and 2 respectively, and the spectra of Ib and IIb are given.

Spectra hue

Compounds Ig and IIg, when examined in Nujol show bands characteristic of hydrogen bonded OH groups. In order to investigate the influence of dilution on the position of particular bands, I.R. spectra of these compounds were measured in the molten state and in $CHCl_3$ and CCl_4 solutions. These conditions caused only a shift of OH bands. The results are collected in Table 3.

TABLE 3.

Compound	Nujol mull	Melt	1% $CHCl_3$ soln.	0·05% CCl_4 soln.
Ig	3308	3558	3606	3624
IIg	3410	3530	3590	3630

The 3308 cm^{-1} band is broad whereas the 3410 cm^{-1} one is sharp. The fact that both are shifted strongly towards higher frequencies (3624 and 3620 cm^{-1} respectively) when in solution establishes the presence of intramolecular hydrogen bonds. The position and the shape of 3308 and 3410 cm^{-1} bands suggests polymeric association Ig and dimeric association in IIg.

All compounds of I show a strong absorption at 1600 cm^{-1} whereas compounds of II give in this region only weak bands or shoulders. This frequency should be assigned to the aromatic C=C in-plane stretching vibrations but the difference of intensity of these bands is difficult to explain.

All compounds examined give frequencies at 1550 cm^{-1} characteristic for NO_2 asymmetrical vibrations. In the region 1360–1340 cm^{-1} nitrocompounds give a frequency which coincides with frequencies in Nujol of 1380–1350 cm^{-1}. All compounds of I and II, when examined in a Nujol mull, show two strong bands in this region—1380 cm^{-1} and 1360–1350 cm^{-1}.

Compounds Ig and IIg, when in a molten state, give a very distinct band at 1360 cm^{-1} whereas the 1380 cm^{-1} band has almost disappeared. The lower frequency band (1360–1350 cm^{-1}) may be assigned to symmetric vibrations of the NO_2 group.

All borocompounds (I) show a very strong maximum at 1320 cm^{-1} characteristic for B—O vibrations. This band is absent in the spectra of II.

Both groups of compounds show several bands in the 1200–1100 cm^{-1} region—1200–1160, 1145, 1126–1112 and 1180–1150, 1145–1130, 1120–1100 cm^{-1}—as well as two bands (770 and 705 cm^{-1}) characteristic of monosubstituted benzene derivatives, but the 705 cm^{-1} band is of much higher intensity in compounds I than that of compounds II. This may be due to the presence in the same region of a band characteristic of the boronic acid anhydride structure.[11,12]

EXPERIMENTAL

Derivatives of 2-*phenyl* 5-*nitro*-1,3-*dioxa*-2-*boracyclohexane* (I)

A. Phenylboronic acid (0·03 mole) and the corresponding 2-nitropropanediol-1,3 (0·03 mole) were heated under reflux in 20 ml acetone for ½–1 hr. Active carbon was added, the solution filtered and the solvent evaporated. The colourless, crystalline products (I) were crystallized from methanol (Ia, Ic, Ie), acetone (Ib, Id, If, Ih) or benzene (Ig). The yields were ca. 95%; The m.ps. and analyses are given in Table 1.

B. 2-Phenyl-5-nitro-5-alkyl-1,3-dioxa-2-boracyclohexanes (Ib, Ic, Id, Ie) may also be prepared by adding phenylboronic acid (0·03 mole) to a solution of crude 2-nitro-2-alkylpropanediol-1,3 obtained by heating paraformaldehyde (0·06 mole), a primary nitroparafin RCH_2NO_2 ($R = CH_3$, C_2H_5, n-C_3H_7 and n-C_4H_9; 0·03 mole) and a small amount of triethylamine in 10 ml ethanol. The ethanol was evaporated on a steam bath, then acetone added and the solution refluxed for ½ hr. Further procedure was as under A, the yields were ca. 50%.

Derivatives of 2-*phenyl* 5-*nitro*-1,3-*dioxane* (II)

A. Benzaldehyde (0·1 mole), the corresponding 2-nitropropanediol-1,3 (0·1 mole) and a small amount of *p*-toluenesulphonic acid were heated in 50 ml benzene, the reaction water being removed in the form of an azeotrope with benzene. After 1·8 ml water had been collected, the benzene solution was cooled, washed with sodium bicarbonate solution, dried and evaporated. The crude product was purified by crystallization from ethanol, yields ca. 95%. The properties of the compounds are listed in the Table 2.

B. 2-*Phenyl*-5-*nitro*-1,3-*dioxane* (IIa). 2-Phenyl-5-nitro-5-hydroxymethyl-1,3-dioxane (4·8 g; 0·02 mole) in methanol (25 ml) were mixed with a 4% solution of sodium methoxide in methanol (27 ml; 0·02 mole) and heated for 5 min at 40–45°. The mixture was cooled and dry ether (300 ml) added. The precipitated sodium salt was filtered off, dissolved in water (20 ml) and carefully neutralized with an aqueous solution of hydroxylamine hydrochloride. The product was extracted with ether, the extract dried, evaporated and the residue crystallized from ethanol, yield 38% (1·60 g).

I.R. absorption spectra of all the compounds I and II were examined in a Nujol mull, Ig and IIg were also examined in the molten state as well as dissolved in chloroform and carbon tetrachloride to obtain a concentration of 0·005 M/P. I.R. spectrophotometer Hilgher H-800 with sodium chloride prism was used.

The authors are indebted to Mrs. U. Dabrowska for measuring the I.R. spectra.