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PROCESS FOR PURIFYING LACTAMS

The invention relates to a process for purifying lactams, in particular the lactams obtained by cyclizing hydrolysis of an aminoalkylnitrile.

5 The invention relates more particularly to the purification of ϵ -caprolactam obtained by cyclizing hydrolysis of aminocapronitrile.

Lactams and in particular ϵ -caprolactam are important chemical compounds used as starting materials
10 in the manufacture of many products. One of the most important applications is the manufacture of polymers such as polyamides.

Among the processes for synthesizing lactams and in particular ϵ -caprolactam which have been
15 proposed is a process consisting in manufacturing an aminoalkylnitrile such as aminocapronitrile and then in carrying out a cyclizing hydrolysis of this aminonitrile. This process, which may be carried out in liquid or gaseous medium with or without solvent, is
20 disclosed, for example, in patents EP 0 729 454, EP 0 729 453, EP 0 793 650, EP 0 793 651, EP 0 794 943, EP 0 815 077, EP 0 815 078, EP 748 797, EP 659 741 and WO 96/22974.

An important step in the manufacture of
25 lactams, in particular ϵ -caprolactam, when these need to be used as monomers in the manufacture of polymers

such as polyamides, is the purification of the products. Specifically, for these applications, the lactam must satisfy highly stringent and demanding purity criteria. These criteria are defined by various
5 indices or concentrations corresponding to several types or categories of impurity. These main criteria are:

permanganate number (I_{KMnO_4})

content of volatile bases (I_{VB})

10 UV index (I_{UV})

Various purification processes have already been proposed. Thus, US patent 5 496 941 discloses a process for purifying caprolactam extracted from the reaction medium of a cyclizing hydrolysis by
15 distillation comprising a hydrogenation step followed by a treatment in acidic medium (treatment on ion-exchange resin or distillation in sulphuric acid medium) and a distillation in basic medium.

European patent application No. 94/3608
20 discloses a process for purifying crude ϵ -caprolactam obtained by cyclization of an alkyl 6-aminocaproate, which consists in carrying out a crystallization of the caprolactam. According to the said document, certain components such as N-methylcaprolactam,
25 methylvalerolactam and valeramide are removed by crystallization. The process disclosed indicates that

the caprolactam thus crystallized satisfies the required purity criteria regarding the content of volatile bases and the UV index for absorption at a wavelength of 290 nm.

5 However, the said document does not specify whether or not the third purity criterion, the permanganate number, is achieved.

 In the case of a caprolactam obtained from the cyclizing hydrolysis of an aminocapronitrile
10 obtained by semihydrogenation of adiponitrile, the purity criteria of the caprolactam are achieved by carrying out purification processes described above comprising several successive treatments, in particular an acidic treatment and a final distillation in basic
15 medium.

 In such processes, the production of a caprolactam of the desired purity requires the implementation of a distillation operation with a large heavy fraction (fraction of products with a high
20 boiling point) comprising a large amount of lactam in the form of lactam or oligomers. This loss of lactam is detrimental to the process.

 One of the aims of the present invention is especially to overcome this drawback by proposing a
25 process for purifying lactams making it possible to obtain a product that satisfies the desired purity

criteria, thus limiting the lactam treatment steps and more particularly those which may generate the formation of oligomers.

To this end, the invention proposes a process
5 for purifying a lactam obtained from the cyclization of an aminoalkylnitrile obtained by semihydrogenation of an alkyl dinitrile, which consists, after removing the volatile compounds from the cyclization medium, in extracting the lactam formed by crystallization.

10 According to another preferred characteristic of the invention, the crystalline lactam can be subjected to one or more other crystallization steps to obtain the desired purity. Other purification treatments may be carried out on the crystalline lactam
15 without departing from the scope of the present invention.

According to another embodiment, the cyclization medium may be subjected to a hydrogenation before the step to remove the volatile compounds.

20 According to yet another embodiment, the crystallization of the caprolactam is carried out on the cyclization medium which may or may not have undergone a hydrogenation, after treating it in acid medium, for example by passing it through an
25 ion-exchange resin or a distillation in acidic medium.

According to another embodiment, a

hydrogenation of the cyclization medium may be carried out after removing the volatile compounds.

For simplicity, the expression "cyclization medium" for carrying out the crystallization means
5 either the reaction medium obtained from the cyclization step on which the various treatments described above are carried out, or the medium formed by the caprolactam extracted after the cyclization reaction, for example by distillation or entrainment,
10 in other words after removal or separation of the volatile compounds and the high-boiling compounds. The classification into volatile compounds and high-boiling compounds is made relative to the boiling point of the lactam to be recovered.

15 According to the invention, the extraction and recovery of the lactam by a crystallization make it possible to obtain a product which satisfies the desired purity criteria, without the need for treatment at temperatures which may generate the formation of
20 oligomers, for example.

Thus, the degradation or polymerization of the lactam, which arises when it is heated to high temperatures, especially in order to distil it, is avoided.

25 The process of the invention applies more particularly to the purification of ϵ -caprolactam

obtained by cyclizing hydrolysis of aminocapronitrile.

This aminocapronitrile is synthesized by semihydrogenation of adiponitrile. These various semihydrogenation processes are disclosed, for example,
5 in patents EP 737 100, EP 737 181 and WO 96/18603.

According to the invention, the solvents that are suitable for the crystallization may be a lactam, water, saturated hydrocarbons such as hexane or cyclohexane, alcohols, aromatic hydrocarbons,
10 organohalogen compounds such as CCl_4 or CHCl_3 , ketones or the like.

Solvents that will preferably be used include water and/or a lactam and more preferably a lactam which is identical to the one which needs to be
15 purified, or, more preferably, a saturated aqueous lactam solution.

The crystallization may be carried out in one step or in several steps. The mother liquor obtained in one step is advantageously recycled into one of the
20 preceding steps. More generally, the crystallization may be carried out according to the conventional industrial crystallization techniques.

According to another characteristic of the process of the invention, the compound obtained after
25 crystallization is filtered off, spin-filtered or isolated by any other common solid/liquid separation

technique. The solid recovered may be advantageously washed with a solvent, preferably with a saturated lactam solution.

Advantageously, the medium containing the
5 lactam to be crystallized is concentrated by any means which is suitable to obtain a weight concentration of lactam of greater than 80% by weight, preferably greater than 90%.

Thus, examples of techniques for saturating
10 or concentrating the solution which may be mentioned include techniques of cooling and evaporation advantageously under reduced pressure to work at lower temperature.

In addition, the crystallization can be
15 performed with seeding of the solution in order to promote nucleation of the lactam.

The pure lactam recovered after solid/liquid separation, for example filtration, and optional washing, is dried or the solvent, for example water, is
20 distilled off according to usual techniques (when the solvent is water, the caprolactam is dehydrated).

The process of the invention thus makes it possible to produce a lactam, more particularly an ϵ -caprolactam, which has the desired purity criteria
25 for use as monomer in the manufacture of polyamides such as PA6. The polyamides thus obtained are suitable

in particular for the manufacture of textile yarns or fibres with working properties that are equivalent to those of the current polyamides.

Other advantages and details of the invention
5 will be illustrated by the implementation examples below, given purely as a guide.

Example 1

An ϵ -caprolactam is manufactured according to the process disclosed in the patents cited above.

10 Thus, this ϵ -caprolactam is obtained according to Example 1 of patent EP 748 797 by semihydrogenation of adiponitrile followed by cyclizing hydrolysis of aminocapronitrile according to the conditions described in the said example.

15 The medium obtained is subjected to a hydrogenation according to the process disclosed in the as yet unpublished French patent application filed under No. 98/14735 on 19 November 1998.

The ammonia present in the hydrogenated
20 cyclizing hydrolysis reaction medium is then removed by evaporation or entrainment.

The cyclization medium thus obtained is then treated by passing it through an ion-exchange resin according to the conditions disclosed in the patents or
25 patent applications WO 98/05636 or WO 96/20923.

The medium obtained after treatment with

resin contains 65% by weight of ϵ -caprolactam and numerous other products which were not all identified.

The medium thus recovered is analysed to determine the purity criteria defined above. The
5 results of these analyses are indicated in the table below.

In accordance with the process of the invention, the caprolactam is recovered by crystallization from this solution after concentration
10 under reduced pressure at a caprolactam content in the region of 90% by weight.

The concentrated solution is at a temperature of 40°C and is then cooled to a temperature in the region of 20°C at a cooling rate of about 10°C per
15 hour.

The crystals formed are recovered by filtration on a sinter funnel. The mother liquors recovered are stored for possible recycling.

The solid cake of caprolactam crystals is
20 washed with a saturated aqueous caprolactam solution. The degree of washing with wet base is advantageously between 1 and 5.

The crystalline caprolactam is analysed. The purity characteristics are collated in Table I below.

Test	Medium	I_{UV}	I_{KM04}	I_{VB} (meq/kg)
	Medium before crystallization	0.45	32.06	2.69
	Wet cake after washing	0.02	2.03	0.04

Example 2

A caprolactam is manufactured according to
5 the process described in Example 1 and with reference
to the process disclosed in patent application
EP 748 797.

However, in this example, the medium obtained
from the cyclizing hydrolysis is only treated to remove
10 the volatile compounds, more particularly ammonia.

The crystallization of the caprolactam formed
is carried out directly using this solution after
concentration by evaporation of water.

The crystallization is carried out in two
15 successive steps. The cake recovered in the first step
is taken up to give a new saturated aqueous solution
and is then recrystallized. The purity characteristics
of the cake recrystallized after washing are given in
Table II below.

Test	Medium	I_{UV}	I_{KMnO_4}	I_{VB} (meq/kg)
2	Medium before crystallization	17.7	400	130
	Wet cake recrystallized after washing	0.03	2.0	0.20

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CLAIMS

1. Process for purifying lactams obtained by cyclization of an aminoalkylnitrile, characterized in that it consists in recovering the lactam by
5 crystallization after removing the volatile compounds from the cyclization medium.
2. Process according to Claim 1, characterized in that the crystallization is carried out in several steps.
- 10 3. Process according to Claim 1 or 2, characterized in that the cyclization medium is subjected to a hydrogenation before removing the volatile compounds.
- 15 4. Process according to one of the preceding claims, characterized in that the cyclization medium is treated with an ion-exchange resin before recovering the lactam by crystallization.
- 20 5. Process according to one of Claims 1 to 3, characterized in that the cyclization medium is treated by distillation in sulphuric medium.
6. Process according to one of the preceding claims, characterized in that the cyclization medium from which the lactam is crystallized consists of the reaction medium obtained from the cyclization
25 reaction after removal of the volatile compounds and the high-boiling compounds.

7. Process according to one of Claims 1, 2 and 4 to 6, characterized in that the cyclization medium is subjected to a hydrogenation after separation of the volatile compounds and/or of the high-boiling compounds.

8. Process according to one of the preceding claims, characterized in that the lactam is ϵ -caprolactam.

9. Process according to Claim 8, characterized in that the ϵ -caprolactam is produced by cyclizing hydrolysis of aminocapronitrile.

10. Process according to Claim 9, characterized in that the aminocapronitrile is synthesized by semihydrogenation of adiponitrile.

11. Process according to one of the preceding claims, characterized in that the crystallization solvent is chosen from the group comprising a lactam, an aqueous lactam solution, water, saturated hydrocarbons, alcohols, aromatic hydrocarbons, organohalogen compounds and ketones.

12. Process according to Claim 11, characterized in that the solvent is a saturated aqueous lactam solution.

13. Process according to one of the preceding claims, characterized in that the weight concentration of lactam in the solution to be crystallized is greater than 80% by weight.

14. A lactam obtained by a process according

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to any one of claims 1 to 13..