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# Synthesis and Basic Hydrolysis of Diesters of α-Anilinobenzylphosphonic Acid. Conformational Study of Esters by Nuclear Magnetic Resonance Spectroscopy

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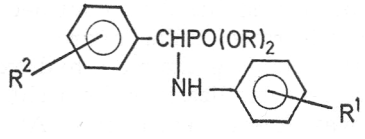
Neutral esters of α-anilinobenzylphosphonic acid, $R^1C_6H_4$—$NHCH(C_6H_4R^2)PO(OR)_2$, ($R^1$, $R^2$ = H, $NO_2$, $NH_2$, OH, COOH, Br; R = Et, Oct.), were prepared and the influence of the substituents on their alkaline hydrolysis was investigated. In most cases, even with an excess of NaOH, sodium salts of the monoesters were formed. Exceptions were *p*-nitro derivatives (*1, 2*) where a rupture of the P—C bond took place, and a 2-hydroxybenzyl derivative (*7*) which afforded disodium salt of phosphonic acid (*15*). The corresponding monoester (*21*) was prepared in a high yield from *7* with an equimolar amount of NaOH. The NMR spectral studies indicated that the ethyl ester groups in neutral esters are not equivalent. This phenomenon is discussed in terms of hydrogen bonding and different conformation. A triplet was obtained for the $CH_3$ group only in ethyl monoesters and their sodium salts where a $PO_2^-$ ion presumedly exists.

The preparation of certain monoesters of α-anilinobenzylphosphonic acid has been reported.[1-3] Since some of them have been applied as extractants[4] and reagents for the spectrophotometric determination[5] of metals, the present investigations have been undertaken as a continuation of our search for such new potential agents. To prepare monesters, alkaline hydrolysis of the corresponding diesters have been found a safe and convenient procedure.[1-3] An objective of this study was to synthesize some new derivatives of α-anilinobenzylphosphonic acid (type I and II) and to examine the influence of various substituents in I on either aromatic ring on the basic hydrolysis of such neutral esters. Particularly interesting were the hydroxyaryl-substituted esters and their stability in basic medium since it is well known that the C—P link in α-hydroxyalkylphosphonates is readily cleaved by the action of alkalies.[6] The $^1H$ NMR spectra were studied to learn about the conformation of these compounds in solution.

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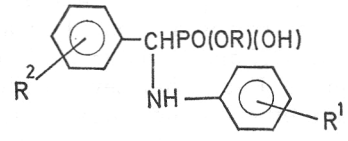


II

The neutral esters (I) were prepared by the known procedure[7] modified in that no catalyst was used, except for the preparation of *12* which was possible to obtain only in the presence of sodium ethoxide. In most cases, the condensation of dialkyl phosphonates and Schiff's bases afforded diesters as crystalline compounds. Dioctyl esters *4* and *6* were obtained as oils difficult to purify because of their extreme solubility in organic solvents. Also, 2-hydroxybenzyl diester *7* was obtained as a glassy solid which did not crystallize. This compound was described by Pudovik and Korchemkina[7] as an oil. Since no other data on the purity of this compound were available, we reexamined the preparation of *7* by the NMR study. About 3 hr of heating was found sufficient to obtain a quantitative yield of *7*, as during this time a peak at $\delta$ ($CDCl_3$) 8.9 due to the Schiff's base N=*CH*(Ph) proton disappeared and was substituted by a new doublet at $\delta$ 5.06 of the benzyl N—*CH*(Ph)—P proton. In most cases 6—8 hr of heating sufficed. The preparation of *5* was accomplished by keeping a mixture of diethyl phosphonate and 2-bromobenzalaniline over night at room temperature. However, a mixture of dioctyl phosphonate and 2-bromobenzalaniline ought to be heated for 50 hr at 100 °C. Since no significant difference in reactivity between diethyl and dioctyl phosphonate was otherwise observed, the noted difference must have been caused by the steric hindrance due to a large bromine atom.

An attempted hydrolysis of *1* and *2* gave only products of decomposition. Reduction of the nitro group in *1* and *2* was attempted with hydrogen (about 3 atm) in a Parr apparatus and in the presence of Raney-Nickel. This procedure was applied to reduce diethyl nitrophenylphosphonate.[8] When applied to *1* and *2*, the reduction brought about some cleavage of the P—C bond. Reduction with a mixture of iron-water-acetic acid[9], gave *3* and *4* in a more than 60% yield. Hydrolysis of *3* and *4* with a moderate excess of NaOH afforded the corresponding sodium salts *13* and *14* of which only *14* could be purified because of its better solubility in organic solvents. Both sodium salts were treated with dil. HCl to give orange solids insoluble in organic solvents. These products must be some polymers which, due to their insolubility, were not identified.

Hydrolysis of the hydroxy-substituted diesters *8*, *9* and *12*, with an OH group in the *meta* or *para* position, as well as the *ortho*-hydroxyanilino derivative *10*, afforded sodium salts of the monoesters, though an excess of at least 2 mole equivalents of NaOH was used. *Ortho*-hydroxybenzyl diester *7* behaved differently and was the only exception. Under the same condition, *7* gave disodium salt of the phosphonic acid *15*. Hydrolysis of both ethoxy groups must be affected by the presence of the vicinal phenolic OH group. However, the coresponding monoester *21* was obtained in 86% yield when the hydrolysis was carried out with one mole equivalent of NaOH.

The properties of *21* differ from those of other hydroxysubstituted monoesters in that it is quite stable and could be recrystallized without decomposition. The stability is attributed to a strong intramolekular hydrogen bonding between the OH and P=O group. The most unstable is the meta-hydroxybenzyl monoester *22*. Even after several sucessive recrystallizations from chloroform--petroleum ether, some tarry material was formed each time. Although a quite pure *22* could not be obtained, the product gave a reasonable elemental analysis and its composition was further verified by the NMR spectrum.

*Para*-hydroxybenzyl monoester *23* was obtained after recrystallization from ethanol as a solid, m. p. 158—160 °C (decomp.). Prolonged heating in ethanol yielded a new product with m. p. 235—240 °C (decomp.) which was insoluble in organic solvents including ethanol. The NMR spectrum of the latter compound, taken in trifluoroacetic acid, showed the features of *23*, the elemental analysis was consistent with the formula $(C_{15}H_{18}NO_4P)_x$, but the ir spectrum did not show the phenolic OH absorption. Therefore, this compound must be a polymer. More stable was 2-hydroxyanilino monoester *24*. Its stability could also be attributed to the intramolecular hydrogen bonding between the OH and P=O group. The introduction of a carboxylic group, vicinal to a phenolic OH group, leads to an increased stability of such a monoester. An example is *26* where an intramolecular hydrogen bonding occurs between the COOH and OH group. One another peculiarity of the less stable monoesters *22*, *24*, and, to a certain degree of *23*, is that they show great affinity to bind the water of crystallization. The amount of water varies and affects the melting point of the compounds. The loss of the water brings about decomposition of the compounds. Therefore, the water appears to be essential to stabilize the molecule by forming hydrogen bridges. Such a property has not been observed with other monoesters of α-anilinobenzylphosphonic acid[1-3], but only with their sodium salts.[10]

The $^1$H NMR spectra of the neutral esters of α-anilinobenzylphosphonic acid (Table I) show that the two esters groups are not equivalent. Dioctyl esters gave a too broad and complex absorption of the alkyl chains to allow analysis. Our discussion will be therefore restricted mainly to diethyl esters. The complexity may also arise from an asymmetric center at the benzylic carbon atom. Thus, *para*-substituted diesters *1*, *3*, *9*, *and 12* gave four peaks for the two $CH_3$ groups. These resonances result from a partial overlapping of signals of the non-equivalent $CH_3$ groups. A non-substituted ester *28*, *ortho*-*5*, *7*, *10* and *meta*-substituted ester *8* gave two distinctive triplets (J=7 Hz), each corresponding to one $CH_3$ group. A doubling of signals have been observed with some esters of phosphonic acid but rarely with ethyl esters.[11] The resonance doubling has been discussed as a result of hindered rotation around the P—O—C bonds. Since this rotation is rapid[12], the restricted rotation is due to the presence of benzene rings. Because of the diamagnetic anisotropy of the benzene rings, protons of the other groups, if they are close to the ring, will resonate at a different field than those far from the ring.[13] A Fischer-Hirschfelder-Taylor model of the diesters demonstrates that the ethoxy groups cannot be, on the average, in the same proximity to the benzene rings and thus in the same magnetic environment. This is also shown in Figure 1 in which the phosphorus atom is represented with a tetrahedron (full line) and, below it, the α-carbon atom of the benzyl group, so that the C—P bond is perpendicular to the plane of the paper. Intramolecular hydrogen bonding which exists in diesters *7*, *8* and *10* would further restrict the free rotation around the C—P linkage. A large substituent, such as the bromine in *5* would have a similar effect. In a rigid structure, the position of the $CH_3$ groups is even more fixed. They are in a different magnetic environment and appear as two sets of separate resonances.

The absorption of the methylene protons of the ethoxy groups in diesters is complex. In addition to the coupling between the $CH_2$ and $CH_3$ protons,

TABLE I

*$^1H$ NMR spectral data for diesters of α-anilinobenzylphosphonic acid*

| Compd. | Formula | $^1H$ NMR spectral assignments |
|---|---|---|
| *1* | $C_6H_5NHCH(4\text{-}O_2NC_6H_4)PO(OC_2H_5)_2$ | $\delta^a$ 6.2—8.32 (m, 10 H, ArH, NC$^c$), 5.3 (dd, 1 H, J=25 and 10 Hz, CH), 3.64—4.35 (m, 4 H, $CH_2$), 0.99—1.31 (4 lines, 6 H, $CH_3$). |
| *2* | $C_6H_5NHCH(4\text{-}O_2NC_6H_4)PO(OC_8H_{17})_2$ | $\delta^a$ 6.2—8.32 (m, 10, H, ArH, NH$^c$), 5.3 (broad d, 1 H, J=26 Hz, CH), 3.6—4.3 (m, 4 H, α-$CH_2$), 0.6—1.8 (m, 30 H, $(CH_2)_6CH_3$). |
| *3* | $C_6H_5NHCH(4\text{-}H_2NC_6H_4)PO(OC_2H_5)_2$ | $\delta^b$ 6.45—7.4 (m, 9 H, ArH), 4.66 (broad d, 2 H, J=24 Hz, CH, NH$^c$), 3.0—4.26 (m, 6 H, $CH_2$, $NH_2{}^c$), 0.95—1.4 (4 lines, 6 H, $CH_3$). |
| *4* | $C_6H_5NHCH(4\text{-}H_2NC_6H_4)PO(OC_8H_{17})_2$ | $\delta^b$ 6.4—7.4 (m, 9 H, ArH), 4.66 (broad d, 2 H, J=24 Hz, CH overlapping with NH$^c$), 3.3—4.3 (m, 6 H, α-$CH_2$, $NH_2{}^c$), 0.6—1.6 (m, 30 H, $(CH_2)_6CH_3$). |
| *5* | $C_6H_5NHCH(2\text{-}BrC_6H_4)PO(OC_2H_5)_2$ | $\delta^a$ 6.32—7.82 (m, 10 H, ArH, NH$^c$), 5.23 (dd, 1 H, J=25 and 9 Hz, CH), 3.47—4.39 (m, 4 H, $CH_2$), 1.22 (t, 3 H, J=7 Hz, $CH_3$), 1.02 (t, 3 H, J=7 Hz, $CH_3$). |
| *5* | $C_6H_5NHCH(2\text{-}BrC_6H_4)PO(OC_2H_5)_2$ | $\delta^b$ 6.5—7.78 (m, 9 H, ArH), 5.4 (dd, 2 H, J=25 and 8 Hz, CH overlaping with NH$^c$), 3.4—4.48 (m, 4 H, $CH_2$), 1.2 (t, 3 H, J=7 Hz, $CH_3$), 1.0 (t, 3 H, J=7 Hz, $CH_3$). |
| *7* | $C_6H_5NHCH(2\text{-}HOC_6H_4)PO(OC_2H_5)_2$ | $\delta^a$ 9.75 (broad s, 1 H, OH$^c$), 6.4—7.78 (m, 9 H, ArH), 6.13 (broad s, 1 H, NH$^c$), 5.35 (dd, 1 H, J=24 and 10 Hz, CH), 3.6—4.4 (m, 4 H, $CH_2$), 1.25 (t, 3 H, J=7 Hz, $CH_3$), 1.02 (t, 3 H, J=7 Hz, $CH_3$). |
| *7* | $C_6H_5NHCH(2\text{-}HOC_6H_4)PO(OC_2H_5)_2$ | $\delta^b$ 6.54—7.51 (m, 11 H, ArH, NH$^c$, OH$^c$), 5.06 (d, 1 H, J=23 Hz, CH), 3.67—4.41 (m, 4 H, $CH_2$), 1.22 (t, 3 H, J=7 Hz, $CH_3$), 1.16 (t, 3 H, J=7 Hz, $CH_3$). |

| | | |
|---|---|---|
| *8* | $C_6H_5NHCH(3\text{-}HOC_6H_4)PO(OC_2H_5)_2$ | $\delta^b$ 8.33 (broad s, 1 H, OH[c]), 6.45—7.35 (m, 9 H, ArH), 4.75 (broad d, 2 H, J=23 Hz, CH, NH[c]), 3.42—4.23 (m, 4 H, $CH_2$), 1.25 (t, 3 H, J=7 Hz, $CH_3$), 1.05 (t, 3 H, J=7 Hz, $CH_3$). |
| *9* | $C_6H_5NHCH(4\text{-}HOC_6H_4)PO(OC_2H_5)_2$ | $\delta^b$ 8.26 (broad s, 1 H, OH[c]), 6.45—7.4 (m, 9 H, ArH), 4.72 (broad d, 2 H, J=24 Hz, CH, NH[c]), 3.62—4.34 (m, 4 H, $CH_2$), 0.98—1.34 (4 lines, 6 H, $CH_3$). |
| *10* | $2\text{-}HOC_6H_4NHCH(C_6H_5)PO(OC_2H_5)_2$ | $\delta^b$ 8.56 (broad s, 1 H, OH[c]), 6.32—7.6 (m, 10 H, ArH, NH[c]), 4.9 (d, 1 H, J=25 Hz, CH), 3.3—4.45 (m, 4 H, $CH_2$), 1.25 (t, 3 H, J=7 Hz, $CH_3$), 1.05 (t, 3 H, J=7 Hz, $CH_3$). |
| *11* | $4\text{-}HOOCC_6H_4NHCH(C_6H_5)PO(OC_8H_{17})_2$ | $\delta^b$ 8.94 (broad s, 1 H, COOH[c]), 6.56—8.1 (m, 9 H, ArH), 6.4 (broad s, 1 H, NH[c]), 4.88 (broad d, 1 H, J=24 Hz, CH), 3.4—4.35 (m, 4 H, $\alpha$-$CH_2$), 0.7—1.76 (m, 30 H, $(CH_2)_6CH_3$). |
| *12* | $(3\text{-}HO,4\text{-}HOOCC_6H_3)NHCH(C_6H_5)PO(OC_2H_5)_2$ | $\delta^a$ 13.83 (broad s, 2 H, OH[c], COOH[c]), 6.24—7.70 (m, 9 H, ArH, NH[c]), 5.15 (dd, 1 H, J=24 Hz and 9 Hz, CH), 3.6—4.3 (m, 4 H, $CH_2$), 0.92—1.33 (4 lines, 6 H, $CH_3$). |
| *28* | $C_6H_5NHCH(C_6H_5)PO(OC_2H_5)_2$[21] | $\delta^a$ 6.6—7.7 (m, 11 H, ArH, NH[c]), 5.01 (dd, 1 H, J=25 and 10 Hz, CH), 3.45—4.32 (m, 4 H, $CH_2$), 1.16 (t, 3 H, J=7 Hz, $CH_3$), 1.02 (t, 3 H, J=7 Hz, $CH_3$). |
| *28* | $C_6H_5NHCH(C_6H_5)PO(OC_2H_5)_2$[21] | $\delta^b$ 6.5—7.68 (m, 10 H, ArH), 4.8 (d, 2 H, J=24 Hz, CH overlapping with NH[c]), 3.44—4.38 (m, 4 H, $CH_2$), 1.18 (t, 3 H, J=7 Hz, $CH_3$), 1.03 (t, 3 H, J=7 Hz, $CH_3$). |

[a] Dissolved in DMSO-$d_6$; [b] Dissolved in $CDCl_3$; [c] Exchangeable protons were determined by the $D_2O$ exchange.

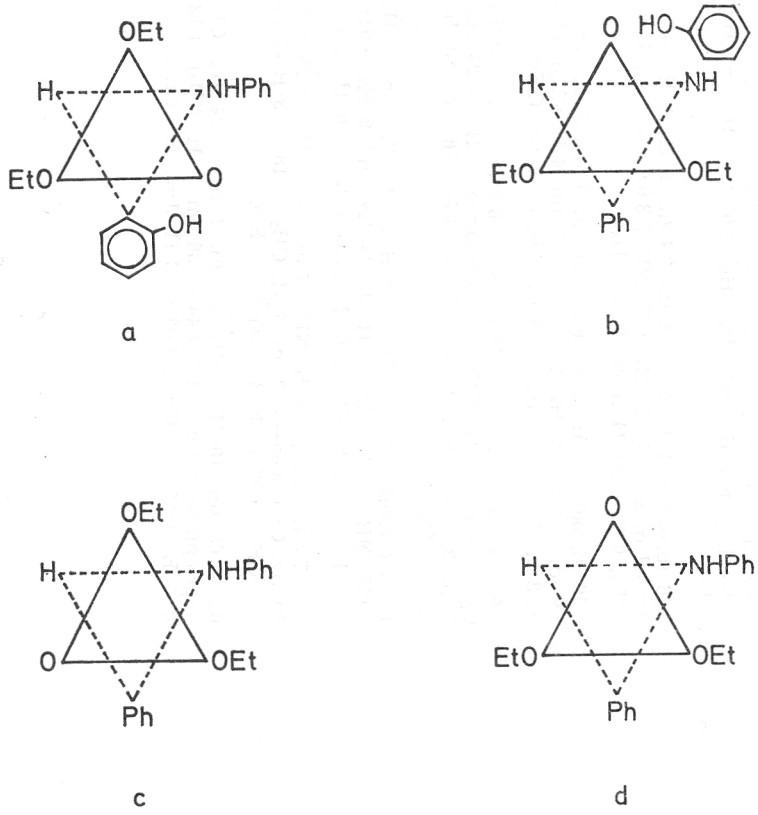


Figure 1

there is a spin-spin splitting of the $CH_2$ protons by the phosphorus. The complexity is further increased because the two $CH_2$ groups, and even both hydrogens in one $CH_2$ group, are not equivalent, as one of them is closer to a benzene ring than the other and they resonate at different field.

The proton of the benzylic CH group usually appeared in $(CD_3)_2SO$ as a doublet of a doublet, because of the spin-spin interaction with the phosphorus ($J = 23—25$ Hz) and with the NH proton ($J = 8—10$ Hz). $D_2O$ exchange eliminated the smaller splitting and retained the larger one. In $CDCl_3$, a doublet for the CH group was observed because of the splitting with the phosphorus. The interaction between the NH and CH protons was not always observed even in $(CD_3)_2SO$. The doublets observed in *3*, *8*, and *9* were broad and blurred. They were integrated for 2 protons and were therefore overlapping with the NH resonances. Shaking with $D_2O$ always produced sharp doublets for the CH proton coupled to the phosphorus.

The position of the NH resonances was helpful in chosing between the conformations *c* and *d* shown in Figure 1. Because of its tendency to form hydrogen bonds, a P=O group would come, if sterically possible, in proximity to an NH group. This would result in a downfield shift of the NH resonance. If a compound contains a substituent, such as an OH, $NH_2$, or COOH group,

capable of forming strong intra- or inter-molecular hydrogen bonds with the P=O group, the interaction between the NH and P=O group would become either sterically impossible or much weaker which would result in an upfield shift of the NH resonances. This is what was actually been observed. *Para*--amino (*3, 4*), *meta*-hydroxy (*8*) and *para*-hydroxy (*9*) groups may form intermolecular hydrogen bonds with the P=O group leaving thus the NH group »free« so that its resonance was shifted, as expected, toward a higher field, often overlapping with the CH absorption. On the other hand, *para*-nitro (*1, 2*), *ortho*-hydroxy (*7, 10*), *ortho*-bromo (*5*) and a non-substituted compound (*28*) gave rise to a downfield shift of the NH resonances. On the basis of these observation it could be inferred that *7* and *10* in solution have the conformations *a* and *b*, respectively, as shown in Figure 1. The compounds in which the NH group is involved in hydrogen bonding are shown in Figures 1*d* (for simplicity the substituents have been omitted), and those compounds in which such a bonding is precluded, *e. g.* because of an intermolecular P=O and OH bonding, in Figure 1*c*. These conclusions are also substantiated by the phenolic OH resonances observed.

The NMR spectra of the monoesters (Table II) and their sodium salts (Table III) are relatively simple in that they show only one triplet (J = 7 Hz) for the $CH_3$ part of the $POCH_2CH_3$ grouping. It has been observed with some acidic phosphorus compounds[11,13] that the P—OH group does not show the spin-spin coupling with phosphorus. The lack of doublets is thought to arise either from a rapid exchange of the proton between the two oxygens or from an equal distribution between them. In either case, the average magnetic environment for the $CH_3$ group would be the same as it cannot be far from or close to either P=O or P—OH group but rather to a $PO_2^-$ group. Therefore, only a triplet would result bacause of coupling between the $CH_2$ and $CH_3$ groups. Such a reasoning is also applicable to the monoesters of α-anilinobenzylphosphonic acid. In addition, all monoesters show an exchange between the $PO_2^-H^+$ and the NH proton. The monoesters gave a broad single peak, comprising of two protons, which disappeared after the $D_2O$ exchange. A similar explanation also holds good for the observed triplets (J=7 Hz) in the sodium salts of the monoesters in which sodium is presumably bonded to both oxygens, *i. e.* to a $PO_2^-$ ion.

The methylene proton resonances in monoesters and sodium salts are very complex. The non-equivalence of the methylene protons has been observed in some ethyl esters of aliphatic phosphorus compounds.[14] It has been attributed to an internal asymmetry of the phosphorus atom bearing three different substituents what brings methylene protons in a non-equivalent environment. This explanation is not applicable to the monoesters of α-anilinobenzylphosphonic acid where the same factors that have been discussed for the diesters are responsible for the complexity. Although the overlapping of the singnals usually resulted in an unresolved mulitiplet, monoesters *23, 24, 26,* and *30* gave five distinctive peaks.

In monoesters and their sodium salts the benzyl CH resonances showed only coupling with the phosphorus, the magnitude of which varied between J = 22—24 Hz. The lack of the coupling to the NH proton in monoesters is consistent with the observed exchange of the NH and $PO_2^-H^+$ protons. Since most of the sodium salts are insufficiently soluble in organic solvents, the

TABLE II

*$^1$H NMR spectral data for sodium salts of monoesters α-anilinobenzylphosphonic acid*

| Compd. | Formula | $^1$H NMR spectral assignments |
|---|---|---|
| *13* | $C_6H_5NHCH(4\text{-}H_2NC_6H_4)PO(OC_2H_5)ONa$ | $\delta^d$ 6.2—7.4 (m, 9 H, ArH), 4.56 (d, 1 H, J=23 Hz, CH), 3.38—4.12 (m, 2 H, $CH_2$), 1.08 (t, 3 H, J=7 Hz, $CH_3$). |
| *14* | $C_6H_5NHCH(4\text{-}H_2NC_6H_4)PO(OC_8H_{17})ONa \cdot H_2O$[1] | $\delta^a$ 6.25—7.18 (m, 9 H, ArH), 5.4 (broad s, 2 H, $H_2O^c$), 4.12 (broad d, 2 H, J=22 Hz, CH, $NH^c$), 3.2—3.75 (m, 4 H, α-$CH_2$, $NH_2^c$), 0.6—1.5 (m, 15 H, $(CH_2)_6CH_3$). |
| *15* | $C_6H_5NHCH(2\text{-}HOC_6H_4)PO(ONa)_2$ | $\delta^d$ 6.55—7.5 (m, 9 H, ArH), 4.62 (d, 1 H, J=22 Hz, CH). |
| *16* | $C_6H_5NHCH(2\text{-}BrC_6H_4)PO(OC_2H_5)ONa$ | $\delta^d$ 6.13—7.5 (m, 9 H, ArH), 5.07 (d, 1 H, J=23 Hz, CH), 3.4—3.97 (m, 2 H, $CH_2$), 0.98 (t, 3 H, J=7 Hz, $CH_3$). |
| *17* | $C_6H_5NHCH(2\text{-}BrC_6H_4)PO(OC_8H_{17})ONa$ | $\delta^d$ 6.15—7.6 (m, 9 H, ArH), 5.08 (d, 1 H, J=23 Hz, CH), 3.4—4.0 (m, 2 H, α-$CH_2$), 0.4—1.5 (m, 15 H, $(CH_2)_6CH_3$). |
| *29* | $C_6H_5NHCH(C_6H_5)PO(OC_8H_{17})ONa \cdot 0.5H_2O$[1] | $\delta^a$ 6.25—7.6 (m, 10 H, ArH), 5.75 (broad s, 1H, $NH^c$), 4.4 (broad d, 1 H, J=22 Hz, CH), 3.35—3.76 (m, 3 H, α-$CH_2$, 0.5 $H_2O^c$), 0.65—1.5 (m, 15 H, $(CH_2)_6CH_3$). |

[a] Dissolved in DMSO-$d_6$; [c] Exchangeable protons were determinedd by the $D_2O$ exchange
[d] Dissolved in $D_2O$.

TABLE III

*$^1H$ NMR spectral data for monoesters of α-anilinobenzylphosphonic acid*

| Compd. | Formula | $^1H$ NMR spectral assignments |
|---|---|---|
| *19* | $C_6H_5NHCH(2\text{-}BrC_6H_4)PO(OC_2H_5)OH$ | $\delta^a$ 6.35—8.2 (m, 11 H, ArH, OH$^e$, NH$^e$), 5.1 (d, 1 H, J=24 Hz, CH), 3.56—4.16 (m, 2 H, $CH_2$), 1.08 (t, 3 H, J=7 Hz, $CH_3$). |
| *20* | $C_6H_5NHCH(2\text{-}BrC_6H_4)PO(OC_8H_{17})OH$ | $\delta^b$ 9.18 (broad s, 2 H, OH$^e$, NH$^e$), 6.6—7.8 (m, 9 H, ArH), 5.38 (d, 1 H, J=24 Hz, CH), 3.66—4.05 (m, 2 H, α-$CH_2$), 0.67—1.33 (m, 15 H, $(CH_2)_6CH_3$). |
| *21* | $C_6H_5NHCH(2\text{-}HOC_6H_4)PO(OC_2H_5)OH$ | $\delta^a$ 6.35—8.1 (m, 12 H, ArH, POH$^e$, OH$^e$, NH$^e$), 5.15 (d, 1 H. J=24 Hz, CH), 3.28—4.14 (m, 2 H, $CH_2$), 1.06 (t, 3 H, J=7 Hz, $CH_3$). |
| *22* | $C_6H_5NHCH(3\text{-}HOC_6H_4)PO(OC_2H_5)OH \cdot 0.5H_2O$ | $\delta^a$ 5.0—7.8 (m, 13 H, ArH, POH$^e$, OH$^e$, NH$^e$, 0.5$H_2O^e$), 4.5 (d, 1 H, J=24 Hz, CH), 3.76 (m, 2 H, $CH_2$), 1.03 (t, 3 H, J=7 Hz, $CH_3$). |
| *23* | $C_6H_5NHCH(4\text{-}HOC_6H_4)PO(OC_2H_5)OH$ | $\delta^a$ 6.38—7.5 (m, 9 H, ArH), 5.95 (broad s, 3 H, POH$^e$, OH$^e$, NH$^e$), 4.68 (d, 1 H, J=24 Hz, CH), 3.88 (5 lines, 2 H, $CH_2$), 1.08 (t, 3 H, J=7 Hz, $CH_3$). |
| *24* | $2\text{-}HOC_6H_4NHCH(C_6H_5)PO(OC_2H_5)OH \cdot 0.5H_2$ | $\delta^a$ 5.5—7.8 (m, 13 H, ArH, POH$^e$, OH$^e$, NH$^e$, 0.5$H_2O^e$), 4.8 (d, 1 H, J=24 Hz, CH), 3.9 (5 lines, 2 H, $CH_2$), 1.1 (t, 3 H, J=7 Hz, $CH_3$). |
| *25* | $4\text{-}HOOCC_6H_4NHCH(C_6H_5)PO(OC_8H_{17})OH$ | $\delta^a$ 10.81 (broad s, 3 H, POH$^e$, COOH$^e$, NH$^e$), 6.65—7.77 (m, 9 H, ArH), 4.95 (d, 1 H, J=24 Hz, CH), 3.6—4.05 (m, 2 H, α-$CH_2$), 0.63—1.66 (m, 15 H, $(CH_2)_6CH_3$). |
| *26* | $3\text{-}HO,4\text{-}HOOCC_6H_3NHCH(C_6H_5)PO(OC_2H_5)OH$ | $\delta^a$ 10.83 (broad s, 4 H, POH$^e$, COOH$^e$, OH$^e$, NH$^e$), 6.05—7.7 (m, 8 H, ArH), 4.95 (d, 1 H, J=24 Hz, CH), 3.93 (5 lines, 2 H, $CH_2$), 1.12 (t, 3 H, J=7 Hz, $CH_3$). |
| *27* | $C_6H_5NHCH(2\text{-}HOC_6H_4)PO(OH)_2 \cdot H_2O$ | $\delta^a$ 5.8—7.52 (m, 15 H, ArH, P$(OH)_2{}^e$, OH$^e$, NH$^e$, $H_2O^e$), 5.0 (d, 1 H, J=24 Hz, CH). |
| *30* | $C_6H_5NHCH(C_6H_5)PO(OC_2H_5)OH$[1] | $\delta^a$ 8.68 (broad s, 2 H, NH$^e$, OH$^e$), 6.35—7.67 (m, 10 H, ArH), 4.83 (d, 1 H, J=24 Hz, CH), 3.64—4.18 (5 lines, 2 H, $CH_2$), 1.09 (t, 3 H, J=7 Hz, $CH_3$). |
| *31* | $C_6H_5NHCH(C_6H_5)PO(OC_8H_{17})OH$[1] | $\delta^e$ 10.34 (broad s, 2 H, OH$^e$, NH$^e$), 6.5—7.6 (m, 10 H, ArH), 4.68 (d, 1 H, J=22 Hz, CH), 3.4—3.9 (m, 2 H, α-$CH_2$), 0.65—1.66 (m, 15 H, $(CH_2)_6CH_3$). |

[a] Dissolved in DMSO-$d_6$; [b] Dissolved in $CDCl_3$; [c] Exchangeable protons were determined by the $D_2O$ exchange; [e] Dissolved in $CCl_4$.

spectra were recorded in $D_2O$ so that the NH resonances were not visible. Having an octyl chain, sodium salts *14* and *29* were soluble in $(CD_3)_2SO$ in which solvent they gave a broad doublet for the CH proton coupled to the phosphorus. The broad shape of the doublets results from a weak coupling to the NH proton since, after the $D_2O$ exchange, the doublets became sharp (J = 22 Hz). The overlapping of the CH doublet in *14* with the NH absorption indicates that the NH group is »free« because of the hydrogen bonding between the $NH_2$ and $PO_2^-$ group. To the contrary, the NH absorption in *29* is shifted downfield indicating hydrogen bonding between this group and the $PO_2^-$ group.

In all these compounds, no spin-spin coupling was observed between the $CH_3$ group and the phosphorus nucleus under the conditions of measurement used.

## EXPERIMENTAL

Melting points are uncorrected. The $^1H$ NMR spectra were recorded on a Model A-60 A Varian spectrometer with tetramethylsilane as the internal standard using a sweep width of 500 Hz. The analyses were performed in the Analytical Laboratory of the Ruđer Bošković Institute.

### *Preparation of Schiff's Bases*

4-Nitrobenzalaniline[15], 2-hydroxybenzalaniline[16], 3-hydroxybenzalaniline[17], 4-hydroxybenzalaniline[18], benzal-(2-hydroxyaniline)[19] and benzal-(4-carboxyaniline)[20] were prepared as reported.

*2-Bromobenzalaniline* was prepared by heating of equimolar amounts of aniline and 2-bromobenzaldehyde under nitrogen in a water bath for 15 min. A yellow oil was obtained which was used without purification; ir (film): $\nu_{max}$ 1610 (C=)N), 1580 $cm^{-1}$ (aromatics).

*Benzal-(3-hydroxy-4-carboxyaniline)* was obtained by refluxing a mixture of benzaldehyde (6.94 g, 0.066 mol) and 3-hydroxy-4-carboxyaniline (10 g, 0.066 mol) in benzene (150 ml) for 5 hr in an apparatus provided with a Dean-Stark trap to remove water. The hot mixture was filtered and the solid product was washed with warm benzene to give the title compound (12 g, 75.5%), m. p. 192—194 °C; ir (Nujol): $\nu_{max}$ 1650 (C=N), 1600 $cm^{-1}$ (aromatics).

*Anal.* $C_{14}H_{11}NO_3$ (241.23) calc'd.: C 69.70; H 4.60; N 5.54%
found: C 69.83; H 4.65; N 6.06%

*Dioctyl phosphonate* was prepared according to the procedure described by Nylèn.[21]

### *Diethyl α-Anilino-(4-nitrobenzyl)phosphonate (1)*

A mixture of diethyl phosphonate (11.3 g, 0.05 mol) and 4-nitrobenzalaniline[15] (6.9 g, 0.05 mol) solidified after 8 hr of heating in the water bath. Recrystallization from ethanol (50 ml) afforded *1* (17 g, 93.5%), m.p. 154—156 °C. Repeated recrystallization gave yellow crystals, m.p. 155—157 °C.

*Anal.* $C_{17}H_{21}N_2O_5P$ (364.31) calc'd: C 56.04; H 5.81; N 7.69; P 8.50%
found: C 55.84; H 5.76; N 7.98; P 8.36%

### *Dioctyl α-Anilino-(4-nitrobenzyl)phosphonate (2)*

Heating of dioctyl phosphonate[21] (18 g, 0.059 mol) and 4-nitrobenzalaniline[15] (13 g, 0.058 mol) for 8 hr produced a yellow oil which solidified after cooling and had m.p. 45—48°. The product was dissolved in ether and the solution was washed with aqueous $Na_2CO_3$ (10%) solution and then with vater. After drying ($Na_2SO_4$) and removal of the ether, the remaining oil solidified to give *2* (13.9 g, 98%), m.p. 46—50 °C.

*Anal.* $C_{29}H_{45}N_2O_5P$ (532.62) calc'd: N 5.26; P 5.82%
found: N 5.18; P 5.74%

*Diethyl α-Anilino-(4-aminobenzyl)phosphonate (3)*

A procedure described by Kosolapoff[9] was applied and modified as follows: A suspension of *1* (3.64 g, 0.01 mol) in 8% acetic acid (8 ml) was stirred with a magnetic stirrer in an oil bath. The temperature of the bath was gradually increased to 70 °C and powder iron (6.75 g) was added in small portions. After the addition was completed, the temperature was increased and maintained at 85—90 °C for 45 min. The mixture was extracted with several portion of hot benzene (total 40 ml). The benzene extracts were combined and the excess of benzene was evaporated to give *3* (3.25 g, 97.4%), m.p. 88—90 °C. The product was dissolved in benzene and the solution was purified by column chromatography ($Al_2O_3$, benzene). The eluate was concentrated to yield white crystals (2.6 g, 78%), m.p. 143—145 °C.

*Anal.* $C_{17}H_{23}N_2O_3P$ (334.34) calc'd: C 61.07; H 6.93; N 8.38; P 9.26%
found: C 60.88; H 7.10; N 8.33; P 9.16%

*Dioctyl α-Anilino-(4-aminobenzyl)phosphonate (4)*

Compound *4* was prepared in 60% yield by the reduction of *2* according to the above procedure. A viscous oil was obtained which was used without purification to prepare *14*. It was identified by the NMR spectrum.

*Diethyl α-Anilino-(2-bromobenzyl)phosphonate (5)*

A mixture of diethyl phosphonate (10 g, 0.038 mol) and 2-bromobenzalaniline (5.3 g, 0.038 mol) was allowed to stand at room temperature overnight to solidify. Recrystallization from ethanol gave *5* (10.9 g, 71.3%), m.p. 116—117 °C.

*Anal.* $C_{17}H_{21}BrNO_3P$ (398.23)
calc'd: C 51.27; H 5.32; Br 20.07; N 3.52; P 7.78%
found: C 51.20; H 5.22; Br 19.79; N 3.82; P 7.58%

*Diethyl α-Anilino-(2-hydroxybenzyl)phosphonate (7)*

Heating of diethyl phosphonate (1.38 g, 0.01 mol) and 2-hydroxybenzalaniline[16] (1.97 g, 0.01 mol) in water bath for 4 hr gave a quantitative yield of 7 in the form of an oil which became a hard glassy mass after standing at room temperature.

*Anal.* $C_{17}H_{22}NO_4P$ (335.32) calc'd: C 60.89; H 6.61; N 4.17; P 9.24%
found: C 60.35; H 6.53; N 4.27; P 9.36%

*Diethyl α-Anilino- (3-hydroxybenzyl)phosphonate (8)*

Diethyl phosphonate (6.9 g, 0.05 mol) and 3-hydroxybenzalaniline[17] (9.85 g, 0.05 mol) gave after 7 hr of heating an oil which solidified after cooling. The product was dissolved in benzene and the solution was purified by a short chromatography colum ($Al_2O_3$, benzene). The eluate was evaporated to dryness and the residue was recrystallized from ether-petroleum ether (30—50 °C) to give *8* (15.2 g, 90.8%), m.p. 104—105 °C.

*Anal.* $C_{17}H_{22}NO_4P$ (335.32) calc'd: C 60.89; H 6.61; N 4.17; P 9.24%
found: C 60.97; H 6.88; N 4.27; P 9.23%

*Diethyl α-Anilino-(4-hydroxybenzyl)phosphonate (9)*

Diethyl phosphonate (6.9 g, 0.05 mol) and 4-hydroxybenzalaniline[18] (9.85 g, 0.05 mol) were heated for 7 hr. The resulting oil was triturated with ether until it solidified. The precipitate was collected to yield *9* (13.2 g, 78%), m.p. 98—107 °C. Recrystallization from ethanol-water afforded pure compound (10.5 g, 62.8%), m.p. 110—111 °C.

*Anal.* $C_{17}H_{22}NO_4P$ (335.32) calc'd: C 60.89; H 6.61; N 4.17; P 9.24%
found: C 60.85; H 6.78; N 4.16; P 8.95%

*Diethyl α-(2-hydroxyanilino)benzylphosphonate (10)*

A mixture of diethyl phosphonate (6.9 g, 0.05 mol) and benzal-(2-hydroxyaniline)[19] (9.85 g. 0.05 mol) was heated for 7 hr to yield a glassy mass. It was triturated with ether and the resulting solid (12.6 g, 75.4%) was collected, m.p. 101—102° C. Recrystallization from ethanol afforded pure *10*, m.p. 103—104 °C.

*Anal.* $C_{17}H_{22}NO_4P$ (335.32) calc'd: C 60.89; H 6.61; N 4.17; P 9.24%
found: C 60.70; H 6.86; N 4.21; P 9.04%

*Dioctyl α-(4-carboxyanilino)benzylphosphonate (11)*

A mixture of dioctyl phosphonate[21] (3.06 g, 0.01 mol) and benzal-(4-carboxyaniline)[20] (2.25 g, 0.01 mol) was heated for 4 hr. Cooling afforded a solid which was recrystallized from ethanol-water to give *11* (4.45 g, 83.8%), m.p. 120—121 °C.

*Anal.* $C_{30}H_{46}NO_5P$ (531.64) calc'd: C 67.77; H 8.72; N 2.63; P 5.83%
found: C 68.01; H 8.64; N 2.77; P 5.81%

*Diethyl α-(3-hydroxy-4-carboxyanilino)benzylphosphonate (12)*

A mixture of diethyl phosphonate (1.38 g, 0.01 mol), benzal-(3-hydroxy-4-carboxyaniline) (2.41 g, 0.01 mol), concentrated sodium ethoxide (5 ml) in ethanol and abs. ethanol (10 ml) was heated in a water bath for 2 hr to give the sodium salt of *12* as a solid. It was filtered and washed with ether to leave a white product (2.95 g, 73.8%), m.p. 210—212° C. Its solution in ethanol was purified with charcoal and, upon the addition of ether, a pure product (2.25 g) was obtained, m.p. 193—196 °C. A sample (1.15 g) was dissolved in water and the solution was acidified with dil. HCl to precipitate *12*. The precipitate was extracted with ether from which white crystals (0.8 g) were obtained, m.p. 193—194 °C (dec.). Recrystallization from ethanol--ether afforded an analytical sample, m.p. 194—196 °C (dec.).

*Anal.* $C_{18}H_{22}NO_6P$ (379.33) calc'd: C 56.99; H 5.85; N 3.69; P 8.17%
found: C 57.04; H 6.19; N 3.79; P 8.22%

*General Procedure for Preparation of Monoesters of α-Anilino--benzylphosphonic Acid*

The hydrolysis of diesters was carried out as described previously.[3] The majority of the sodium salts obtained were hygroscopic solids difficult to purify. These were converted without purification to the monoesters. Sodium salts were dissolved in water and this solution was acidified with dil. HCl or $H_2SO_4$. Those monoesters which separated as a solid were filtered, dried and recrystallized. If a monoester separated as a slurry, it was extracted with ether or $CHCl_3$, the extract was dried ($Na_2SO_4$), the solvent was evaporated and the residue was recrystallized.

*Sodium Monoethyl α-Anilino-(4-aminobenzyl)phosphonate (13)*

Hydrolysis of *3* (1 g, 0.003 mol) with NaOH (0.24 g, 0.006 mol) afforded a quantitative yield of *13* in the form of a very hygroscopic solid, m.p. $>$ 160 °C (dec.). It was identified by the NMR spectrum.

*Sodium Monooctyl α-Anilino-(4-aminobenzyl)phosphonate (14)*

Hydrolysis of crude *4* (11.6 g, 0.021 mol) with NaOH (2.4 g, 0.06 mol) gave a product which was recrystallized from abs. ethanol-*iso*-propyl ether to yield a white solid (1.6 g, 17%), m.p. 180 °C (dec.). Recrystallization from abs. ethanol-petroleum ether (40—70 °C) gave pure *14*, m.p. 270 °C (dec.).

*Anal.* $C_{21}H_{30}N_2O_3PNa \cdot 0.5H_2O$ (412.42)
calc'd: C 59.85; H 7.41; N 6.64; P 7.35; Na 5.46%
found: C 59.73; H 7.81; N 6.72; P 7.17; Na 5.61%

*Disodium α-Anilino-(2-hydroxybenzyl)phosphonate (15)*

The hydrolysis of *7* (8.36 g, 0.025 mol) with NaOH (2 g, 0.05 mol) in ethanol (50 ml) was carried out in an apparatus provided with a magnetic stirrer. During the heating, *15* separated as a precipitate which was collected and washed with ethanol to leave a white solid (7.6 g, 94%). Its recrystallization from water-ethanol afforded *15* (6.2 g, 76.8%) which did not melt.

*Anal.* $C_{13}H_{12}NO_4PNa_2 \cdot 2H_2O$ (359.22) calc'd: P 8.62; Na 12.80; $H_2O$ 10.03%
found: P 8.58; Na 12.77; $H_2O$ 10.34%

*Sodium Monoethyl α-Anilino-(2-bromobenzyl)phosphonate (16)*

The hydrolysis of *5* (1.9 g, 0.0048 mol) with NaOH (0.6 g, 0.015 mol) in ethanol (30 ml) gave a crude product which was recrystallized from $CHCl_3$-ethanol (4 : 1) to give *16* (1.45 g, 77.6%), m.p. 251—255 °C. Recrystallization from abs. ethanol-petroleum ether (40—70 °C) raised the m.p. to 257—259 °C.

*Anal.* $C_{15}H_{16}BrNO_3PNa$ (392.17) calc'd: Br 20.38; P 7.90; Na 5.86%
found: Br 20.19; P 7.67; Na 5.52%

*Sodium Monooctyl α-Anilino-(2-bromobenzyl)phosphonate (17)*

Dioctyl α-anilino-(2-bromobenzyl)phosphonate (*6*) was prepared from dioctyl phosphonate[21] (10.7 g, 0.035 mol) and 2-bromobenzalaniline (9.2 g, 0.035 mol) by heating in an oil bath at 100 °C for 50 hrs. The viscous oil obtained was not purified. Crude *6* (19.9 g, 0.035 mol) was hydrolyzed with NaOH (2.8 g, 0.07 mol) in ethanol (80 ml). The product was recrystallized from ether-petroleum ether (40—70° C) to yield *17* (6.1 g, 36.6%), m.p. 205—207 °C. Recrystallization from *iso*-propyl ether afforded 5.1 g, m.p. 210—211 °C.

*Anal.* $C_{21}H_{28}BrNO_3PNa$ (476.32) calc'd: Br 16.78; P 6.50; Na 4.83%
found: Br 16.87; P 6.48; Na 4.91%

*Monoethyl α-Anilino-(2-bromobenzyl)phosphonate (19)*

Compound *16* was dissolved in water and it was acidified with dil. HCl to give *19* (100%), m.p. 153—154 °C. Two recrystallizations from abs. ethanol-petroleum ether (40—70 °C) gave pure *19*, m.p. 155—156 °C.

*Anal.* $C_{15}H_{17}BrNO_3P$ (371.18)
calc'd: C 48.53; H 4.89; Br 21.53; N 3.77; P 8.35%
found: C 48.55; H 4.68; Br 21.19; N 4.00; P 8.22%

*Monooctyl α-Anilino-(2-bromobenzyl)phosphonate (20)*

Compound *20* was obtained from *17* in 85% yield. Recrystallization from petroleum ether (40—70 °C) gave an analytical sample, m.p. 108—109 °C.

*Anal.* $C_{21}H_{29}BrNO_3P$ (454.33) calc'd: C 55.51; H 6.43; Br 17.59; P 6.82%
found: C 55.10; H 6.48; Br 17.02; P 6.81%

*Monoethyl α-Anilino-(2-hydroxybenzyl)phosphonate (21)*

Crude sodium salt, obtained by the hydrolysis of *7*, gave *21* (85.8%), m.p. 158—161 °C (dec.). Recrystallization from ethanol raised the m.p. to 163—165 °C (dec.).

*Anal.* $C_{15}H_{18}NO_4P$ (307.27) calc'd: C 58.63; H 5.90; N 4.56; P 10.08%
found: C 58.34; H 6.16; N 4.50; P 9.41%

*Monoethyl α-Anilino-(3-hydroxybenzyl)phosphonate (22)*

Crude sodium salt, obtained by the hydrolysis of *8*, gave *22* (60.3%), m.p. 104 °C (dec.). Recrystallization from $CHCl_3$-petrolem ether (40—70° C) raised the m.p. to 105—107 °C (dec.).

*Anal.* $C_{15}H_{18}NO_4P \cdot 0.5H_2O$ (316.28) calc'd: C 56.96; H 6.06; N 4.43; P 9.79%
found: C 56.38; H 6.20; N 4.40; P 9.28%

*Monoethyl α-Anilino-(4-hydroxybenzyl)phosphonate (23)*

Crude sodium salt obtained by the hydrolysis of *9*, gave *23* (32.6%), m.p. > 150 °C (dec.). Recrystallization from ethanol gave an analytical sample, m.p. 158—160 °C (dec.).

*Anal.* $C_{15}H_{18}NO_4P$ (307.27) calc'd: C 58.63; H 5.90; N 4.56; P 10.08%
found: C 58.76; H 6.07; N 4.53; P 10.32%

*Monoethyl α-(2-hydroxyanilino)benzylphosphonate (24)*

Crude sodium salt, obtained by the hydrolysis of *10*, gave *24* (27.7%), m.p. 105—107 °C (dec.). Recrystallization from ethanol-water gave an analytical sample, m.p. 120 °C (dec.).

*Anal.* $C_{15}H_{18}NO_4P \cdot 0.5H_2O$ (316.28) calc'd: C 56.96; H 6.06; N 4.43; P 9.79%
found: C 56.60; H 6.32; N 4.44; P 9.52%

*Monooctyl α-(4-carboxyanilino)benzylphosphonate (25)*

Crude disodium salt, obtained by the hydrolysis of *11*, gave *25* in a quantitative yield, m.p. 163—164 °C. Recrystallization from ethanol-water gave an analytical sample, m.p. 165—166 °C.

*Anal.* $C_{22}H_{30}NO_5P$ (419.44) calc'd: C 62.99; H 7.21; N 3.34; P 7.39%
found: C 63.27; H 7.01; N 3.09; P 7.20%

*Monoethyl α-(3-hydroxy-4-carboxyanilino)benzylphosphonate (26)*

Crude sodium salt, obtained by the hydrolisis of *12*, gave *26* (71.4%), m.p. 166—167 °C. Recrystallization from ethanol-ether raised the m.p. to 167—169 °C.

*Anal.* $C_{16}H_{18}NO_6P$ (351.28) calc'd: C 54.70; H 5.17; N 3.99; P 8.82%
found: C 54.97; H 5.66; N 4.14; P 8.65%

*α-Anilino-(2-hydroxybenzyl)phosphonic Acid (27)*

Disodium salt *15* gave *27* (90.2%), m.p. > 160 °C (dec.). Recrystallization from ethanol gave an analytical sample, m.p. > 170 °C (dec.).

*Anal.* $C_{13}H_{14}NO_4P \cdot H_2O$ (297.23) calc'd: C 52.53; H 5.43; N 4.71; P 10.42%
found: C 53.04; H 5.53; N 4.46; P 9.92%

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REFERENCES

1. V. Jagodić, *Chem. Ber.* **93** (1960) 2308.
2. V. Jagodić and M. J. Herak, *J. Inorg. Nucl. Chem.* **32** (1970) 1323.
3. V. Jagodić and Lj. Tušek, *J. Org. Chem.* **37** (1972) 1222.
4. B. Tamhina, M. J. Herak and V. Jagodić, *Croat. Chem. Acta* **45** (1973) 593.

5. B. Tamhina, M. J. Herak and V. Jagodić, *Analyt. Chim. Acta* **76** (1975) 417.
6. V. S. Abramov, L. P. Semenova and L. G. Semenova, *Doklady Akad. S.S.S.R.* **84** (1952) 281.
7. A. N. Pudovik and M. V. Korchemkina, *Izv. Akad. Nauk S.S.S.R. Ser. Kim.* (1952) 940.
8. L. D. Freedman and H. H. Jaffé, *J. Amer. Chem. Soc.* **77** (1955) 920.
9. G. M. Kosolapoff, *J. Amer. Chem. Soc.* **71** (1949) 4021.
10. V. Jagodić, and Lj. Tušek, *Croat. Chem. Acta* **44** (1972) 445.
11. T. H. Siddall, III and C. A. Prohaska, *J. Amer. Chem. Soc.* **84** (1962) 3467.
12. J. A. Pople, W. G. Schneider and H. J. Bernstein, *High-Resolution Nuclear Magnetic Resonance*, Mc-Graw Hill, New York 1969.
13. T. H. Siddall, III and C. A. Prohaska, *J. Amer. Chem. Soc.* **84** (1962) 2502.
14. M. P. Williamson and C. E. Griffin, *J. Phys. Chem.* **72** (1968) 4043.
15. O. Fischer, *Ber.* **14** (1881) 2524.
16. H. Schiff, *Ann.* **150** (1869) 194.
17. E. Bamberger and J. Müller, *Ann.* **313** (1900) 112.
18. H. Herzfeld, *Ber.* **10** (1877) 1271.
19. T. J. Lane and A. J. Kandathil, *J. Amer. Chem. Soc.* **83** (1961) 3782.
20. G. W. Stacy, R. L. Day and R. J. Morath, *J. Amer. Chem. Soc.* **77** (1955) 3869.
21. P. Nylen, *Dissertation*, Uppsala 1930.
22. E. K. Fields, *J. Amer. Chem. Soc.* **74** (1952) 1528.

## SAŽETAK

**Sinteza i bazna hidroliza diestera α-anilinobenzilfosfonske kiseline. Studij konformacije estera pomoću nuklearne magnetske rezonancije**

*V. Jagodić*

Sintetizirani su neutralni esteri α-anilinobenzilfosfonske kiseline, $R^1C_6H_4NHCH(C_6H_4R^2)PO(OR)_2$, ($R^1 = R^2 = H$, $NO_2$, $NH_2$, OH, COOH, Br; R = Et, Oct.), i ispitan je utjecaj supstituenata na njihovu alkalnu hidrolizu. U većini slučajeva, i uz suvišak NaOH, nastaju natrijeve soli monoestera. Izuzeci su *p*-nitro derivati (*1*, *2*) gdje dolazi do pucanja veze P—C, te 2-hidroksibenzil derivat (*7*) koji daje dinatrijevu sol fosfonske kiseline (*15*). Bio je priređen odgovarajući monoester (*21*) u visokom iskorištenju iz *7* s ekvimolarnom količinom NaOH. NMR studije pokazale su da etilne esterske skupine u neutralnim esterima nisu ekvivalentne. Do te pojave dolazi zbog vodikovih veza i različite konformacije. Samo u monoesterima i njihovim natrijevim solima $CH_3$ skupina pojavljuje se kao triplet zbog toga što u tim spojevima postoji ion $PO_2^-$.

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