Aqueous Synthesis of a New 1,3,2-Diazaphospholidine

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N,N',N''-Trimethylphosphoric triamide reacts with aqueous glyoxal to produce a 1,3,2-diazaphospholidine 5-membered ring system (III) in good yield. The ease of this synthesis belies the results with other phosphoramides where no cyclic species could be isolated.

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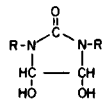
The reactions of glyoxal with various amides and amines have received considerable interest in the past (2-4). In particular, its addition to urea and substituted ureas has been widely discussed due to the commercial utility of some of these species for providing permanent press properties in cellulosic substrates (5-9). These syntheses are generally carried out under slightly basic conditions in water and yield 4,5-dihydroxy-2-imidazolidinones (I).

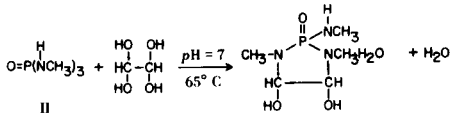


I

Evidence for "*cis*" and "*trans*" isomers (R = CH_3) has been presented with the equilibrium product predominantly in the "*trans*" configuration (7).

The substitution of phosphorus for the carbonyl carbon in such structures *via* these methods would provide easy access to new phospholidine species. In most cases these cyclic structures are obtained from the reactions of -P-Cl_2 species with ethylenediamine-like moieties under non-aqueous conditions (10-12). In addition, this might prove to be an avenue for incorporating phosphorus and nitrogen into the cellulosic matrix in a truly durable manner for a long-term fire retardant effect. In this paper we wish to report the facile synthesis of such a species (13).

The reaction between aqueous glyoxal and *N,N',N''*-trimethylphosphoric triamide proceeds smoothly with proper *p*H control. The phosphorus nmr of the reaction

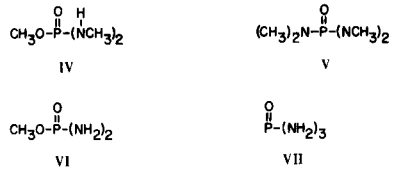


II III

mixture indicates complete conversion to a single material. The product is isolated as a white solid with the proposed structure III, 1,3-dimethyl-2-methylamino-2-oxo-4,5-dihydroxy-1,3,2-diazaphospholidine monohydrate. This assignment is supported by elemental analysis, molecular weight, proton nmr and phosphorus nmr data.

The proton nmr data are particularly interesting in that they also provide evidence that the product exists as a 50/50 mixture of "*cis/trans*" isomers. Figure 1 shows the spectrum of III after all exchangeable protons have been replaced. This spectrum also shows *three* sets of methyl protons with part of the signal of the *exo* methyl protons superimposed on the *endo* group's absorption. Also, the CH region provides a set of doublets with slightly different coupling constants. Similar observations were made by Vail when accounting for the proton spectra of the urea-based product as "*cis/trans*" isomers (7).

Several other phosphoramides (IV, V, VI, VII) have been substituted for II in this reaction. It is surprising,



IV V VI VII

particularly for IV and V, that no phospholidine structures were isolated using the above or modified procedures. Westheimer *et al.*, (11a,b) have considered the problems in the formation and stability of similar phospholidine systems which might account for the unsubstituted amides VI and VII not cleanly giving cyclic species. However, the dominant role played by the methylamino *exo* group in directing our successful addition reaction to III, when those in IV and V fail to do so, seems unusual.

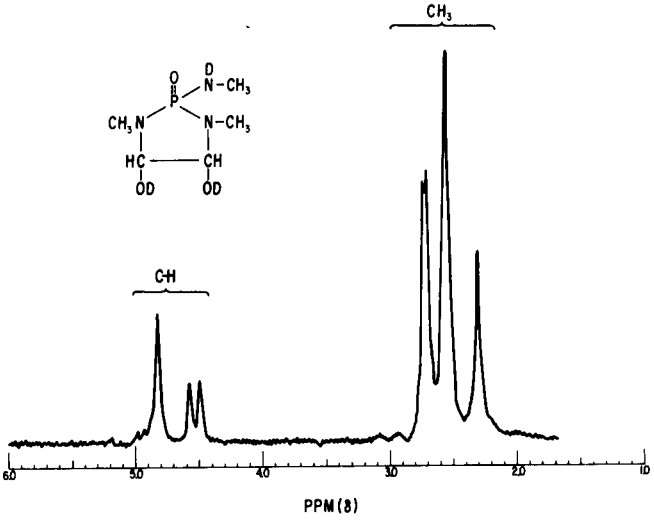


Figure 1: Proton spectrum of III in deuterium oxide after replacing exchangeable protons.

EXPERIMENTAL

Proton magnetic resonance spectra were recorded on a Varian A-60 instrument. A Perkin-Elmer R 20-A was used to obtain ^{31}P spectra. Thermogravimetric analyses were made on a DuPont 950 instrument. Elemental analyses were performed by Industrial Testing Laboratories, Inc., St. Louis, Missouri.

Glyoxal (40% aqueous solution) was filtered before use. Trimethylphosphoric triamide (II), was prepared by a modification of the procedure described by Holmes and Forstner (14). The product melted at 104-105° and gave a ^{31}P signal at -23.0 ppm. Other phosphoramides were prepared by similar procedures. All solid products were purified until chloride levels were less than 1.0%. Phosphorus purity was verified by ^{31}P nmr.

1,3-Dimethyl-2-methylamino-2-oxo-4,5-dihydroxy-1,3,2-diazaphospholidine Monohydrate (III).

Filtered 40% aqueous glyoxal (159 g., 1.1 moles) was weighed into a 500 ml. RB3N flask. The flask was equipped with a magnetic stirring bar, a thermometer, and a *p*H electrode. The *p*H was adjusted to 7.0 with 50% sodium hydroxide solution. Solid trimethylphosphoric triamide (150 g., 1.1 moles) was then added and the *p*H maintained at 7.0. The pale yellow solution was heated to 65° with dropwise addition of sodium hydroxide solution to keep the *p*H neutral. The contents were held at 65° for 10 minutes and then quenched in ice to 25°. Solid began to precipitate in three hours. Allowing the vessel to stand in a refrigerator overnight gave a large crop of crystals. These were filtered, washed with small portions of an 80/20 THF/ethanol solution, and dried in a stream of nitrogen. A yield of 98 g. (42%) of off-white crystals was recovered, m.p. 106-115°.

Compound III is soluble in water and the lower alcohols, insoluble in THF and chloroform. It loses slightly more than a mole of water with some degree of oligimerization when heated to 100°.

The ^{1}H spectrum of III in deuterium oxide was identical to that shown in Figure 1 with the exception that the free proton signal at δ = 4.81 was greater. In this spectrum the ratio of the easily distinguishable NCH_3 protons to the NH/CH/OH protons (including the water of hydration) was 9/7, supporting III. Compound III was then dissolved in deuterium oxide and on a vacuum line subjected to five cycles of evaporation/condensation with fresh deuterium oxide to replace all exchangeable protons. The deuterium oxide spectrum of this material is reproduced in Figure 1. This shows the removal of 5 protons from the 4.81 region, reducing the above ratio to 9/2. The ^{31}P signal for III occurs at -29.0 ppm (*vs.* 85% phosphoric acid). This downfield shift from the parent amide is typical for cyclic species (11).

The molecular weight in methanol was 202 (213 Theory). Compound III could be recrystallized from hot water to give snow-white crystals which give identical spectral results and elemental analyses as the original reaction product.

Anal. Calcd. for $C_5H_{16}N_3O_4P$: C, 28.16; H, 7.58; N, 19.71; P, 14.53. Found: C, 28.13; H, 7.66; N, 19.55; P, 14.49.

Acknowledgments.

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