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## LETTERS TO THE EDITOR

# **Enantioselective Addition of Dimenthyl and Dibornyl Phosphites to Schiff Bases**

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Recently we described  $C_N$ -symmetrical chiral esters of phosphorous acid, prepared from cheap optically active natural alcohols (menthol, borneol, glucofuranose, etc.) [1–3]. These compounds are convenient asymmetric inductors in additions to C=N, C=O, and C=C bonds [4–6]. In the present work we

found that replacement of the (1R, 2S, 5R)-menthyl groups on the phosphorus atom of dialkyl phosphites by (1S)-*endo*-bornyl changes the configuration of the stereogenic center on the  $\alpha$ -carbon atom of aminophosphonic acids.



Mnt = (1R, 2S, 5R)-mentyl, Brn = (1S)-endo-bornyl; R = Brn (a), Mnt (b).

Dialkyl phosphites I react with benzylaminoaniline at 80°C, affording diesters of substituted aminophosphonic acids with preference for *R* diastereomer IIa (R = Mnt) *S* diastereomer IIb (R = Brn). One or two crystallizations give absolutely pure diastereomers IIa and IIb. Their structure was confirmed by NMR spectra, and configuration, by chemical transformations. Compounds II were converted to aminophosphonic acids IV whose configuration is known. First, by hydrolysis of diesters II with hydrochloric acid in dioxane we obtained *S*- and *R*-*N*-benzyl-1-aminobenzylphosphonic acids and measured their optical rotation,  $[\alpha]_D$ , deg (*c* 0.3, DMSO): IIIa +26 and IIIb -26. Then compounds **III** were subjected to catalytic reduction with hydrogen in the presence of palladium on charcoal to obtain (*S*)- and (*R*)-**IV** whose configuration was established by comparison with the previously described (*S*)- and (*R*)-1-aminobenzyl-phosphonic acid hydrochlorides [6] and sodium salts [7, 8]: (*R*)-**IV**  $[\alpha]_{578}^{20}$  +18.1° (*c* 1, 1 N aqueous NaOH) and (*R*)-**IV**  $HCl [\alpha]_D -20^\circ$  (*c* 0.3, DMSO). The *S* configuration of dibornyl ether **IIb** was established by X-ray diffraction [3].

**Di-**(1*S*)-*endo*-**bornyl** [(*S*)- $\alpha$ -(**benzylamino**)**benzyl]phosphonate** (IIa). Yield 60%, mp 144°C,

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[α]<sub>D</sub><sup>20</sup> -47° (*c* 1.0, toluene). <sup>1</sup>H NMR spectrum (CDCl<sub>3</sub>) δ, ppm (*J*, Hz): 0.5 s (3H, CH<sub>3</sub>); 0.73 s, 0.75 s, 0.79 s, 0.82 s (12H, 4CH<sub>3</sub>); 1.0–1.8 m (16H, CH<sub>2</sub> + CH); 3.5 d (1H, PhCH<sup>a</sup>,  $J_{HH}$  13.3); 3.8 d (1H, PhCH<sup>b</sup>,  $J_{HH}$  13.3); 3.95 d (1H, CHP,  $J_{HH}$  20.8), 4.52 d.t (1H, NH,  $J_{HP}$  26.8,  $J_{HH}$  7), 7.2–7.4 m (10H, 2C<sub>6</sub>H<sub>5</sub>). <sup>31</sup>P NMR spectrum (CDCl<sub>3</sub>): δ<sub>P</sub> 24.0 ppm. Found, %: P 5.31. C<sub>35</sub>H<sub>50</sub>NO<sub>3</sub>P. Calculated, %: P 5.49.

**Di**-(1*R*,2*S*,5*R*)-ment-2-yl [(*R*)-α-(benzylamino)benzyl]phosphonate (IIb). Yield 60%, mp 86–87°C,  $[α]_D^{20}$  –57.9° (*c* 1.0, toluene). <sup>1</sup>H (CDCl<sub>3</sub>) δ, ppm, (*J*, Hz): 0.5 s (CH<sub>3</sub>), 0.6–0.95 m (18H, 6CH<sub>3</sub>), 1.1– 2.2 m (16H, CH<sub>3</sub> + CH); 3.55 d (PhCH<sup>a</sup>, *J*<sub>HH</sub> 13), 3.75 d (PHCH<sup>b</sup>, *J*<sub>HH</sub> 13), 3.98 d (1H, CHP, *J*<sub>HP</sub> 20.6), 4.43 m (1H, NH), 7.2–7.4 m (10H, C<sub>6</sub>H<sub>5</sub>). <sup>31</sup>P NMR spectrum (CDCl<sub>3</sub>):  $δ_P$  21.95 ppm. Found, %: P 5.32. C<sub>34</sub>H<sub>52</sub>NO<sub>3</sub>P. Calculated, %: P 5.59.

(*S*)-(Benzylamino)phenylmethylphosphonic acid (IIIa) was isolated as hydrochloride and purified by crystallization from water. Yield 60%, mp 219°C (EtOH + H<sub>2</sub>O),  $[\alpha]_D^{20}$  -26° (*c* 1, DMSO). <sup>1</sup>H NMR spectrum (DMSO),  $\delta$ , ppm: 7.28 m (10H, C<sub>6</sub>H<sub>5</sub>), 3.74–4.07 m (3H, NCH + NCH<sub>2</sub>), 3.48 s (NH<sub>2</sub><sup>+</sup>).  $\delta_P$ 7.87 ppm (corresponds to previously described racemate [9]).

(*R*)-(Benzylamino)phenylmethylphosphonic acid (IIIb). Hydrochloride. Purified by crystallization from water. mp 219°C (EtOH + H<sub>2</sub>O),  $[\alpha]_D^{20}$  +29.9° (*c* 1, DMSO). <sup>1</sup>H NMR spectrum (DMSO),  $\delta$ , ppm: 7.35 m (10H, C<sub>6</sub>H<sub>5</sub>), 3.74–4.07 m (3H, NCH + NCH<sub>2</sub>), 3.48 s (NH<sub>2</sub><sup>+</sup>).  $\delta_P$  7.87 ppm.

(*S*)-(Amino)phenylmethylphosphonic acid (IVa). Hydrochloride. Yield 90%, mp 226°C,  $[\alpha]_D^{20} -20^\circ$ (*c* 0.32, 0.1 N aqueous NaOH). Published data [7, 8]: (–)-(*S*)-(amino)phenylmethylphosphonic acid,  $[\alpha]_{578}^{20}$ –129° (*c* 1, 1 N aqueous NaOH). <sup>1</sup>H NMR spectrum (D<sub>2</sub>O),  $\delta$ , ppm: 7.28 s (5H, C<sub>6</sub>H<sub>5</sub>), 4.25 d (1H, PCH,  $J_{\rm HP}$  17 Hz).

(*R*)-(Amino)phenylmethylphosphonic acid (**IVb**). Hydrochloride. Yield 90%, mp 226°C,  $[\alpha]_D^{20}$ +18.1° (*c* 0.32, 0.1 N aqueous NaOH). Published data [7, 8]: (+)-(*R*)-(amino)phenylmethylphosphonic acid,  $[\alpha]_{578}^{20}$  + 19° (*c* 1, 1 N aqueous NaOH). <sup>1</sup>H NMR spectrum (D<sub>2</sub>O),  $\delta$ , ppm: 7.28 (5H, C<sub>6</sub>H<sub>5</sub>), 4.25 d (1H, PCH, J<sub>HP</sub> 17 Hz).

The NMR spectra were recorded on Varian (300 MHz) and Jeol (90 MHz) spectrometers in deuterated solvents against 85% phosphoric acid. The optical rotation was measured on a Perkin-Elmer 241 spectropolarimeter . All operations were carried out in thoroughly dried and purified solvents with protection from air moisture.

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