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Purification of ϵ -caprolactam

Description

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The present invention relates to a process for purifying ϵ -caprolactam.

ϵ -Caprolactam is an important starting material for the production of polyamides (nylon 6). There are various ways of producing it industrially. The most popular option is by Beckmann rearrangement of cyclohexanone oxime (K. Weissmerl, H.J. Arpe, Industrielle Organische Chemie, 4th edition, pp. 272). Alternatively, cyclohexanecarboxylic acid is produced from toluene via benzoic acid and rearranged with nitrosylsulfuric acid to the ϵ -caprolactam. Other processes are based on the cyclization of ω -aminocaproic acid derivatives, for example 6-aminocaproic esters (EP-A 376 123) or 6-aminocapronitrile (EP 659 741), in the presence of suitable, typically acidic, catalysts to form ϵ -caprolactam.

All ϵ -caprolactam processes give rise to by-products, the nature and quantity of which depend on the principle of the process, on the quality of the starting materials and also on the process parameters. On the other hand, the ϵ -caprolactam has to meet high purity requirements, especially in fibermaking. For this reason, each manufacturing process requires its own optimized purification process. The various purification processes are cited for example in Process Economics Program Report No. 41 B, Caprolactam and Nylon 6, March 1988, pp. 69.

These purification processes are generally combinations of extraction, distillation and/or crystallization processes. Highly contaminated caprolactam fractions, for example caprolactam purification residues, are frequently subjected to a catalytic hydrogenation. Removal of the catalyst is generally followed by a distillative workup or the return into the purification cycle. In the case of a catalytic suspension hydrogenation of the crude ϵ -caprolactam using Raney nickel (EP-A-138 241, JP-A-60-21145) the removal of the catalyst presents problems. In the case of a hydrogenation of the crude ϵ -caprolactam over fixed-bed catalysts (DE-A-1004616, DD-A-75083), decreasing activity or poisoning of the catalysts is likely over time.

It is an object of the present invention to provide a low-cost universally deployable purification process for ϵ -caprolactam.

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I have found that this object is achieved, surprisingly, by using a complex hydride of aluminum or of boron.

The present invention accordingly provides a process for purifying ϵ -caprolactam, which comprises reacting crude ϵ -caprolactam with a complex hydride of aluminum or of boron.

Suitable complex hydrides of aluminum or of boron for the process of this invention are in particular sodium borohydride, lithium borohydride, potassium borohydride, calcium borohydride, sodium cyanoborohydride, sodium methoxyethoxyaluminum hydride, lithium tri-*t*-butoxyaluminum hydride.

The amount of hydride hydrogen used naturally depends on the concentration of the impurities in the ϵ -caprolactam. It is chosen so that an excess of hydride hydrogen is present, based on the impurities to be reduced. Preference is given to an excess of from 1.5 to five times, based on the stoichiometrically required hydride quantity.

It has been found that, to obtain an adequate reaction rate in the ϵ -caprolactam purification process of this invention, from 10 to 50 % by weight of water, based on crude ϵ -caprolactam, [lacuna] to be added to the reaction mixture when a borohydride is used.

In a preferred embodiment, the reaction is carried out in the presence of from 0.5 to 5 mol%, in particular from 1 to 4 mol% of NaBH_4 and of from 10 to 50 % by weight of water, based on crude ϵ -caprolactam. The sodium borohydride can be used in solid form or in the form of a commercially available aqueous solution.

The reaction is preferably carried out within the range from 10 to 150°C, in particular within the range from 20 to 100°C. The reaction time is within the range from 0.5 h to 200 h, preferably within the range from 1 h to 100 h.

After the reaction has ended, water and the reduced impurities are distilled off under a slightly reduced pressure. It is also possible to distil off water and impurities continuously even during the reaction by applying a slight reduced pressure. Thereafter the reaction mixture is subjected to a conventional distillation under reduced pressure (0.5-8 mm Hg). Pure ϵ -caprolactam is obtained as distillate with a UV number < 10 (see below).

The process of this invention is suitable for purifying ϵ -caprolactam produced by any of the conventional manufacturing processes. This process is advantageously suitable for purifying



ϵ -caprolactam produced by cyclization of ω -aminocaproic acid derivatives, for example ω -aminocaproic acid, ω -aminocaproamide, ω -aminocaproic ester and ω -aminocapronitrile.

5 Examples:

Purification of a caprolactam produced by cyclization of ω -aminocapronitrile

- 10 The purity of the ϵ -caprolactam is determined in terms of the UV number. The UV number is defined as the sum of all absorbances of a 50 % strength by weight aqueous caprolactam solution measured at intervals of 10 nm in the wavelength range from 280 nm to 400 nm in a cell having a pathlength of $d = 5$ cm. The UV number
15 of the purified ϵ -caprolactam should not exceed 10.

Example 1

Preparation of ϵ -caprolactam in accordance with DE-A 43 396 48
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- 100 parts by weight of ω -aminocapronitrile were dissolved in 1000 parts by weight of ethanol and 30 parts by weight of water and passed over a fixed bed of titania (anatase) at 220°C with a residence time of 12 min. The solvent was then distilled off. The
25 crude caprolactam thus obtained was used in the following purification stage.

Purification of the crude ϵ -caprolactam

- 30 70 parts by weight of crude caprolactam and 30 parts by weight of water were admixed with 1 % by weight of sodium borohydride (based on crude ϵ -caprolactam) in a stirred vessel equipped with a still head. After 100 h, the reaction mixture was subjected to fractional distillation. ϵ -Caprolactam passed over at 119°C
35 (2 mbar) with a UV number of 3.1.

Example 2

- Crude caprolactam prepared by Beckmann rearrangement (see
40 Progress [sic] Economics Program Report (SRI Report) No. 41 B, Caprolactam and Nylon 6, March 1988) was reacted as described in Example 1 in the presence of 0.4 % by weight NaBH_4 . After 24 h, the reaction mixture was subjected to fractional distillation. ϵ -Caprolactam passed over at 125°C (3 mbar) with a UV number of
45 3.5.

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I claim:

1. A process for purifying ϵ -caprolactam, which comprises
5 reacting ϵ -caprolactam with a complex hydride of aluminum or
of boron.
2. A process as claimed in claim 1, wherein the complex hydride
is selected from the group consisting of NaBH_4 , LiBH_4 , KBH_4 ,
10 $\text{Ca}(\text{BH}_4)_2$, $\text{NaAlH}_2(\text{OCH}_3)(\text{OC}_2\text{H}_5)$, $\text{LiAlH}(\text{Ot-Bu})_3$ and NaBH_3CN .
3. A process as claimed in either of the preceding claims,
wherein from 2 to 20 mol% of hydridic hydrogen is used, based
on the ϵ -caprolactam to be purified.
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4. A process as claimed in any of claims 2 to 5 [sic], wherein
 ϵ -caprolactam is reacted in the presence of from 0.5 to
5 mol% of NaBH_4 and from 10 to 50 % by weight of water, based
on the ϵ -caprolactam to be purified.
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