its ability to chelate Fe^{3+} ions; Wade & Morgan, 1953) into a ninhydrin-positive material of increased mobility towards the cathode. Glycerol (2 ml) was then added to the solution to destroy the excess of periodate.

The solution was then poured on to a column (60 ml) of the sulphonic resin Zerolit 225 SRC 15 in the acid form. The resin was washed with water until free of iodate (i.e. no precipitate with AgNO_3), after which the product was displaced by washing with ammonia solution (400 ml, 1 M). The effluent was concentrated to an oil by evaporation. 2-Aminoethylarsonic acid crystallized from water on addition of ethanol; the yield was 0.3 g (32%).

Elemental analysis gave C, 13.8; H, 4.80; N, 8.19% (Calc. for $\text{C}_2\text{H}_8\text{AsNO}_3$: C, 14.2; H, 4.77; N, 8.28%). ^1H n.m.r. at 400 MHz: δ (p.p.m.) ($^2\text{H}_2\text{O}$) setting (Me_3Si) $_2\text{O}$ to 0.055: 2.53 (2H, t, 8 Hz) and 3.43 (2H, t, 8 Hz). There was slight splitting of the central line of each triplet, possibly because of restricted rotation about the C–C bond, which could be due to attraction between the charged groups.

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APPENDIX

Application of the synthetic method to other amines

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Taurine and 2-aminoethylphosphonic acid were synthesized by the method of the main paper [Geoghegan & Dixon (1989) *Biochem. J.* **260**, 295–296], i.e. by treating the corresponding halo compound with 2-aminoethanol and then with periodate.

INTRODUCTION

Taurine has been made by treating 2-bromoethanesulphonic acid with ammonia, but the reaction is slow and takes several days (Marvel *et al.*, 1927; Marvel & Bailey, 1943). We found it convenient to use the procedure given in the main paper (Geoghegan & Dixon, 1989), and so to replace the ammonia with 2-aminoethanol and cleave the product with periodate.

2-Aminoethylphosphonic acid is also biologically important, and occurs both in phosphonolipids [reviewed by Florin-Christensen *et al.* (1986) and by Kittredge & Roberts (1969)] and in proteins (Stevenson *et al.*, 1974). It has been synthesized both (Finkelstein, 1946) by the Hofmann degradation of $(\text{EtO})_2\text{P}(\text{O})\text{CH}_2\text{CH}_2\text{CONH}_2$,

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which requires several steps to prepare, and (Chavanne, 1947; Kosolapoff, 1947) by the phthalimide method, by an Arbuzov reaction on *N*-(2-bromoethyl)phthalimide. Similarly Carayon-Gentil *et al.* (1967) used an Arbuzov reaction on 2-bromoethylamine, after protecting the amino group by substitution with $(\text{PrO})_2\text{P}(\text{O})-$. The present method seems simpler. Since the phosphono group of 2-bromoethylphosphonic acid became masked, probably esterified, when this compound was treated with 2-aminoethanol, we used its diethyl ester (from which the free acid is normally made), and de-esterified it in the course of the synthesis.

Hence both compounds were conveniently made by the procedure used for aminoethylarsonic acid. Since

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they differ from it and from each other in acidity, each requires a slightly different isolation. We believe that the main losses were in handling, and that the yields in the reactions were good.

EXPERIMENTAL

Taurine

Sodium 2-bromoethane-1-sulphonate (1.16 g, 5.5 mmol) was suspended in 10 ml of 2-aminoethanol, and heated at 80 °C for 16 h, during which it dissolved. The mixture was dissolved in 100 ml of water, passed through a column of 37 ml of Dowex 2 X8 in the acetate form and washed with water to remove the excess of aminoethanol (there was slight loss of product at this stage). The column was eluted with 1 M-acetic acid (125 ml, 5 column volumes) and the effluent was evaporated to dryness. It was then dissolved in water (100 ml), and adjusted to pH 7 with NaOH; NaIO₄ (2 g, 9.3 mmol) was dissolved in it, and the pH was re-adjusted to 7 with NaOH solution. After 1 h at room temperature, 1 ml of glycerol was added to destroy the excess of periodate. The taurine formed was separated from Na⁺ ions by adsorption on the resin acetate form, just as the *N*-(2-hydroxyethyl)-2-aminoethanesulphonic acid had been. The column was washed with water until free of Na⁺ (again slight loss of taurine), and the product was eluted with 1 M-acetic acid (leaving iodate on the column). Samples were analysed for taurine by paper electrophoresis; spots were detected by their ability to retain chlorine (Reindel & Hoppe, 1954). The taurine had all emerged by about 200 ml, and the effluent was evaporated to dryness. The solid was dissolved in 6 ml of water, and crystallized on addition of 30 ml of ethanol. The product was washed with ethanol and then diethyl ether. The yield was 0.25 g (36 %).

Elemental analysis gave C, 19.8; H, 5.78; N, 11.1% (Calc. for C₂H₇NO₃S: C, 19.2; H, 5.64; N, 11.2%). It ran at the same speed as authentic taurine on paper electrophoresis in 10 g/l 'ammonium carbonate' adjusted with ammonia to pH 9.4; its mobility was 0.44 (cm/h)/(V/cm).

2-Aminoethylphosphonic acid

Diethyl 2-bromoethylphosphonate (1.23 g, 5 mmol, made from dry 1,2-dibromoethane and triethyl phosphite; Kosolapoff, 1948) was incubated in 10 ml of 2-aminoethanol at 80 °C for 16 h. It was mixed with 200 ml of 6 M-HCl, boiled under reflux for 3 h, evaporated to low volume, and dissolved in 200 ml of water. It was

passed through a column (24 cm × 3 cm) of sulphonic resin (free acid form) and washed through with 2 column volumes of water to remove chloride. The product and the excess of aminoethanol were displaced by washing with 0.5 M-ammonia, and this solution was evaporated to low volume. The product was adsorbed on the acetate form of a basic resin, just as the taurine had been, and the resin was washed with water until the effluent was ninhydrin-negative, to remove the aminoethanol. The *N*-(2-hydroxyethyl)-2-aminoethylphosphonic acid was displaced from the resin in the same manner as for taurine, except that 1 M-formic acid was used. The filtrate was evaporated to dryness, toluene was added, and the liquid was re-evaporated. The residue was dissolved in 150 ml of water, adjusted to pH 7 with NaOH, and NaIO₄ (2 g, 9.3 mmol) was dissolved in it. After 3 h at room temperature, 1 ml of glycerol was added to destroy the excess of periodate, and the mixture was filtered. The filtrate was passed through a column (15.5 cm × 2 cm) of sulphonic resin in the acid form, which was washed with water to remove iodate. The product was displaced with 0.5 M-ammonia, and the effluent evaporated to dryness. It was dissolved in 10 ml of water and reprecipitated with 100 ml of ethanol. The solid was washed with ethanol and diethyl ether. The yield was 0.25 g (40 %).

Elemental analysis gave C, 19.1; H, 6.55; N, 11.21% (Calc. for C₂H₈NO₃P: C, 19.2; H, 6.45; N, 11.2%).

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