

1

3,658,824

PROCESS FOR THE PREPARATION OF
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5 Claims

ABSTRACT OF THE DISCLOSURE

A process for the preparation of piperidine is described in which 4-cyanobutyraldehyde is hydrogenated in the presence of a suitable catalyst and ammonia.

The present invention relates to a process for the preparation of piperidine.

Several methods are presently known for the preparation of piperidine, but of these known methods only the preparation of piperidine by the reduction of pyridine, is of any practical importance. Even this method, however, has the disadvantage that pyridine is a rather expensive starting material.

It has now been found that piperidine can be prepared quite economically according to the process of the present invention, whereby 4-cyanobutyraldehyde is hydrogenated in the presence of a hydrogenation catalyst and ammonia. The 4-cyanobutyraldehyde starting material for this process may be prepared in a suitable manner from relatively inexpensive basic materials such as acetaldehyde and acrylonitrile by a process, for example, according to application U.S. Ser. No. 8,704 filed Feb. 4, 1970 by the present applicants.

When practicing the process of the present invention, it is possible to achieve a yield of over 85% piperidine calculated on the basis of 4-cyanobutyraldehyde. Such a high yield is particularly surprising in light of prior experience with the catalytic hydrogenation of 4-cyano-2,2-dimethylbutyraldehyde to 3,3-dimethylpiperidine as disclosed in German Auslegeschrift 1,222,931. When this latter hydrogenation is carried out in the presence of ammonia, a yield of no more than 25% is attained. On the other hand, when the same hydrogenation is carried out in the absence of ammonia, a higher yield can be realized, but in no event greater than 80%.

The amount of ammonia required in practicing the present invention is not critical, and may be varied over a wide range. A favorable influence on the yield can be noticed at an ammonia to 4-cyanobutyraldehyde molar ratio as low as about 2:1. For optimum results, however, it is preferable to use an ammonia to 4-cyanobutyraldehyde molar ratio within a range from about 5:1 to 25:1.

In practicing the process according to the present invention, various known and typical hydrogenation catalysts may be employed, such as nickel or cobalt on a carrier or in the form of a Raney-catalyst and catalysts containing a platinum-metal such as platinum and palladium.

The present process can be carried out with or without an inert solvent. Examples of suitable solvents include water, lower alkanols such as methanol, ethanol and isopropanol, and lower alkyl ethers, or mixtures of any of the above.

The present process is preferably carried out at a temperature in the range of between about 50° C. up to about 200° C., but most preferably at a temperature of about 80 to 150° C. A pressure in the range from about 1 to 300 atmospheres may be used but a pressure of 25 to 125 atmospheres is preferable.

2

The resulting reaction product obtained by the present process consists primarily of piperidine. There may also be some by-product formation of 1,5-diaminopentane, but this is not objectionable in that 1,5-diaminopentane can be recovered and easily converted to piperidine, for example by a process as disclosed in *Chemische Berichte*, volume 95, 1962, page 1992.

The process of the present invention can be carried out either continuously or as a batch process by any of a number of known hydrogenation methods. When a batch process is used, it is preferably carried out by adding the 4-cyanobutyraldehyde to the ammonia-catalyst mixture while the latter is kept under hydrogen pressure. In this way, the by-product formation of 1,5-diaminopentane is minimized.

The following examples show some of the various means by which the invention can be carried into practice, but are merely illustrative and are in no way intended to limit the scope of the invention.

EXAMPLE 1

Methanol (250 ml.) and ammonia (425 g., 25 moles) were introduced into a 5 l. autoclave provided with a stirrer and a feed line, along with a Raney nickel catalyst (30 g.). The ammonia was introduced by connecting the autoclave with a bomb containing liquid ammonia. Hydrogen was fed into the autoclave until a pressure of 55 atmospheres was reached whereupon this mixture in the autoclave was heated to 125° C. A solution of 4-cyanobutyraldehyde (121.3 g., 1.25 moles) in methanol (750 ml.) was then added to the autoclave with simultaneous stirring over a period of 1.5 hours while maintaining the mixture temperature at 125° C. An additional 50 ml. of methanol was fed to the autoclave in order to wash out the feed line. The temperature was then raised to 130° C. and maintained, with continuous stirring, for one hour. The mixture was then cooled to room temperature. The autoclave was opened and ammonia was released, the catalyst recovered by filtration and the methanol was recovered from the filtrate by distillation whereby the ammonia dissolved in the filtrate was released. Benzene (250 g.) was then added to the remaining reaction product in order to facilitate the removal of water by azeotropic distillation. The remaining product was then further distilled to yield a small quantity of benzene, 92 g. of piperidine (1.00 mole) having a boiling point 103–105° C., and 14 g. of 1,5-diaminopentane (0.14 mole) having a boiling point of 175–178° C. The yield calculated on the basis of 4-cyanobutyraldehyde was 86.5% for the piperidine, and 11% for the 1,5-diaminopentane.

EXAMPLE 2

Methanol (350 ml.) and ammonia (170 g., 10 moles) were introduced into a 5 l. autoclave provided with a stirrer and feed line, along with a Raney nickel catalyst (40 g.). Hydrogen was fed into the autoclave until a pressure of 80 atmospheres was reached whereupon the mixture in the autoclave was heated to 120° C. A solution of 4-cyanobutyraldehyde (121.3 g., 1.25 moles) in methanol (750 ml.) was then added to the autoclave with simultaneous stirring over a period of 2 hours while maintaining the mixture temperature at 120° C. An additional 75 ml. of methanol was fed to the autoclave in order to wash out the feed line. Stirring was then continued for another 1.5 hours while maintaining the mixture temperature at 120° C. The mixture was then cooled to room temperature. The autoclave was opened, the catalyst recovered by filtration, and the filtrate was dried with potassium hydroxide. The dried solution was subsequently distilled resulting in the recovery of methanol, and a yield of 79.7 g. of piperidine (0.937 mole) having a boiling point of 104–105° C., and 10.2 g. of 1,5-diaminopentane (0.1

3

mole) having a boiling point of 175–177° C. The yield calculated on the basis of 4-cyanobutylaldehyde was 75% for the piperidine and 8% for the 1,5-diaminopentane.

EXAMPLE 3

Methanol (400 ml.) and ammonia (380 g., 22.5 moles) were introduced into a 5 l. autoclave provided with a stirrer and feed line, along with a Raney nickel catalyst (30 g.). Hydrogen was fed into the autoclave until a pressure of 115 atmospheres was reached whereupon this mixture in the autoclave was heated to 95° C. A solution of 4-cyanobutylaldehyde (120 g. of impure 4-cyanobutylaldehyde, equivalent to 1.16 moles of pure 4-cyanobutylaldehyde) in methanol (700 ml.) was then added to the autoclave with simultaneous stirring over a period of 2 hours while maintaining the mixture at temperature of 95° C. An additional 50 ml. of methanol was fed to the autoclave in order to wash out the feed line. The temperature in the autoclave was maintained at 95° C. for an additional period of 2 hours with continuous stirring. The mixture was then cooled to room temperature. The autoclave was opened, the catalyst recovered by filtration, and the filtrate was dried with sodium sulphate. Distillation of the dried filtrate yielded 82.7 g. of piperidine (0.973 mole having) having a boiling point of 104–105° C., and 12 g. of 1,5-diaminopentane (0.117 mole) having a boiling point of 174–177° C. The yield calculated on the basis of 4-cyanobutylaldehyde was 84% for the piperidine and 10% for the 1,5-diaminopentane.

EXAMPLE 4

4-cyanobutylaldehyde (121.3 g., 1.25 moles) dissolved in methanol (750 ml.), and ammonia (425 g., 25 moles) were fed into a 5 l. autoclave provided with a stirrer and feed line, along with a Raney nickel catalyst (40 g.). Hydrogen was fed into the autoclave until a pressure of 60 atmospheres was reached. The mixture in the autoclave was then heated to 105° C. with simultaneous stirring over a period of 1 hour and thereafter maintained at this temperature for an additional hour with continuous stirring. The mixture was then cooled to room temperature. The autoclave was opened, the catalyst re-

4

covered by filtration, and the filtrate was dried with sodium sulphate. The dried filtrate was then distilled to recover the methanol, and the remaining product contained 73.3 g. of piperidine (0.86 mole) having a boiling point of 103–104° C. and 30.6 g. of 1,5-diaminopentane (0.3 mole) having a boiling point of 174–177° C. The yield calculated on the basis of 4-cyanobutylaldehyde was 69% for the piperidine, and 24% for the 1,5-diaminopentane.

What is claimed is:

1. A process for the preparation of piperidine consisting essentially in the hydrogenation of 4-cyanobutylaldehyde in the presence of a hydrogenation catalyst and ammonia wherein said hydrogenation is carried out at a temperature of between 50 and 200° C. and at a pressure of between 1 and 300 atmospheres.

2. A process according to claim 1 wherein the hydrogenation is carried out in the presence of a solvent.

3. A process according to claim 1 wherein the molar ratio of ammonia to 4-cyanobutylaldehyde is at least 2:1.

4. A process according to claim 3 wherein the molar ratio of ammonia to 4-cyanobutylaldehyde is at least 5:1 and no greater than 25:1.

5. A process according to claim 1 wherein said hydrogenation is carried out in a batch reactor under a positive hydrogen pressure and said 4-cyanobutylaldehyde is added to said ammonia and hydrogenation catalyst while said ammonia and hydrogenation catalyst are under said positive hydrogen pressure.

References Cited

UNITED STATES PATENTS

2,794,806 6/1957 Elam et al. ----- 260—293.2

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1,222,931 8/1966 Germany ----- 260—293.2

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260—585

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,658,824 Dated April 25, 1972

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It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, between lines 7 and 8, there should appear -- claims priority, application Netherlands, March 29, 1969, No. 6904908 --; line 32, "~~maner~~" should appear -- manner --; line 35 should read -- present assignee and one of the present co-applicants --; column 3, line 2; "4-cyanobuyraldehyde" should appear -- 4-cyanobutyraldehyde --; line 25 "having", first occurrence, should be cancelled.

Signed and sealed this 12th day of December 1972.

(SEAL)
Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents