

PATENT SPECIFICATION

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- (72) Inventors DAVID IRWIN RANDELL
 CALVIN VOGEL



(54) PRODUCTION OF HALOETHYL PHOSPHONIC ACIDS

(71) We, GAF CORPORATION, a corporation organized and existing under the laws of the State of Delaware, United States of America, having its main office at 140 West 51st Street, City, County and State of New York, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to an improved process for the preparation of 2-haloethylphosphonic acids by anhydrous hydrogen halide cleavage of the corresponding 2-acyloxyethylphosphonic acids and/or esters.

2-Haloethylphosphonic acids are known in the art as valuable plant growth stimulants or regulators in the agricultural field. These compounds, particularly the 2-chloroethyl compounds, have been extensively used as plant growth hormones for increasing crop yields of plants such as soybeans, pineapples and tomatoes. The use of these compounds is described, for example, in *Nature*, Vol. 218, page 974, (1968), by Cook and Randall.

The 2-haloethylphosphonic acid compounds produced by the process of this invention are soluble in varying degree in water and thus they can be applied to plants in aqueous or partly aqueous solutions. These include aqueous solutions containing acetone or methyl ethyl ketone. The compounds may also be adsorbed on solid carriers such as vermiculite, "Attaclay" and talc for application in granular form. "Attaclay" is a Trademark for a naturally absorbent material produced from the mineral attapulgite, a clay mined only in southwestern Georgia and northwestern Florida, and activated by specific thermal treatment and ground to fine particle size. Dusts may also be used to dilute the compounds with clays or other powders, for

[Price 25p]

example pyrophyllite, diatomaceous earth and attapulgite.

The compounds can be applied to the plants at a concentration of from 1/2 to 10 lbs/acre or higher. A preferred rate of application ranges from 2-5 lbs./acre. The compounds need only be applied to the plant in low volume of water to achieve satisfactory flower initiation, and this is an important advantage of the compounds. Whereas it is necessary to apply known agents in larger volumes of water, of the order of 200-400 gallons/acre, even up to 1,000 gallons/acre in the case of ethylene to achieve flower initiation, it is possible to apply a compound produced by the process of this invention in far lower volumes of water to achieve satisfactory flower initiation. For example, 2-chloroethylphosphonic acid can be applied in 50 gallons of water at the rate of 1 lb./acre to achieve 100% flower induction on pineapples of the Smooth Cayenne variety. The ability to apply the agent in a reduced volume of water is a great agronomic advantage because a larger acreage of plantation can be treated before recourse to a water supply is necessary, smaller equipment can be used, and costs can be reduced generally.

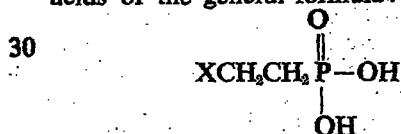
The processes for the preparation of these compounds have not been satisfactory as they have not been able to provide products completely free of impurities toxic to plants. The compounds have been prepared by hydrolysis or cleavage of the corresponding 2-chloroethylphosphonate diester with either aqueous hydrochloric acid or anhydrous hydrogen chloride. While both the aqueous hydrochloric acid hydrolysis and anhydrous hydrogen chloride cleavage have proceeded satisfactorily from a chemical standpoint, the resulting products have been found to contain enough by-products to make the processes unsatisfactory for use on a commercial scale. The anhydrous hydrogen

chloride cleavage of 2-chloroethylphosphorus esters to 2-chloroethylphosphonic acid has the disadvantage of providing a considerable amount of the mono ester derivative which is a potential source of the toxicant 2-chloroethanol.

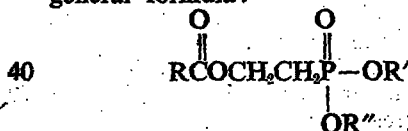
In the hydrolysis reaction with concentrated hydrochloric acid of esters of 2-chloroethylphosphonic acid, the reaction generally must be carried out under pressure. Expensive corrosion-resistant equipment must be used and there is an inherent danger that equipment failure would lead to the release of hydrogen chloride. The aqueous hydrolysis process has also the disadvantage that by the time the ester groups have been hydrolyzed off, some of the halogen in the ethane group has been hydrolyzed to hydroxyl so that a substantial amount of 2-hydroxyethanephosphonic acid is present in the product.

The process of the present invention provides a process wherein substantially none of the potential by-products which may be toxic to plants are produced.

The present invention provides a process for the preparation of 2-haloethylphosphonic acids of the general formula:

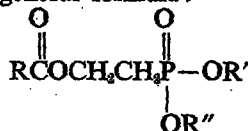


wherein X is halogen, preferably chlorine or bromine, which comprises treating a 2-acyloxyethylphosphonic acid or ester of the general formula:



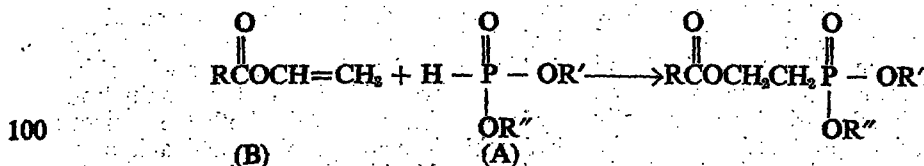
where R is alkyl of 1 to 7 carbon atoms, cycloalkyl of 3 to 8 carbon atoms, haloalkyl of about 1 to 7 carbon atoms or aryl of 6 to 12 carbon atoms, R' and R'' are hydrogen, alkyl of 1 to 7 carbon atoms, haloalkyl of 2 to 7 carbons, cycloalkyl of 3 to 8

carbon atoms or aryl and R' and R'' are the same or different, or R' and R'' together with the oxygen atoms attached to the P atom represent 2 to 6 methylene groups to form a heterocyclic ring; with anhydrous hydrogen halide at a temperature ranging between 30° and 200°C., products substantially free from impurities being obtained. These starting materials, 2-acyloxyethylphosphonic acids and ester derivatives, have the general formula:



wherein R, R' and R'' are as defined above. R is for example methyl, ethyl, *n*-propyl, *n*-butyl, *isopropyl* or *n*-pentyl; or for example cyclopropyl, cyclobutyl, cyclopentyl, cyclohexyl, cycloheptyl or cyclooctyl; or for example chloromethyl, 2-chloroethyl, 3-chloropropyl or 4-chlorobutyl, or the corresponding bromo derivatives; or e.g. phenyl or naphthyl or alkyl substituted aryl groups such as tolulyl and xylyl; R' and R'' are for example methyl, ethyl, *n*-propyl, *isopropyl* or *n*-butyl; or for example 2-chloroethyl, 2-chloropropyl; 3-chloropropyl or 4-chlorobutyl, or the corresponding bromo, iodo and fluoro derivatives; or e.g. cyclopropyl, cyclobutyl, cyclopentyl or cyclohexyl. Thus the starting materials include 2-acyloxyethylphosphonic acids, corresponding diesters and the cyclic esters. Compounds where R' and R'' represent hydrogen are particularly preferred. An example of a suitable starting material is one where R is methyl and R' and R'' are 2-chloroethyl.

These acyloxyethylphosphonic acids and derivatives may be prepared by treating a hydrogen phosphite compound (A) with a vinyl ester of a carboxylic acid (B) in the presence of a free-radical generator such as tertiary butyl perbenzoate. This reaction proceeds as follows:



where R, R' and R'' are as described above. The acids (when R' and R'' are hydrogen) or the ester derivatives may be prepared by this method. The addition of dialkyl phosphonates to unsaturated compounds has been described as being conducted in the presence of a free-radical initiator. These reactions were carried out generally at temperatures of between 100° and 110°C.

It has now been found that these acyloxyethylphosphonic acids and/or corresponding esters can be cleaved by hydrogen halide, preferably hydrogen chloride, to yield the desired 2-haloethylphosphonic acids in good yields and high purity. The reaction is preferably conducted at atmospheric pressure, although higher pressures may be employed if desired.

The reaction is conducted at a temperature of between 30° and 200°C. with temperatures between 100° and 160°C. for example 150°C. being preferred for best results and ease of reaction.

When the acid is used as the starting material (R' and $R'' = H$), it is cleaved by the hydrogen halide only at the acyloxy radical to yield the 2-haloethylphosphonic acid. However, when R' and/or R'' are other than hydrogen, the ester starting materials will require cleavage in two or three positions and it is generally necessary to use higher temperatures in the reaction.

The reaction is generally conducted by charging the starting material into a reactor, raising it to the desired temperatures and passing the required amount of anhydrous hydrogen halide (preferably hydrogen chloride), into the mixture which is being vigorously agitated. Generally about three moles of hydrogen halide are employed per mole of starting material. The reaction time will vary from about 5. to about 25 hours, depending on the amounts of the material used. At the end of the reaction period the acid cleaved from the ester portion is removed to provide the final product. As the hydrogen halide employed is in the anhydrous form, care should be taken to maintain the reaction mixture essentially free from moisture.

As indicated, the process of the invention has the advantage over the prior processes discussed above in that the hydrogen halide used is fully utilized to cleave the 2-acyloxyethyl group and thereby provide a final product in substantially pure form, without appreciable formation of impurities.

The following Examples illustrate the process of the invention.

PREPARATION

Preparation of 2-Acetoxyethylphosphonic Acid:

A solution of 82 grams (1 mole) of phosphorous acid in 500 ml. 50% aqueous acetic acid was purged with nitrogen gas for one hour at 90°C. Five grams of *tert*-butyl perbenzoate were added. Vinyl acetate (86 grams, 1 mole) was then dropped in continuously with vigorous stirring over the course of six hours while the temper-

ature was maintained at 90°C. An additional 5 grams of *tert*-butyl perbenzoate were added after two hours and again after four hours. At the end of this time the solvent was removed by flash distillation at reduced pressure. The residue, which was a pale yellow liquid, was extracted thoroughly with benzene. There were obtained 155 grams of pale yellow liquid. The NMR spectrum of this liquid showed a pentet at 4.05-4.55 ppm. (two triplets partially superimposed at 1.82-2.45 ppm., singlet at 2.05 ppm.) relative intensity 2.6 (due to CH_2P and CH_2C), the OH line was at 6.54 ppm. All lines are relative to sodium 2,2-dimethyl-2-silapentane sulphonate. This material was used as the starting material for Example II below.

EXAMPLE I

Dry hydrogen chloride was passed into 39.2 grams (0.2 mole) of vigorously stirred 2-acetoxyethylphosphonic acid diethyl ester at a rate of 125 ml./minute and a temperature of 150°C. The total reaction time was 16 hours. At the end of this time the product was a thick pale yellow liquid. Acetic acid was removed at reduced pressure leaving 28.0 grams of a pale yellow liquid which solidified on standing. Titration of the product showed that it contained at least 75% 2-chloroethylphosphonic acid. The NMR spectrum had a singlet at 5.7 ppm., intensity 1, OH; multiplet at 3.5-4.0 ppm., intensity 1, CH_2Cl ; two triplets at 2.0-2.0 ppm., intensity 1, CH_2P . There were no lines due to vinyl protons. All lines were relative to sodium 2,2-dimethyl-2-silacyclopentane sulphonate.

EXAMPLE II

Example I was repeated except that 33.6 grams (0.2 mole) of 2-acetoxyethylphosphonic acid from the "Preparation" above were used. There was isolated 27.4 grams which was shown to contain 85% 2-chloroethylphosphonic acid. The NMR spectrum was identical with that obtained in Example I.

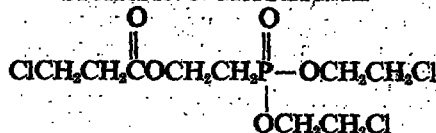
EXAMPLES III to VII

The reaction of Example I was repeated except that the acyloxy starting materials were as follows:

EXAMPLE NO.

III

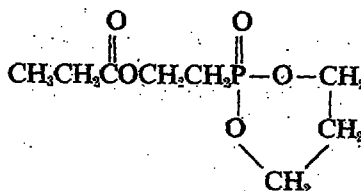
STARTING MATERIAL



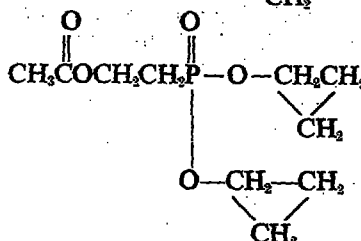
IV



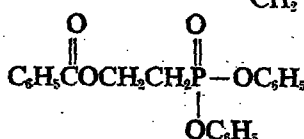
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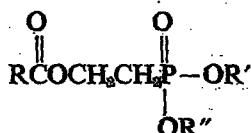
VII



Using the same reaction conditions and recovery techniques as in Example I, 2-chloroethylphosphonic acid in good purity was obtained in each of Examples III to VII.

WHAT WE CLAIM IS:—

1. A process for the preparation of a 2-haloethylphosphonic acid which comprises reacting a 2-acyloxyethylphosphonic acid of the general formula:



wherein R is alkyl of 1 to 7 carbon atoms, cycloalkyl of 3 to 8 carbon atoms, haloalkyl of 1 to 7 carbon atoms, or aryl of 6 to 12 carbon atoms, R' and R'' are hydrogen, alkyl of 1 to 7 carbon atoms, haloalkyl of 2 to 7 carbon atoms, or cycloalkyl of 3 to 8 carbon atoms or aryl and R' and R'' are the same or different, or R' and R'' together with the oxygen atoms attached to the P atom represent 2 to 6 methylene groups to form a heterocyclic ring system, with anhydrous hydrogen halide at a temperature between 30°C. and 200°C.

2. The process as claimed in Claim 1, wherein the hydrogen halide is hydrogen chloride and the final product is 2-chloroethylphosphonic acid.

3. The process as claimed in Claim 1

or Claim 2, wherein the reaction is conducted at atmospheric pressure.

4. The process as claimed in any preceding claim, wherein at least 3 moles of anhydrous hydrogen chloride is employed in the reaction.

5. The process as claimed in any preceding claim, wherein the reaction is conducted at a temperature between 100° and 160°C.

6. The process as claimed in Claim 5, wherein the reaction is conducted at 150°C.

7. The process as claimed in any one of Claims 1 to 6, wherein R is methyl, and R' and R'' are ethyl.

8. The process as claimed in any one of Claims 1 to 6, wherein R is methyl and R' and R'' are hydrogen.

9. The process as claimed in any one of Claims 1 to 6, wherein R is methyl and R' and R'' are 2-chloroethyl.

10. The process as claimed in Claim 1 substantially as herein described and exemplified.

11. A 2-haloethyl-phosphonic acid when obtained by the process claimed in any preceding claim.

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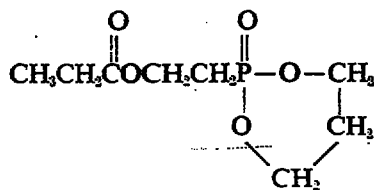
Chartered Patent Agents,

70-72 Chancery Lane,

London, W.C.2.

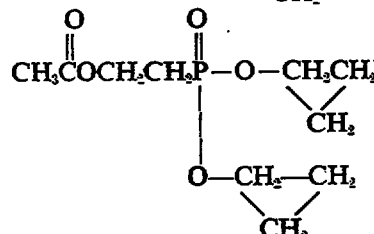
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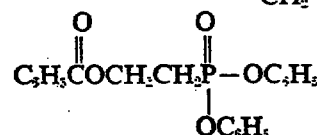
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VII



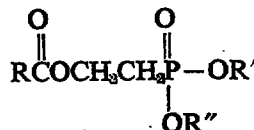
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Using the same reaction conditions and recovery techniques as in Example I, 2-chloroethylphosphonic acid in good purity was obtained in each of Examples III to VII.

WHAT WE CLAIM IS:—

1. A process for the preparation of a 2-haloethylphosphonic acid which comprises reacting a 2-acyloxyethylphosphonic acid of the general formula:

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wherein R is alkyl of 1 to 7 carbon atoms, cycloalkyl of 3 to 8 carbon atoms, haloalkyl of 1 to 7 carbon atoms, or aryl of 6 to 12 carbon atoms, R' and R'' are hydrogen, alkyl of 1 to 7 carbon atoms, haloalkyl of 2 to 7 carbon atoms, or cycloalkyl of 3 to 8 carbon atoms or aryl and R' and R'' are the same or different, or R' and R'' together with the oxygen atoms attached to the P atom represent 2 to 6 methylene groups to form a heterocyclic ring system, with anhydrous hydrogen halide at a temperature between 30°C. and 200°C.

2. The process as claimed in Claim 1, wherein the hydrogen halide is hydrogen chloride and the final product is 2-chloroethylphosphonic acid.

3. The process as claimed in Claim 1

or Claim 2, wherein the reaction is conducted at atmospheric pressure.

4. The process as claimed in any preceding claim, wherein at least 3 moles of anhydrous hydrogen chloride is employed in the reaction.

5. The process as claimed in any preceding claim, wherein the reaction is conducted at a temperature between 100° and 160°C.

6. The process as claimed in Claim 5, wherein the reaction is conducted at 150°C.

7. The process as claimed in any one of Claims 1 to 6, wherein R is methyl, and R' and R'' are ethyl.

8. The process as claimed in any one of Claims 1 to 6, wherein R is methyl and R' and R'' are hydrogen.

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