

Chemical treatment of recovered liquid caprolactam

The present invention relates to a process for preparing a liquid high-purity ϵ -caprolactam stream, wherein the process comprises the chemical permanganate treatment of a pre-purified ϵ -caprolactam stream. Further, the present invention relates to the liquid high-purity ϵ -caprolactam stream such which, in particular, exhibits excellent storage properties in terms of color stability. Further, the present invention relates to the use of this stream for preparing a polymer, preferably polyamide 6. According to the present invention, the pre-purified ϵ -caprolactam stream is preferably prepared by subjecting a solid material which comprises polyamide 6 to hydrolytic depolymerization and purifying the resulting depolymerization mixture with respect to ϵ -caprolactam; therefore, the present invention preferably relates to a full polyamide 6 (or ϵ -caprolactam) recycle loop.

Polyamide 6 characterized by the formula $(-\text{NH}-(\text{CH}_2)_5-\text{CO}-)_n$, can be found in numerous materials, such as packaging, engineering plastics from automotive, and textile filaments. The latter represents about 40 % of the polyamide 6 global market. At present, only a very small part of the textile filaments is recycled while it represents a significant percentage of the global CO_2 emissions. There is thus a need to recycle polyamide 6 from such materials. The purification process for ϵ -caprolactam downstream of the depolymerization step is not a straight-forward task, for example due to the various possible chemical compositions of waste materials comprising polyamide 6 which form the educt materials for the recycling process. Therefore, there is the need for a purification process which results in a high-purity ϵ -caprolactam material based on which said recycle loop can be advantageously realized, i.e. the re-polymerization of polyamide 6 can be carried out. Yet further, once such a purified ϵ -caprolactam material is obtained from depolymerisation and downstream purification stages, it is not guaranteed that it can be used as educt material immediately after its preparation. Often times, it will be necessary to store said mixture for a certain period of time prior to further use. As far as such storing is concerned, it is necessary that in the course thereof, the quality of the mixture is kept essentially constant, in particular as far as the color properties, most commonly expressed in terms of the APHA color values. Therefore, there is also the need for the preparation of high purity ϵ -caprolactam which exhibits said advantageous storage characteristics.

WO 2023/144338 A1 discloses a process for recovering purified ϵ -caprolactam from material derived from polyamide 6 comprising fishing nets in a plant, wherein the plant comprises a depolymerization section, a recovery section, and a purification section.

BASF "Caprolactam liquid – Product Information", August 2014, pages 1 to 2, is a product information of liquid ϵ -caprolactam from BASF, and Fibrant "EcoLactam liquid – Product Data Sheet", May 20 2021, pages 1 to 2, is a product data sheet of liquid ϵ -caprolactam from Fibrant.

Surprisingly, it was found that a process for specifically chemically treating a pre-purified

ϵ -caprolactam stream which is obtained from the depolymerization of a material M comprising polyamide 6 results in an ϵ -caprolactam material which exhibits the desired purity to be re-usable for realizing said recycling loop and, further, exhibits said advantageous storage characteristics.

- 5 Therefore, the present invention relates to a process for preparing a liquid high-purity ϵ -caprolactam stream S_T , the process comprising
- (i) preparing a liquid stream S_C comprising ϵ -caprolactam, said preparing comprising depolymerizing a material M comprising polyamide 6, said liquid stream S_C further comprising one or more oxidizable organic impurity compounds X, wherein the stream S_C has an ϵ -caprolactam purity $\Omega_{GC}(S_C)$ of at least 99 % and exhibits a weight ratio r_{XCC} of the one or more organic compounds X relative to ϵ -caprolactam;
 - (ii) providing a stream S_O comprising at least one permanganate;
 - (iii) preparing an oxidation reaction educt mixture M_{OE} from the stream S_C and the stream S_O , and subjecting the mixture M_{OE} to oxidation reaction conditions, obtaining an oxidation reaction product stream S_P comprising ϵ -caprolactam, further comprising one or more oxidation products Y obtained from the oxidation of at least a part of the one or more compounds X, and optionally further comprising a part of the one or more organic compounds X, wherein the stream S_P exhibits a weight ratio r_{XCP} of organic compound X relative to ϵ -caprolactam with $0 \leq r_{XCP} < r_{XCC}$ and further exhibits a weight ratio r_{YCP} of the one or more products Y relative to ϵ -caprolactam with $r_{YCP} > 0$;
 - (iv) separating at least a part of the one or more oxidation products Y and optionally at least a part of organic compound X from the stream S_P , obtaining the stream S_T exhibiting a weight ratio r_{YCT} of oxidation product Y relative to ϵ -caprolactam with $0 \leq r_{YCT} < r_{YCP}$, and further exhibiting a weight ratio r_{XCT} of organic compound X relative to ϵ -caprolactam with $0 \leq r_{XCT} \leq r_{XCP}$, wherein the stream S_T exhibits an ϵ -caprolactam purity $\Omega_{GC}(S_T)$ of at least 99.5 % with $\Omega_{GC}(S_T) > \Omega_{GC}(S_C)$, and an APHA value $\Omega_{APHA}(S_T)$ of at most 10.

Preferably, the stream S_C prepared according to (i) further comprises water. Preferred ranges of the water content of the stream S_C are from 0.01 to 10 weight-% or from 0.01 to 5 weight-% or from 0.01 to 2 weight-% or from 0.01 to 1 weight-% or from 0.01 to 0.5 weight-%.

The at least one permanganate comprised in the stream S_O provided according to (ii) preferably comprises, more preferably consists of, at least alkali metal permanganate, wherein more preferably, the at least one alkali metal permanganate comprises one or more of sodium permanganate and potassium permanganate. Preferably from 0.5 to 100 weight-% of the stream S_O provided according to (b) consist of permanganate. Therefore, generally, it is conceivable that the permanganate is used in its solid form. Preferably, the stream S_O provided according to (b) further comprises water. Preferably, the oxidation reaction educt mixture M_{OE} prepared according to (iii) exhibits a permanganate concentration, calculated as MnO_4 , in the range of from 0.005 to 5 weight-%, more preferably in the range of from 0.01 to 3 weight-%, more preferably in the range of from 0.05 to 1 weight-%. Yet further, the oxidation reaction conditions according to (iii) preferably comprise a temperature T_{OE} of the mixture M_{OE} in the range of from 40 to 140 °C, more preferably in the range of from 60 to 100 °C, more preferably in the range of from 70 to 90 °C.

Still further preferably, the mixture M_{OE} prepared according to (c) further comprises water. Preferably, subjecting the mixture M_{OE} to oxidation reaction conditions is carried out in an oxidation reaction unit U_{OR} which preferably comprises one or more of at least one continuous stirred tank reactor and at least one tube reactor.

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Further preferably, the process of the present invention further comprises providing a stream S_B comprising at least one hydroxide, wherein the oxidation reaction educt mixture M_{OE} according to (iii) is prepared from the stream S_C , the stream S_O and the stream S_B . The at least one hydroxide comprised in the stream S_B preferably comprises, more preferably consists of, at least one alkali metal hydroxide, wherein more preferably, the at least one alkali metal hydroxide comprises, more preferably consists of, sodium hydroxide. Preferably from 0.5 to 100 weight-% of the stream S_B consist of hydroxide. Therefore, generally, it is conceivable that the hydroxide is used in its solid form. Preferably, the stream S_B further comprises water. Preferably, the oxidation reaction educt mixture M_{OE} prepared according to (iii) exhibits a hydroxide concentration, calculated as OH, in the range of from 0.005 to 0.75 weight-%, more preferably in the range of from 0.01 to 0.5 weight-%, more preferably in the range of from 0.1 to 0.25 weight-%.

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Preferably according to the present invention, the one or more oxidizable organic compounds X have a boiling point $\delta_X/^\circ\text{C}$ with $0.5 \leq (\delta_X / \delta_C) \leq 1.5$, $\delta_C/^\circ\text{C}$ being the boiling point of ϵ -caprolactam and wherein at least one of the one or more oxidation products Y has a boiling point $\delta_Y/^\circ\text{C}$ with $\delta_Y/^\circ\text{C} \neq \delta_C/^\circ\text{C}$, wherein the difference $\Delta\delta$ between the boiling points δ_Y and δ_C is preferably at least 1°C . Usually, the one or more oxidizable organic compounds X will have a higher boiling point than ϵ -caprolactam; however, it is conceivable that there are oxidizable organic compounds having a lower boiling point than ϵ -caprolactam, for example certain aldehydes and/or ketones.

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In particular depending on the chemical composition of the material M according to (i), such oxidizable compounds X may include, but not be limited to,

- diol compounds such as ethylene glycol, diethylene glycol, 1,4-butanediol, neopentylglycol, 2-methyl-1,3-pentanediol;
- aromatic alcohols and amines such as phenol, o- toluidine, m- toluidine, p-toluidine, aniline, diamino toluenes;
- aliphatic amines such as hexamethylene diamine, 4-amino-2,2,6,6-tetramethyl-piperidin, 2,2,6,6-tetramethyl-piperidine, bis[2-(N,N-dimethylamino)-ethyl]ether.

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According to the present invention, it is preferred that separating at least a part of the one or more oxidation products Y and optionally at least a part of organic compound X from the stream S_P according to (iv) comprises subjecting the stream S_P obtained according to (iii) to distillation in a distillation unit U_{DT} . In this case, a stream S_{DT} is obtained from the distillation unit U_{DT} which comprises ϵ -caprolactam, wherein this stream S_{DT} is the stream S_T . Preferably, the unit U_{DT} comprises one or more distillation columns, more preferably one or two distillation columns, wherein at least one distillation column is optionally configured as side stream column or as divided wall column. According to the process of the present invention, the distillation unit U_{DT} can be design so as to accomplish one of the following separation tasks:

- a simple evaporation of ϵ -caprolactam;
 - separating one or more light boiling compounds from ϵ -caprolactam;
 - separating one or more high boiling compounds from ϵ -caprolactam;
 - separating one or more high boiling compounds and one or more light boiling compounds from ϵ -caprolactam
- 5 -- in one side-stream distillation column; or
- in two separate distillation columns; or
- in one divided wall distillation column; or
- 10 -- in one side stream distillation column, and a further distillation column wherein in said further distillation column
- one or more light boiling compounds; or where
- one or more high boiling compounds
- are separated from ϵ -caprolactam.
- 15 It may be preferred that prior to being subjected to separating according to (d), the stream S_P obtained from (c) is subjected to filtration.
- According to the process of the present invention, it may also be preferred that the stream SDT which is obtained from the distillation unit U_{DT} is passed, for further purification, to a crystallization unit UCR . In this case, separating at least a part of the one or more oxidation products Y and optionally at least a part of organic compound X from the stream S_P according to (iv) further comprises subjecting the stream S_{DT} to crystallization in a crystallization unit U_{CR} , obtaining from the unit U_{CR} a stream S_{CR} comprising ϵ -caprolactam as the stream S_T .
- 20 According to the present invention, it is preferred that preparing the stream S_C according to (i) comprises
- (i.1) providing a stream S_M comprising a solid material M comprising polyamide 6;
- (i.2) preparing an aqueous depolymerization mixture based on S_M ;
- (i.3) subjecting the depolymerization mixture prepared according to (i.2) to polyamide 6
- 30 depolymerization conditions in a reaction unit U_R , obtaining a liquid aqueous stream S_R comprising ϵ -caprolactam dissolved in water at a concentration c_{SR} , the stream S_R further comprising one or more impurities;
- (i.4) preferably passing the liquid aqueous stream S_R into an evaporation unit U_E , obtaining from S_R a liquid aqueous stream S_L comprising ϵ -caprolactam dissolved in water at a
- 35 concentration c_{SL} with $c_{SL} > c_{SR}$, and further obtaining from S_R one or more aqueous vapor streams S_V ;
- (i.5) passing the stream S_R , preferably the stream S_L , into a purification unit U_P , obtaining from the stream S_R , preferably from the stream S_L , the stream S_C .
- 40 According to (i.1), a stream S_M is provided which comprises a solid material M comprising polyamide 6. Preferably, the material M comprises, preferably consists of, waste material, wherein said waste material more preferably comprises, more preferably consists of, one or more

of at least one textile waste material and at least one engineering plastics waste material, more preferably comprises, more preferably consists of at least one textile waste material;

wherein preferably from 10 to 99 weight-%, more preferably from 30 to 98.5 weight-%, more preferably from 50 to 98 weight-%, more preferably from 80 to 98 weight-% of the material M

5 consist of polyamide 6;

wherein preferably, in addition to polyamide 6, the material M comprises one or more further organic polymeric compounds, more preferably including, but not limited to, one or more of at least one elastanes, at least one polyethylene terephthalate, at least one polytetrahydrofuran, at least one polyamide 6.6, at least one polyurethane, at least one polyester, at least one cellulose

10 material, and at least one rubber material comprising one or more of at least one natural rubber material and at least one synthetic rubber material.

Prior to being provided to the process of the present invention, the collected textile waste material can be suitably sorted. In this regard, it is possible to spread the collected textile waste material

15 on a conveyor, which spreading can be carried out either manually and/or mechanically.

Thereafter, the respectively spread textile waste material is subjected to sorting, either by composition and/or by color. Sorting can be carried out either manually and/or optically. If carried out optically, the sorting preferably comprises an infrared sorting, more preferably a near-infrared sorting and/or a mid-infrared sorting. Optionally, prior to sorting, the textile waste material can be

20 subjected to a suitable metal removing step. If a metal removing step is carried out, ferrous elements are preferably separated, for example by suitable magnetic means, and/or non-ferrous elements are preferably separated, for example by suitable eddy current separating means. After said sorting, the respectively obtained textile waste material can be subjected to a further treatment, such as cutting and/or milling.

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Generally, the solid material M can be provided according to any suitable method. Preferably according to the present invention, providing the solid material M comprises providing the solid material M in a delivering unit U_{MD} , wherein U_{MD} preferably comprises one or more of at least one big bag station and at least one a bulk container station; passing the provided solid material M via

30 a first connecting line from the unit U_{MD} to a material collecting unit U_{MC} , preferably a collecting drum, wherein the first connecting line preferably comprises one or more of at least one material receiving and discharge unit U_{MRD} , at least one first material feeding unit U_{FMF} , and at least one first particle separation unit U_{FMPS} ; passing the solid material M from the unit U_{MC} via a second

35 connecting line to the unit U_M , wherein the second connecting line preferably comprises one or more of at least one second material feeding unit U_{SMF} , at least one second particle separation unit U_{SMPs} , and at least one metal detector.

Generally, the solid material M may be provided from different sources if desired. For example, the collected textile waste material as a source of the solid material M may origin from different

40 textile waste material sources and may be combined, after which the collected textile waste material can be suitably sorted as indicated above. The textile waste material may generally have different grades of quality, different grades of impurities and different material combinations.

Nevertheless, such material is of course suitable for the process in accordance with the present

invention. The ϵ -caprolactam for the process in accordance with the present invention may be obtained via hydrolytic depolymerisation and subsequent purification as described in the context of the present invention, which, depending from the sources and the quality of the material collected and sorted, may result in slight variation of the properties of the solid material M while of course still being suitable for the process described herein.

Preferably, the solid material M is provided in the form of granules, wherein the particle size distribution of said granules is preferably characterized by one or more of the following pairs of values, preferably by two or more of the following pairs of values, more preferably by the following three pairs of values:

- a D10 value of the particle width in the range of from 0.1 to 15 mm and a D10 value of the particle length in the range of from 0.3 to 15 mm;
- a D50 value of the particle width in the range of from 0.2 to 20 mm and a D50 value of the particle length in the range of from 0.5 to 20 mm;
- a D90 value of the particle width in the range of from 0.3 to 30 mm and a D90 value of the particle length in the range of from 0.8 to 30 mm.

Generally, the aqueous depolymerisation mixture according to (i.2) can be prepared according to any method. Preferably, preparing the aqueous depolymerization mixture according to comprises melting in a melting unit U_M the solid material M, obtaining a liquid stream S_M having a temperature T_{SM} at a pressure p_{SM} ; admixing in a pre-reaction unit U_{PR} the stream S_M with an aqueous stream S_W having a temperature T_{SW} at a pressure p_{SW} , obtaining a liquid reaction feed stream S_F having a temperature T_{SF} at a pressure p_{SF} ; feeding the stream S_F obtained according to as the depolymerization mixture into the chemical reaction unit U_R . As far as this process design is concerned, it is preferred that

$$0.8 \leq T_{SF}/T_D \leq 1.05 \text{ and } 0.9 \leq p_{SF}/p_D \leq 1.05;$$

$$0.6 \leq T_{SM}/T_{SF} \leq 1.2 \text{ and } 0.9 \leq p_{SM}/p_{SF} \leq 1.05; \text{ and}$$

$$0.8 \leq T_{SW}/T_{SF} \leq 1.2 \text{ and } 0.9 \leq p_{SW}/p_{SF} \leq 1.05;$$

wherein T_D is the depolymerization temperature and p_D is the depolymerization pressure comprised by the polyamide 6 depolymerization conditions in the reaction unit U_R .

The pre-reaction unit U_{PR} preferably comprises, more preferably consists of, a mixing unit, preferably a static mixing unit, and wherein the melting unit U_M comprises, preferably consists of an extruder, preferably a single-screw extruder or a twin-screw extruder. Further, it is preferred that S_W and S_M are admixed in U_{PR} at a mixing ratio $(m_W/kg) / (m_P/kg)$ in the range of from 1:1 to 20:1, more preferably in the range of from 2:1 to 15:1, more preferably in the range of from 5:1 to 10:1, wherein m_W is the amount of water comprised in S_W and m_P is the amount of polyamide 6 comprised in S_M .

As far as the hydrolytic depolymerization according to the present invention is concerned, it is preferred that the depolymerization pressure p_D in the unit U_R is in the range of from 40 to 140 bar, more preferably in the range of from 40 to 125 bar, more preferably in the range of from 40 to 110 bar; and the depolymerisation temperature T_D in the unit U_R is in the range of from 230

to 335 °C, more preferably in the range of from 250 to 320 °C, more preferably in the range of from 270 to 310 °C.

- Preferably, the reaction unit U_R comprises z chemical reactors R_i , $i=1\dots z$, wherein z is in the range of from 1 to 10, preferably in the range of from 1 to 8, more preferably in the range of from 1 to 6, more preferably in the range of from 1 to 5, more preferably in the range of from 1 to 4, more preferably in the range of from 1 to 3. If $z > 1$, is preferred that at least 2 reactors R_i , more preferably all z reactors R_i , are serially coupled, wherein
- the stream S_F is fed into R_i , with $i = 1$;
 - an aqueous liquid stream S_i containing ϵ -caprolactam dissolved in water is removed from reactor R_i and fed into the reactor R_{i+1} , with $i < z$;
 - the aqueous liquid stream S_z containing ϵ -caprolactam dissolved in water is removed from the reactor R_z as the stream S_R ;
- wherein in every reactor R_i , a depolymerization temperature T_{Di} at a depolymerization pressure p_{Di} is maintained, wherein, independently of each other, T_{Di} is in the range of from 230 to 330 °C and p_{Di} is in the range of from 40 to 140 bar, preferably wherein T_{Di} is in the range of from 250 to 320 °C and p_{Di} is in the range of from 40 to 125 bar, more preferably wherein T_{Di} is in the range of from 270 to 310 °C and p_{Di} is in the range of from 40 to 110 bar. For $z > 1$, it is preferred that the z reactors R_i are vertically arranged, with R_1 being the top-most reactor and R_z being the bottom-most reactor, wherein S_i obtained from R_i is transferred to R_{i+1} by gravity, preferably by gravity only. More preferably, at least 1, preferably all z reactors R_i , are continuous stirred tank reactors (CSTR). Preferably, every continuous stirred tank reactor R_i has, independently from each other, from 2 to 6 compartments, more preferably from 2 to 5 compartments, more preferably from 2 to 4 compartments, said compartments preferably being serially, more preferably being serially and vertically arranged, wherein 2 adjacent compartments are separated by a divider which comprises at least one flow-through opening. Preferably at least one compartment comprised in a reactor R_i comprises at least one agitator, wherein more preferably every compartment of every reactor R_i comprises at least one agitator, wherein more preferably, every compartment of every reactor R_i comprises one agitator, and the process comprises agitating the depolymerization mixture in a given compartment for at least part of the time during subjecting to depolymerization conditions in said compartment. Preferably, the polyamide 6 depolymerization conditions further comprise a total residence time t_D of the aqueous depolymerization mixture in the unit U_R , preferably in the z reactors R_i , more preferably in the z continuous stirred tank reactors, wherein at least 85 weight-%, preferably at least 90 weight-%, more preferably at least 95 weight-% of the aqueous depolymerization mixture have a t_D in the range of from 30 to 90 min. More preferably, the residence time of an aqueous depolymerization mixture in a reactor R_i is t_{Di} and $0.90 \leq (t_{Di} / t_{Di+1}) \leq 1.10$, more preferably $0.95 \leq (t_{Di} / t_{Di+1}) \leq 1.05$.

- If the solid material M comprises one or more elastanes, the aqueous liquid stream S_R obtained from the depolymerization reaction usually contains one or more decomposition products which are formed from the one or more elastanes, for example in the course of the depolymerization reaction in U_R . Additionally or alternatively, one or more decomposition products form the one or more elastanes may also be formed in the melting unit U_M which is described above. By way of

example, said one or more decomposition products from the one or more elastanes preferably include at least one of aniline, butanediol, butanediol oligomers including, for example, butanediol dimer and butanediol trimer, and 4,4'-methylenedianiline (MDA) and isomers thereof such as 2,4'-methylenedianiline and 2,2'-methylenedianiline.

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According to the present invention, it is preferred that preparing the stream S_R according to (i.3) in a hydrolytic depolymerization reaction is carried out in the absence of a polyamide 6 depolymerization catalyst such as a mineral acid and/or a zinc salt such as zinc chloride, zinc acetate or zinc triflate, i.e. that no such polyamide 6 depolymerization catalyst is used for

10 preparing or is contained in the depolymerisation mixture to be subjected to depolymerisation conditions.

Generally, the process of the present invention can be designed as a continuous process, a semicontinuous process, or a batch process.

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Preferably according to the present invention, the purification unit U_P according to (i.5) comprises a water separation unit U_{WS} and a distillation unit U_D , and the process preferably comprises feeding the stream S_R , preferably the stream S_L , to U_{WS} , obtaining from U_{WS} a stream S_{UWS} comprising ϵ -caprolactam at a concentration C_{UWS} , feeding the stream S_{UWS} to the distillation unit

20 U_D , obtaining from U_D the stream S_C comprising ϵ -caprolactam at a concentration C_{SC} , wherein $C_{SR} < C_{UWS} \lll C_{SC}$, preferably wherein $C_{SL} < C_{UWS} \lll C_{SC}$.

The symbol " $\lll$ " compared to the symbol " $<$ " indicates that, for example, the ratio C_{UWS} / C_{SR} is significantly lower than the ratio C_{MF} / C_{UWS} .

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Further preferably, the water separation unit U_{WS} comprises at least two water separation sub-units U_{WS1} and U_{WS2} , preferably two serially coupled water separation sub-units U_{WS1} and U_{WS2} , wherein the stream S_R , preferably the stream S_L , is fed into U_{WS1} , wherein downstream of U_{WS1} and upstream of U_{WS2} , a separation unit U_I is preferably located, the process comprising obtaining

30 from U_{WS1} an aqueous stream S_{UWS1} , feeding the stream S_{UWS1} into the separation unit U_I , obtaining from U_I an aqueous stream S_{UI} , and feeding the stream S_{UI} into the unit U_{WS2} , wherein in U_I , one or more of impurities are separated from S_{UWS1} , thereby obtaining from U_I an impurity stream S_I , said impurities preferably comprising at least one impurity comprised in S_R according to (i.3), wherein at least one of said impurities is an organic compound having a higher boiling

35 point than ϵ -caprolactam, the separation unit U_I being a high boiler separation unit.

With regard to the specific apparatus design of the sub-unit U_{WS1} and sub-unit U_{WS2} , it is preferred that the sub-unit U_{WS1} comprises one or more of a falling film evaporator, a flash tank, a forced circulation evaporator, and a distillation column, more preferably one or more of a falling film

40 evaporator and a flash tank, more preferably a falling film evaporator and a flash tank, and that the sub-unit U_{WS2} comprises one or more of a falling film evaporator, a flash tank and a distillation column, more preferably a distillation column.

- As far as the high boiler separation unit U_i is concerned, no specific restrictions exist provided that in said unit U_i , compounds can be at least partially separated which have a higher boiling point than ϵ -caprolactam. It was found that the waste material which are most preferably used as the solid material M according to (i.1) will contain certain compounds which, either prior to or after
- 5 depolymerization of polyamide 6 according to (i.3), lead to a stream comprising ϵ -caprolactam and compounds having a higher boiling point than ϵ -caprolactam. Due to possibly different chemical compositions of said waste material, however, these compounds having a higher boiling point than ϵ -caprolactam will usually differ from time to time, both with regard to the content in the stream to be purified and in chemical nature. According to a preferred process stage of the
- 10 present invention, said high boiler separation in the unit U_i comprises
- (α) obtaining the stream S_{UWS1} from the water separation sub-unit U_{WS1} , wherein this stream has a temperature T_{UWS1} and exhibits a total concentration $c_{Lo}(\Psi)$ of one or more compounds Ψ which have a higher boiling point than ϵ -caprolactam further have a concentration $c_{Lo}(C)$ of monomeric ϵ -caprolactam;
 - 15 (β) producing in an evaporation unit U_{E1} from the stream S_{UWS1} an aqueous at least partially vaporous stream S_{V1} and a liquid stream S_{L1} , comprising
 - ($\beta.1$) passing the stream S_{UWS1} into the unit U_{E1} , preparing in the unit U_{E1} from the stream S_{UWS1} an evaporation mixture M_{E1} having an evaporation temperature T_{E1} at an evaporation pressure p_{E1} with $T_{E1} > T_{UWS1}$, wherein the one or more organic
 - 20 compounds Ψ have a boiling point T_{BX} and ϵ -caprolactam has a boiling point T_{BC} with $T_{BX} > T_{E1} \geq T_{BC}$ at the evaporation pressure p_{E1} ;
 - ($\beta.2$) removing the stream S_{V1} from the evaporation unit U_{E1} , the stream S_{V1} having a temperature T_{V1} with $T_{V1} \leq T_{E1}$ and exhibiting a total concentration $c_{V1}(\Psi)$ of one or more compounds Ψ and a concentration $c_{V1}(C)$ of monomeric ϵ -caprolactam with
 - 25 $c_{V1}(C) > c_{UWS1}(C)$ and $c_{V1}(\Psi) < c_{UWS1}(\Psi)$;
 - ($\beta.3$) removing the stream S_{L1} from the evaporation unit U_{E1} , the stream S_{L1} having a temperature T_{L1} with $T_{L1} = T_{E1}$ and exhibiting a total concentration $c_{L1}(\Psi)$ of one or more compounds Ψ and a concentration $c_{L1}(C)$ of monomeric ϵ -caprolactam with $c_{L1}(C) < c_{E1}(C)$ and $c_{L1}(\Psi) > c_{UWS1}(\Psi)$;
 - 30 (γ) producing in a separation unit U_{S1} from the stream S_{V1} an aqueous vapor stream S_{V2} and a liquid stream S_{L2} , comprising
 - ($\gamma.1$) passing the stream S_{V1} removed from the evaporation unit U_{E1} according to ($\beta.2$), optionally after cooling, into the separation unit U_{S1} and subjecting the stream S_{V1} , optionally the stream after cooling, in the separation unit U_{S1} to separation conditions;
 - 35 ($\gamma.2$) removing the stream S_{V2} from the separation unit U_{S1} , the stream S_{V2} having a temperature T_{V2} with $T_{UWS1} < T_{V2} \leq T_{V1}$ and exhibiting a total concentration $c_{V2}(\Psi)$ of one or more compounds Ψ and a concentration $c_{V2}(C)$ of monomeric ϵ -caprolactam;
 - ($\gamma.3$) removing the stream S_{L2} from the separation unit U_{S1} , the stream S_{L2} having a temperature T_{L2} with $T_{L2} = T_{V2}$ and exhibiting a total concentration $c_{L2}(\Psi)$ of one or
 - 40 more compounds X and a concentration $c_{L2}(C)$ of monomeric ϵ -caprolactam with $c_{L2}(\Psi) > c_{V2}(\Psi)$ and $c_{L2}(C) < c_{V2}(C)$;
 - (δ) passing the aqueous stream S_{V2} obtained from the separation unit U_{S1} according to ($\gamma.2$) to the water separation sub-unit U_{WS2} .

Generally, it is preferred that preparing the mixture M_{E1} comprises agitating, preferably mechanical agitating, more preferably stirring. Therefore, the unit U_{E1} preferably comprises a stirred reactor, more preferably a stirred tank reactor, more preferably a continuous stirred tank reactor. The separation unit U_{S1} preferably comprises, more preferably consists of, a droplet separator, preferably selected from the group consisting of a hydrocyclone, a demister plate, and an absorption tower, more preferably a hydrocyclone.

Regarding the temperature T_{UWS1} of the stream S_{UWS1} according to (α), it is preferred that T_{UWS1} is in the range of from 75 to 120 °C, more preferably in the range of from 80 to 110 °C, more preferably in the range of from 85 to 100 °C. As far as the chemical composition of the stream S_{UWS1} is concerned, it is preferred that the sum of the concentrations $c_{UWS1}(C)$ and $c_{UWS1}(\Psi)$, $c_{UWS1}(C) + c_{UWS1}(\Psi)$, is at least 60 weight-%, more preferably in the range of from 60 to 95 weight-%, more preferably in the range of from 70 to 90 weight-%, more preferably in the range of from 80 to 85 weight-%, in each case based on the total weight of the stream S_{UWS1} . Further in the stream S_{UWS1} , the weight ratio of the one or more compounds Ψ to monomeric ϵ -caprolactam is preferably in the range of from 50:50 to 5:95. Suitable range include, for example, 50:50 to 40:60, or 45:50 to 35:65, or 40:60 to 30:70, or 35:65 to 25:75, or 30:70 to 20:80, or 25:75 to 15:85, or 20:80 to 10:90, or 15:85 to 5:95. According to the present invention, in particular in case the process of the present invention is carried out as a continuous process, the concentration of Ψ in S_{UWS1} may change over time, depending on which specific material M is fed into the process. In particular for this scenario, the inventive high boiler separation allows for producing a stream S_{V2} having an essentially constant and very low high boiler concentration $c_{V2}(\Psi)$.

Regarding the chemical nature of the high boiler compounds, a comparatively high uncertainty exists, simply in view of the unpredictable chemical composition of the materials subjected to depolymerization and, finally, high boiler separation according to the present invention. However, when developing the process of the present invention, numerous elaborate experiments were carried out, and it was found that in a majority of situations, the one or more compounds Ψ comprised in the stream S_{UWS1} preferably comprise at least one of

- at least one aromatic amine which includes at least one of an aromatic monoamine, an aromatic diamine, an aromatic triamine and an aromatic tetramine;
- at least one aliphatic amine which includes at least one of an aliphatic monoamine, an aliphatic diamine and an aliphatic triamine;
- at least one aliphatic amide;
- at least one aromatic alcohol which includes at least one of an aromatic monool and an aromatic diol;
- at least one aliphatic alcohol which includes at least one of an aliphatic monool and an aliphatic diol;
- at least one aromatic acid;
- at least one and aliphatic acid;
- at least one ϵ -caprolactam oligomer;

- at least other compound selected from the group consisting of one or more cleavage products of dyes such as optionally chlorinated aromatic diamines, one or more water-soluble oligomeric cellulose cleavage products, and one or more water-soluble oligomers of terephthalic acid and hexamethylenediamine.

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Yet further, it was found that

- the at least one aromatic amine preferably includes one or more of 4,4'-methylenedianiline (MDA), isomers thereof such as 2,4'-methylenedianiline and 2,2'-methylenedianiline, and polymethylen polyphenylen polyamines (pMDA);
- 10 - the at least one aliphatic amine and the at least one aliphatic amide preferably include one or more of hexamethylenediamine adipate, 6-aminocaproic acid and oligomers thereof, including 6-aminocaproic acid dimer and higher oligomers such as 6-aminocaproic acid trimer, 6-aminocaproic acid tetramer, 6-aminocaproic acid pentamer, 6-aminocaproic acid hexamer, N'-(6-aminoethyl)hexane-1,6-diamine, N-methylhexane-1,6-diamine, 6-amino-
- 15 hexanamide, derivatives of ϵ -caprolactam other than ϵ -caprolactam oligomers and having a boiling point higher than ϵ -caprolactam such as 1-(6-aminoethyl)azepan-2-one;
- the at least one aliphatic alcohol preferably includes one or more of butanediol and oligomers thereof, including butanediol dimer and higher oligomers such as butanediol trimer, including polytetrahydrofuran;
- 20 - the at least one aromatic acid and the at least one aliphatic acid preferably include one or more of terephthalic acid and adipic acid;
- the at least one ϵ -caprolactam oligomer preferably includes one or more of ϵ -caprolactam dimer ϵ -caprolactam trimer, ϵ -caprolactam tetramer, ϵ -caprolactam pentamer, and ϵ -caprolactam hexamer.

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According to the present invention, it is further preferred that the purification unit U_P further comprises a crystallization unit U_{SCR} , said unit U_{SCR} preferably being located downstream of the distillation unit U_D , wherein the process preferably comprises obtaining a stream S_{UD} from the distillation unit U_D comprising ϵ -caprolactam at a concentration C_{UD} , and feeding the stream to the crystallization unit U_{SCR} , obtaining from U_{SCR} the stream S_C comprising ϵ -caprolactam at a concentration C_{SC} , wherein $C_{SR} < C_{UWS} \lll C_{UD} < C_{SC}$, preferably wherein $C_{SL} < C_{UWS} \lll C_{UD} < C_{SC}$.

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Preferably, the stream S_T has an ϵ -caprolactam purity $\Omega_{GC}(S_T)$ of at least 99.8 %, more preferably of at least 99.9 %. Also preferably, the stream S_T has an APHA value $\Omega_{APHA}(S_T)$ of at most 9, preferably of at most 8. APHA value $\Omega_{APHA}(S_T)$ values may also be at most 7, or at most 6, or at most 5.

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As described above, the process of the present invention results in streams S_T which are characterized by advantageous storing characteristics. Therefore, the process of the present invention preferably further comprises

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- (v) storing the material of the stream S_T obtained according to (iv) at a temperature of the mixture of at least 85 °C under an inert gas atmosphere for a storage time Δt_s , obtaining a stored mixture M_s , wherein the storage time Δt_s is at least 1 d;

wherein according to (v), the material of the stream S_T is preferably stored under exclusion of light, the storage time Δt_Σ is preferably at least 7 d, more preferably at least 14 d, more preferably in the range of from 14 to 28 d, and the inert gas atmosphere preferably comprises one or more of nitrogen and argon. Preferably, the storing according to (v) comprises a storing pressure p_s of the inert gas atmosphere in the range of from 0.5 to 10 bar, more preferably in the range of from 0.75 to 5 bar, more preferably in the range of from 1 to 2 bar. Preferably, the storing according to (v) comprises agitating, preferably mechanically agitating, more preferably stirring the material of the stream S_T for at least part of the storage time Δt_Σ , preferably for essentially the entire storage time Δt_Σ .

Further, the present invention relates to a liquid high-purity ϵ -caprolactam stream S_T , obtainable or obtained by a process as described hereinabove, wherein the stream S_T exhibits an ϵ -caprolactam purity $\Omega_{GC}(S_T)$ of at least 99.5 % and an APHA value $\Omega_{GC}(S_T)$ of at most 10. Preferably, $\Omega_{GC}(S_T)$ of at least 99.8 %, more preferably of at least 99.9 %. Preferably, $\Omega_{APHA}(S_T)$ is at most 9, preferably at most 8. Further, the stream S_T may be characterized by one or more of a permanganate absorption number $\Omega_{PAN}(S_T)$ and an UV absorption $\Omega_{UV}(S_T)$. Preferably, $\Omega_{PAN}(S_T)$ is at most 25 and $\Omega_{UV}(S_T)$ is at most 0.35. In particular in case the process of the present invention is characterized by the presence of a crystallization unit U_{SCR} comprised in the purification unit U_P , $\Omega_{PAN}(S_T)$ preferably may be at most 8, and $\Omega_{UV}(S_T)$ preferably may be at most 0.05.

Generally, in the context of the present, a value $\Omega(S_T)$ such as $\Omega_{GC}(S_T)$ and $\Omega_{APHA}(S_T)$ refers to the respective value $\Omega(S_T)$ essentially immediately after the preparation of the stream S_T , in particular to the respective value $\Omega(S_T)$ prior to storing according to (v) as described above.

As described hereinabove, the stream S_T obtained according to the present invention exhibits advantageous storage characteristics. Therefore, the present invention also relates to the stream S_T , exhibiting a storage stability $\Sigma_{\Delta t}$ after a storage time Δt , wherein $\Sigma_{\Delta t}$ is characterized by an APHA value $\Omega_{APHA}(\Delta t)$.

The storage stability for a given material is preferably determined under an inert (e.g., argon or nitrogen) gas atmosphere for a pre-determined time Δt . The storage temperature is preferably room temperature (e.g. 20°C), and the determination of the storage stability is preferably carried out at constant temperature. Preferably, the materials are stored under exclusion of light. It is also preferred that for the determination of the storage stability, more preferably the material is placed in a glass vessel under constant stirring using a Teflon-coated, magnetic stir bar at 200-500 rpm.

In addition, the container, more preferably the glass vessel, is purged with the inert gas prior to the stability test to remove all contaminants of ambient air such as oxygen, water or carbondioxide. The container may be purged for at least 15 min with a constant flow of 10 nL/h of the inert gas, more preferably for at least 20 minutes. Also, the container may preferably be purged at least with 20 times of its volume with the inert gas to prevent the presence of contaminants present in ambient air.

If the storage time Δt is 14 d and the storage stability Σ_{14} after said storage time is characterized by an APHA value $\Omega_{\text{APHA}}(14)$, it is preferred that

- if $\Omega_{\text{APHA}}(S_T) < 5$, $\Omega_{\text{APHA}}(14) \leq 10$;
- 5 - if $\Omega_{\text{APHA}}(S_T)$ is in the range of from 5 to 8, $\Omega_{\text{APHA}}(14) \leq 1.5 \Omega_{\text{APHA}}(S_T)$;
- if $\Omega_{\text{APHA}}(S_T) > 8$, $\Omega_{\text{APHA}}(14) \leq 1.25 \Omega_{\text{APHA}}(S_T)$.

If the storage time Δt is 28 d and the storage stability Σ_{28} after said storage time is characterized by an APHA value $\Omega_{\text{APHA}}(28)$, it is preferred that

- 10 - if $\Omega_{\text{APHA}}(S_T) < 4$, $\Omega_{\text{APHA}}(28) \leq 10$;
- if $\Omega_{\text{APHA}}(S_T)$ is in the range of from 4 to 10, $\Omega_{\text{APHA}}(28) \leq 3 \Omega_{\text{APHA}}(S_T)$;
- if $\Omega_{\text{APHA}}(S_T) > 10$, $\Omega_{\text{APHA}}(28) \leq 2 \Omega_{\text{APHA}}(S_T)$.

- Further according to the present invention, the storage stability $\Sigma_{\Delta t}$ after a storage time Δt may be further characterized by one or more of a permanganate absorption number $\Omega_{\text{PAN}}(\Delta t)$ and an UV absorption $\Omega_{\text{UV}}(\Delta t)$.
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- If the storage time Δt is 14 d and the storage stability Σ_{14} after said storage time is characterized by one or more of a permanganate absorption number $\Omega_{\text{PAN}}(14)$ and an UV absorption $\Omega_{\text{UV}}(14)$, it is preferred that
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- if $\Omega_{\text{PAN}}(S_T) < 5$, $\Omega_{\text{PAN}}(14) \leq 8$;
- if $\Omega_{\text{PAN}}(S_T)$ is in the range of from 5 to 8, $\Omega_{\text{PAN}}(14) \leq 1.5 \Omega_{\text{PAN}}(S_T)$;
- if $\Omega_{\text{PAN}}(S_T) > 8$, $\Omega_{\text{PAN}}(14) \leq 1.25 \Omega_{\text{PAN}}(S_T)$;

and

- 25 - if $\Omega_{\text{UV}}(S_T) < 0.05$, $\Omega_{\text{UV}}(14) \leq 0.15$;
- if $\Omega_{\text{UV}}(S_T)$ is in the range of from 0.05 to 0.4, $\Omega_{\text{UV}}(14) \leq 3 \Omega_{\text{UV}}(S_T)$;
- if $\Omega_{\text{UV}}(S_T) > 0.4$, $\Omega_{\text{UV}}(14) \leq 2 \Omega_{\text{UV}}(S_T)$.

- If the storage time Δt is 28 d and the storage stability Σ_{28} after said storage time is characterized by one or more of a permanganate absorption number $\Omega_{\text{PAN}}(28)$ and an UV absorption $\Omega_{\text{UV}}(28)$, it is preferred that
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- if $\Omega_{\text{PAN}}(S_T) < 6$, $\Omega_{\text{PAN}}(28) \leq 10$;
- if $\Omega_{\text{PAN}}(S_T)$ is in the range of from 6 to 8, $\Omega_{\text{PAN}}(28) \leq 2 \Omega_{\text{PAN}}(S_T)$;
- if $\Omega_{\text{PAN}}(S_T) > 8$, $\Omega_{\text{PAN}}(28) \leq 1.5 \Omega_{\text{PAN}}(S_T)$;

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- if $\Omega_{\text{UV}}(S_T) < 0.05$, $\Omega_{\text{UV}}(28) \leq 0.20$;
- if $\Omega_{\text{UV}}(S_T)$ is in the range of from 0.05 to 0.1, $\Omega_{\text{UV}}(14) \leq 4 \Omega_{\text{UV}}(S_T)$;
- if $\Omega_{\text{UV}}(S_T) > 0.1$, $\Omega_{\text{UV}}(28) \leq 3 \Omega_{\text{UV}}(S_T)$.

- 40 Further, the present invention relates to a method for preparing polyamide 6, comprising
- (a) preparing a stream S_T according to a process as described hereinabove; and/or providing a stream S_T as described hereinabove;

- (b) optionally storing the material of the stream S_T under an inert gas atmosphere, preferably under exclusion of light, for a storage time Δt_z , obtaining a stored mixture M_S , wherein the material is preferably stored at a temperature of the material of at least 85 °C for a storage time Δt_z preferably of at least 1 d, more preferably of at least 7 d, more preferably of at least 14 d, more preferably in the range of from 14 to 28 d, preferably at a storing pressure p_s of the inert gas atmosphere in the range of from 0.5 to 10 bar, more preferably in the range of from 0.75 to 5 bar, more preferably in the range of from 1 to 2 bar;
- (c) subjecting the stream S_T prepared and/or provided according to (a) and/or the stored mixture M_S according to (b) to polyamide 6 polymerization conditions.

The present invention further relates to the use of the stream S_T as described hereinabove and/or the stored mixture M_S as described hereinabove as an educt material for a chemical process, preferably for a polymerization reaction, more preferably for preparing polyamide 6.

- Further, the present invention relates to polyamide 6, obtainable or obtained by the method as described hereinabove, having an APHA value of at most 10, preferably of at most 9, more preferably of at most 8.

Yet further, the present invention relates to a mixture M_S comprising ϵ -caprolactam, obtainable or obtained by the process or the method as described hereinabove.

The present invention still further relates to a process as hereinabove, further comprising providing at least part of the stream S_T or the mixture M_S to a polyamide 6 production unit U_{PP} , wherein the polyamide 6 produced in U_{PP} is preferably provided as a feedstock to a textile material producing unit U_{TP} , from which unit U_{TP}

- (A) a textile material M_T is obtained which is brought onto the market, wherein, after the life-time T_{MT} of said textile material M_T it is at least partially collected as textile waste material in a textile material collecting unit U_{TC} ;
- (B) remaining material M_R is obtained as textile waste material;
- wherein at least part of the textile waste material according to (A), or at least part of the textile waste material according to (B), or at least part of the textile waste material according to (A) and at least part of the textile waste material according to (B) is suitably provided to U_R as S_M , as defined hereinabove.

The present invention still further relates to a process as hereinabove, further comprising providing at least part of the stream S_T or the mixture M_S to a polyamide 6 production unit U_{PP} , wherein the polyamide 6 produced in U_{PP} is preferably provided as a feedstock to an engineering plastics material producing unit U_{EP} , from which unit U_{EP}

- (A) an engineering plastics material M_E is obtained which is brought onto the market, wherein, after the life-time T_{ME} of said engineering plastics material M_E it is at least partially collected as engineering plastics waste material in an engineering plastics material collecting unit U_{EC} ;
- (B) remaining material M_R is obtained as engineering plastics waste material;

wherein at least part of the engineering plastics waste material according to (A), or at least part of the engineering plastics waste material according to (B), or at least part of the engineering plastics waste material according to (A) and at least part of the engineering plastics waste material according to (B) is suitably provided to U_R as S_M , as defined hereinabove.

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The present invention still further relates to the use of the stream S_T as described hereinabove or of the mixture M_S as described hereinabove for preparing polyamide 6, said use preferably further comprising employing said polyamide 6 as a feedstock for preparing one or more of a textile material and an engineering plastics material, more preferably for preparing a textile material.

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The present invention still further relates to a method for preparing polyamide 6, said method comprising employing the stream S_T as described hereinabove or the mixture M_S as described hereinabove as a starting material, wherein said method preferably further comprises employing said polyamide 6 as a feedstock for preparing one or more of a textile material and an

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engineering plastics material, more preferably for preparing a textile material.

The present invention still further relates to the use of the stream S_T as described hereinabove or of the mixture M_S as described hereinabove for preparing one or more of a polymer and a polymer product; or to a method for preparing one or more of a polymer and a polymer product, said method comprising employing the stream S_T as described hereinabove or the mixture M_S as described hereinabove as a starting material.

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The present invention still further relates to the use of the stream S_T as described hereinabove or of the mixture M_S as described hereinabove for preparing one or more of a polymer and a polymer product; or a method for preparing one or more of a polymer and a polymer product, said method comprising employing the stream S_T as described hereinabove or the mixture M_S as described hereinabove as a starting material.

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Preferably according to said use or said method of above, the polymer, or the polymer product, or the polymer and the polymer product is or are in the form of at least one of a granulate, a strand, a rod, a plate, a pipe, a foil, a layer, a film, a sheet, a fiber, a filament, a coating, an extruded article, a molded article, a soft foam, a half-rigid foam and a rigid foam.

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Also preferably according to said use or said method of above, the polymer, or the polymer product, or the polymer and the polymer product comprises or comprise polyamide 6 and optionally at least one further polymeric compound, said polyamide 6 being at least partially obtainable or obtained as described hereinabove or from the mixture M_S as described hereinabove, wherein the at least one further polymeric compound preferably comprises one or more of at least one polyamide 6.6, at least one polyethylene terephthalate, at least one polyurethane, at least one polyester, at least one cellulose material, and at least one rubber material comprising one or more of at least one natural rubber material and at least one synthetic rubber material.

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Also preferably according to said use or said method of above, the polymer, or the polymer product, or the polymer and the polymer product is or are one of the following or a part of one of the following:

- a part of a car, preferably a cylinder head cover, an engine cover, a housing for a charge air cooler, a charge air cooler flap, an intake pipe, an intake manifold, a connector, a gear wheel, a fan wheel, a cooling water box, a housing or a housing part for a heat exchanger, a coolant cooler, a charge air cooler, a thermostat, a water pump, a radiator, a fastening part or a part of a battery system for electromobility, a dashboard, a steering column switch, a seat, a headrest, a center console, a transmission component, a door module, a car exterior for an A, a B, a C or a D pillar cover, a spoiler, a door handle, an exterior mirror, a windscreen wiper, a windscreen wiper protection housing, a decorative grill, a cover strip, a roof rail, a window frame, a sunroof frame, an antenna panel, a headlight, a taillight, an airbag, a top mount, an oil pan, a fuel cell, a heat shield and/or a cushion;
- a cloth, an apparel, preferably a shirt, trousers, a pullover, a boot, a shoe, a shoe sole, a tight, a yarn, a fabric, and/or or jacket;
- an electrical part, preferably an electrical component, an electronic passive component, an electronic active component, a printed circuit board, a housing component, a foil, a line, a switch such as a microswitch, a plug, a socket, a distributor, a relay, a resistor, a capacitor, an inductor, a bobbin, a lamp, a diode such as an LED, a transistor, a connector, a regulator, an integrated circuit (IC), a processor, a controller, a memory, a sensor, a microbutton, a semiconductor, a reflector housing for example for light-emitting diodes, a fastener for an electrical and/or an electronic component, a spacer, a bolt, a strip, a slide-in guide, a screw, a nut, a film hinge, a snap hook (snap-in), and/or a spring tongue;
- a consumer and/or a pharmaceutical product, preferably a tennis string, a climbing rope, a bristle, a brush, an artificial grass, a 3D printing filament, a grass trimmer, a zipper, a hook and loop fastener, a paper machine clothing, an extrusion coating, a fishing line, a fishing net, an offshore line and rope, a vial, a syringe, an ampoule, a bottle, a sliding element, a spindle nut, a chain conveyor, a plain bearing, a roller, a wheel, a gear, a roller, a ring gear, a screw and spring damper, a hose, a pipeline, a cable sheathing, a socket, a switch, a cable tie, a fan wheel, a carpet, a box and/or a bottle for cosmetics, a mattress, a cushion, an insulation;
- a packaging for the food industry, preferably a mono- and/or multi-layer blown film, a cast film (mono- and/or multi-layer), a biaxially stretched film, a laminating film.

Also preferably according to said use or said method of above, the polymer, or the polymer product, or the polymer and the polymer product contains or contain polyamide 6, obtainable or obtained from the stream S_T as described hereinabove or from the mixture M_S as described hereinabove in an amount of 1 weight-% or more, preferably 2 weight-% or more, more preferably 5 weight-% or more, more preferably 15 weight-% or more, more preferably 30 weight-% or more, more preferably 40 weight-% or more, more preferably 60 weight-% or more, more preferably 80 weight-% or more, more preferably 90 weight-% or more, more preferably 95 weight-% or more; and/or in an amount of 100 weight-% or less, preferably 95 weight-% or less, more preferably 90 weight-% or less, more preferably 50 weight-% or less, more preferably 25 weight-% or less, more preferably 10 weight-% or less.

The present invention is further illustrated by the following set of embodiments and combinations of embodiments resulting from the dependencies and back-references as indicated. In particular, it is noted that in each instance where a range of embodiments is mentioned, for example in the context of a term such as "The process of any one of embodiments 1 to 4", every embodiment in this range is meant to be explicitly disclosed for the skilled person, i.e. the wording of this term is to be understood by the skilled person as being synonymous to "The process of any one of embodiments 1, 2, 3 and 4". Further, it is explicitly noted that the following set of embodiments represents a suitably structured part of the general description directed to preferred aspects of the present invention, and, thus, suitably supports, but does not represent the claims of the present invention.

1. A process for preparing a liquid high-purity ϵ -caprolactam stream S_T , the process comprising
 - (i) preparing a liquid stream S_C comprising ϵ -caprolactam, said preparing comprising depolymerizing a material M comprising polyamide 6, said liquid stream S_C further comprising one or more oxidizable organic impurity compounds X , wherein the stream S_C has an ϵ -caprolactam purity $\Omega_{GC}(S_C)$ of at least 99 % and exhibits a weight ratio r_{XCC} of the one or more organic compounds X relative to ϵ -caprolactam;
 - (ii) providing a stream S_O comprising at least one permanganate;
 - (iii) preparing an oxidation reaction educt mixture M_{OE} from the stream S_C and the stream S_O , and subjecting the mixture M_{OE} to oxidation reaction conditions, obtaining an oxidation reaction product stream S_P comprising ϵ -caprolactam, further comprising one or more oxidation products Y obtained from the oxidation of at least a part of the one or more compounds X , and optionally further comprising a part of the one or more organic compounds X , wherein the stream S_P exhibits a weight ratio r_{XCP} of organic compound X relative to ϵ -caprolactam with $0 \leq r_{XCP} < r_{XCC}$ and further exhibits a weight ratio r_{YCP} of the one or more products Y relative to ϵ -caprolactam with $r_{YCP} > 0$;
 - (iv) separating at least a part of the one or more oxidation products Y and optionally at least a part of organic compound X from the stream S_P , obtaining the stream S_T exhibiting a weight ratio r_{YCT} of oxidation product Y relative to ϵ -caprolactam with $0 \leq r_{YCT} < r_{YCP}$, and further exhibiting a weight ratio r_{XCT} of organic compound X relative to ϵ -caprolactam with $0 \leq r_{XCT} \leq r_{XCP}$, wherein the stream S_T exhibits an ϵ -caprolactam purity $\Omega_{GC}(S_T)$ of at least 99.5 % with $\Omega_{GC}(S_T) > \Omega_{GC}(S_C)$, and an APHA value $\Omega_{APHA}(S_T)$ of at most 10.
2. The process of embodiment 1, wherein the stream S_C prepared according to (i) further comprises water.
3. The process of embodiment 1 or 2, wherein the at least one permanganate comprised in the stream S_O provided according to (ii) comprises, preferably consists of, at least alkali

metal permanganate, wherein more preferably, the at least one alkali metal permanganate comprises one or more of sodium permanganate and potassium permanganate.

4. The process of any one of embodiments 1 to 3, wherein from 0.5 to 100 weight-% of the stream S_O provided according to (ii) consist of permanganate.
5. The process of any one of embodiments 1 to 4, wherein the stream S_O provided according to (ii) further comprises water.
6. The process of any one of embodiments 1 to 5, wherein the oxidation reaction educt mixture M_{OE} prepared according to (iii) exhibits a permanganate concentration, calculated as MnO_4 , in the range of from 0.005 to 5 weight-%, preferably in the range of from 0.01 to 3 weight-%, more preferably in the range of from 0.05 to 1 weight-%.
7. The process of any one of embodiments 1 to 6, wherein the oxidation reaction conditions according to (iii) comprise a temperature T_{OE} of the mixture M_{OE} in the range of from 40 to 140 °C, preferably in the range of from 60 to 100 °C, more preferably in the range of from 70 to 90 °C.
8. The process of any one of embodiments 1 to 7, preferably of embodiment 2 or embodiment 5, wherein the mixture M_{OE} prepared according to (iii) further comprises water.
9. The process of any one of embodiments 1 to 8, wherein subjecting the mixture M_{OE} to oxidation reaction conditions is carried out in an oxidation reaction unit U_{OR} , wherein the unit U_{OR} preferably comprises one or more of at least one continuous stirred tank reactor and at least one tube reactor.
10. The process of any one of embodiments 1 to 9, further comprising providing a stream S_B comprising at least one hydroxide, wherein the oxidation reaction educt mixture M_{OE} according to (iii) is prepared from the stream S_C , the stream S_O , and the stream S_B .
11. The process of embodiment 10, wherein the at least one hydroxide comprised in the stream S_B comprises, preferably consists of, at least alkali metal hydroxide, wherein more preferably, the at least one alkali metal hydroxide comprises, more preferably consists of, sodium hydroxide.
12. The process of embodiment 10 or 11, wherein from 0.5 to 100 weight-% of the stream S_B consist of hydroxide.
13. The process of any one of embodiments 10 to 12, wherein the stream S_B further comprises water.

14. The process of any one of embodiment 10 to 13, wherein the oxidation reaction educt mixture M_{OE} prepared according to (iii) exhibits a hydroxide concentration, calculated as OH, in the range of from 0.005 to 0.75 weight-%, preferably in the range of from 0.01 to 0.5 weight-%, more preferably in the range of from 0.1 to 0.25 weight-%.
15. The process of any one of embodiments 1 to 14, wherein the one or more oxidizable organic compounds X have a boiling point $\delta_X/^\circ\text{C}$ with $0.5 \leq (\delta_X / \delta_C) \leq 1.5$, $\delta_C/^\circ\text{C}$ being the boiling point of ϵ -caprolactam and wherein at least one of the one or more oxidation products Y has a boiling point $\delta_Y/^\circ\text{C}$ with $\delta_Y/^\circ\text{C} \neq \delta_C/^\circ\text{C}$, wherein the difference $\Delta\delta$ between the boiling points δ_Y and δ_C is preferably at least 1 $^\circ\text{C}$.
16. The process of any one of embodiments 1 to 15, wherein separating at least a part of the one or more oxidation products Y and optionally at least a part of organic compound X from the stream S_P according to (iv) comprises subjecting the stream S_P obtained according to (iii) to distillation in a distillation unit U_{DT} , obtaining from the distillation unit U_{DT} a stream S_{DT} comprising ϵ -caprolactam as the stream S_T , wherein the unit U_{DT} comprises one or more distillation columns, preferably one or two distillation columns, wherein at least one column is optionally configured as side stream column or as divided wall column.
17. The process of embodiment 16, wherein separating at least a part of the one or more oxidation products Y and optionally at least a part of organic compound X from the stream S_P according to (iv) further comprises subjecting the stream S_{DT} to crystallization in a crystallization unit U_{CR} , obtaining from the unit U_{CR} a stream S_{CR} comprising ϵ -caprolactam as the stream S_T .
18. The process of any one of embodiments 1 to 17, wherein preparing the liquid stream S_C according to (i) comprises
- (i.1) providing a stream S_M comprising a solid material M comprising polyamide 6;
 - (i.2) preparing an aqueous depolymerization mixture based on S_M ;
 - (i.3) subjecting the depolymerization mixture prepared according to (i.2) to polyamide 6 depolymerization conditions in a reaction unit U_R , obtaining a liquid aqueous stream S_R comprising ϵ -caprolactam dissolved in water at a concentration c_{SR} , the stream S_R further comprising one or more impurities;
 - (i.4) preferably passing the liquid aqueous stream S_R into an evaporation unit U_E , obtaining from S_R a liquid aqueous stream S_L comprising ϵ -caprolactam dissolved in water at a concentration c_{SL} with $c_{SL} > c_{SR}$, and further obtaining from S_R one or more aqueous vapor streams S_V ;
 - (i.5) passing the stream S_R , preferably the stream S_L , into a purification unit U_P , obtaining from the stream S_R , preferably from the stream S_L , the stream S_C .
19. The process of any one of embodiments 1 to 18, preferably of embodiment 18, wherein the material M comprises, preferably consists of, waste material, wherein said waste material more preferably comprises, more preferably consists of, one or more of at least one textile

- waste material and at least one engineering plastics waste material, more preferably comprises, more preferably consists of at least one textile waste material; wherein preferably from 10 to 99 weight-%, more preferably from 30 to 98.5 weight-%, more preferably from 50 to 98 weight-%, more preferably from 80 to 98 weight-%, of the material M consist of the polyamide;
- wherein preferably, in addition to polyamide 6, the material M comprises one or more further organic polymeric compounds, more preferably including, but not limited to, one or more of at least one elastanes, at least one polyethylene terephthalate, at least one polytetrahydrofuran, at least one polyamide 6.6, at least one polyurethane, at least one polyester, at least one cellulose material, and at least one rubber material comprising one or more of at least one natural rubber material and at least one synthetic rubber material.
20. The process of embodiment 18 or 19, wherein the purification unit U_P according to (i.5) comprises a water separation unit U_{WS} and a distillation unit U_D , the process comprising feeding the stream S_R , preferably the stream S_L , to U_{WS} , obtaining from U_{WS} a stream U_{WS} comprising ϵ -caprolactam at a concentration c_{UWS} , feeding the stream S_{UWS} to the distillation unit U_D , obtaining from U_D the stream S_C comprising ϵ -caprolactam at a concentration c_{SC} , wherein $c_{SR} < c_{UWS} \lll c_{SC}$, preferably wherein $c_{SL} < c_{UWS} \lll c_{SC}$.
21. The process of embodiment 20, wherein the water separation unit U_{WS} comprises at least two water separation sub-units U_{WS1} and U_{WS2} , preferably two serially coupled water separation sub-units U_{WS1} and U_{WS2} , wherein the stream S_R , preferably the stream S_L , is fed into U_{WS1} , wherein downstream of U_{WS1} and upstream of U_{WS2} , a separation unit U_I is preferably located, the process comprising obtaining from U_{WS1} an aqueous stream S_{UWS1} , feeding the stream S_{UWS1} into the separation unit U_I , obtaining from U_I an aqueous stream S_{UI} , and feeding the stream S_{UI} into the unit U_{WS2} , wherein in U_I , one or more of impurities are separated from S_{UWS1} , thereby obtaining from U_I an impurity stream S_I , said impurities preferably comprising at least one impurity comprised in S_R according to (i.3), wherein at least one of said impurities is an organic compound having a higher boiling point than ϵ -caprolactam, the separation unit U_I being a high boiler separation unit.
22. The process of embodiment 20 or 21, wherein the purification unit U_P further comprises a crystallization unit U_{SCR} , said unit U_{SCR} preferably being located downstream of the distillation unit U_D , the process preferably comprising obtaining a stream S_{UD} from the distillation unit U_D comprising ϵ -caprolactam at a concentration c_{UD} , and feeding the stream to the crystallization unit U_{SCR} , obtaining from U_{SCR} the stream S_C comprising ϵ -caprolactam at a concentration c_{SC} , wherein $c_{SR} < c_{UWS} \lll c_{UD} < c_{SC}$, preferably wherein $c_{SL} < c_{UWS} \lll c_{UD} < c_{SC}$.
23. The process of any one of embodiment 1 to 22, wherein the stream S_T has an ϵ -caprolactam purity $\Omega_{GC}(S_T)$ of at least 99.8 %, more preferably of at least 99.9 %.

24. The process of any one of embodiment 1 to 23, wherein the stream S_T has an APHA value $\Omega_{\text{APHA}}(S_T)$ of at most 9, preferably of at most 8.
25. The process of any one of embodiments 1 to 24, further comprising
 5 (v) storing the material of the stream S_T obtained according to (iv) at a temperature of the mixture of at least 85 °C under an inert gas atmosphere for a storage time Δt_{Σ} , obtaining a stored mixture M_S , wherein the storage time Δt_{Σ} is at least 1 d; wherein according to (v), the material of the stream S_T is preferably stored under exclusion of light, the storage time Δt_{Σ} is preferably at least 7 d, more preferably at least 14 d, more
 10 preferably in the range of from 14 to 28 d, and the inert gas atmosphere preferably comprises one or more of nitrogen and argon, wherein according to (v), the material of the stream S_T is preferably stored at a storing pressure p_s of the inert gas atmosphere in the range of from 0.5 to 10 bar, more preferably in the range of from 0.75 to 5 bar, more preferably in the range of from 1 to 2 bar.
- 15 26. A liquid high-purity ϵ -caprolactam stream S_T , obtainable or obtained by a process according to any one embodiments 1 to 24, exhibiting an ϵ -caprolactam purity $\Omega_{\text{GC}}(S_T)$ of at least 99.5 % and an APHA value $\Omega_{\text{GC}}(S_T)$ of at most 10.
- 20 27. The stream S_T of embodiment 26, having an ϵ -caprolactam purity $\Omega_{\text{GC}}(S_T)$ of at least 99.8 %, more preferably of at least 99.9 %.
28. The stream S_T of embodiment 26 or 27, having an APHA value $\Omega_{\text{APHA}}(S_T)$ of at most 9, preferably of at most 8.
- 25 29. The stream S_T of any one of embodiments 26 to 28, exhibiting one or more of a permanganate absorption number $\Omega_{\text{PAN}}(S_T)$ of at most 25 and an UV absorption $\Omega_{\text{UV}}(S_T)$ of at most 0.35.
- 30 30. The stream S_T of any one of embodiments 26 to 29, exhibiting a storage stability $\Sigma_{\Delta t}$ after a storage time Δt , wherein $\Sigma_{\Delta t}$ is characterized by an APHA value $\Omega_{\text{APHA}}(\Delta t)$.
31. The stream S_T of embodiment 30, wherein Δt is 14 d and the storage stability Σ_{14} after said storage time is characterized by an APHA value $\Omega_{\text{APHA}}(14)$, wherein
 35 - if $\Omega_{\text{APHA}}(S_T) < 5$, $\Omega_{\text{APHA}}(14) \leq 10$;
 - if $\Omega_{\text{APHA}}(S_T)$ is in the range of from 5 to 8, $\Omega_{\text{APHA}}(14) \leq 1.5 \Omega_{\text{APHA}}(S_T)$;
 - if $\Omega_{\text{APHA}}(S_T) > 8$, $\Omega_{\text{APHA}}(14) \leq 1.25 \Omega_{\text{APHA}}(S_T)$.
32. The stream S_T of embodiment 30 or 31, wherein Δt is 28 d and the storage stability Σ_{28} after
 40 said storage time is characterized by an APHA value $\Omega_{\text{APHA}}(28)$, wherein
 - if $\Omega_{\text{APHA}}(S_T) < 4$, $\Omega_{\text{APHA}}(28) \leq 10$;
 - if $\Omega_{\text{APHA}}(S_T)$ is in the range of from 4 to 10, $\Omega_{\text{APHA}}(28) \leq 3 \Omega_{\text{APHA}}(S_T)$;
 - if $\Omega_{\text{APHA}}(S_T) > 10$, $\Omega_{\text{APHA}}(28) \leq 2 \Omega_{\text{APHA}}(S_T)$.

33. The stream S_T of any one of embodiments 30 to 32, wherein the stream S_T exhibits one or more of a permanganate absorption number $\Omega_{PAN}(S_T)$ and an UV absorption $\Omega_{UV}(S_T)$ and wherein the storage stability $\Sigma_{\Delta t}$ after a storage time Δt is further characterized by one or more of a permanganate absorption number $\Omega_{PAN}(\Delta t)$ and an UV/Vis absorption $\Omega_{UV}(\Delta t)$.
34. The stream S_T of embodiment 33, wherein Δt is 14 d and the storage stability Σ_{14} after said storage time is characterized by one or more of a permanganate absorption number $\Omega_{PAN}(14)$, wherein
- if $\Omega_{PAN}(S_T) < 5$, $\Omega_{PAN}(14) \leq 8$;
 - if $\Omega_{PAN}(S_T)$ is in the range of from 5 to 8, $\Omega_{PAN}(14) \leq 1.5 \Omega_{PAN}(S_T)$;
 - if $\Omega_{PAN}(S_T) > 8$, $\Omega_{PAN}(14) \leq 1.25 \Omega_{PAN}(S_T)$;
- and an UV/Vis absorption $\Omega_{UV}(14)$, wherein
- if $\Omega_{UV}(S_T) < 0.05$, $\Omega_{UV}(14) \leq 0.15$;
 - if $\Omega_{UV}(S_T)$ is in the range of from 0.05 to 0.4, $\Omega_{UV}(14) \leq 3 \Omega_{UV}(S_T)$;
 - if $\Omega_{UV}(S_T) > 0.4$, $\Omega_{UV}(14) \leq 2 \Omega_{UV}(S_T)$.
35. The stream S_T of embodiment 33 or 34, wherein Δt is 28 d and the storage stability Σ_{28} after said storage time is characterized by one or more of a permanganate absorption number $\Omega_{PAN}(28)$, wherein
- if $\Omega_{PAN}(S_T) < 6$, $\Omega_{PAN}(28) \leq 10$;
 - if $\Omega_{PAN}(S_T)$ is in the range of from 6 to 8, $\Omega_{PAN}(28) \leq 2 \Omega_{PAN}(S_T)$;
 - if $\Omega_{PAN}(S_T) > 8$, $\Omega_{PAN}(28) \leq 1.5 \Omega_{PAN}(S_T)$;
- and an UV/Vis absorption $\Omega_{UV}(28)$, wherein
- if $\Omega_{UV}(S_T) < 0.05$, $\Omega_{UV}(28) \leq 0.20$;
 - if $\Omega_{UV}(S_T)$ is in the range of from 0.05 to 0.1, $\Omega_{UV}(14) \leq 4 \Omega_{UV}(S_T)$;
 - if $\Omega_{UV}(S_T) > 0.1$, $\Omega_{UV}(28) \leq 3 \Omega_{UV}(S_T)$.
36. Use of the stream S_T according to any one of embodiments 26 to 35 as an educt material for a chemical process, preferably for a polymerization reaction, more preferably for preparing polyamide 6.
37. A method for preparing polyamide 6, comprising
- (a) preparing a stream S_T according to a process according to any one of embodiments 1 to 24; and/or providing a stream S_T according to any one of embodiments 26 to 35;
 - (b) optionally storing the material of the stream S_T under an inert gas atmosphere, preferably under exclusion of light, for a storage time Δt_s , obtaining a stored mixture M_s , wherein the material is preferably stored at a temperature of the material of at least 85 °C for a storage time Δt_s preferably of at least 1 d, more preferably of at least 7 d, more preferably of at least 14 d, more preferably in the range of from 14 to 28 d, preferably at a storing pressure p_s of the inert gas atmosphere in the range of from

0.5 to 10 bar, more preferably in the range of from 0.75 to 5 bar, more preferably in the range of from 1 to 2 bar;

- (c) subjecting the stream S_T prepared and/or provided according to (a) and/or the stored mixture M_S according to (b) to polyamide 6 polymerization conditions.

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38. Polyamide 6, obtainable or obtained by a method according to embodiment 37, having an APHA value of at most 10, preferably of at most 9, more preferably of at most 8.

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39. A mixture M_S comprising ϵ -caprolactam, obtainable or obtained by the process according to embodiment 25.

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40. The process of any one of embodiments 1 to 24, or 25, further comprising providing at least part of the stream S_T or the mixture M_S to a polyamide 6 production unit U_{PP} , wherein the polyamide 6 produced in U_{PP} is preferably provided as a feedstock to a textile material producing unit U_{TP} , from which unit U_{TP}

- (A) a textile material M_T is obtained which is brought onto the market, wherein, after the life-time T_{MT} of said textile material M_T it is at least partially collected as textile waste material in a textile material collecting unit U_{TC} ;

- (B) remaining material M_R is obtained as textile waste material;

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wherein at least part of the textile waste material according to (A), or at least part of the textile waste material according to (B), or at least part of the textile waste material according to (A) and at least part of the textile waste material according to (B) is suitably provided to U_R as S_M , as defined in embodiment 18.

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41. The process of any one of embodiments 1 to 24, or 25, further comprising providing at least part of the stream S_T or the mixture M_S to a polyamide 6 production unit U_{PP} , wherein the polyamide 6 produced in U_{PP} is preferably provided as a feedstock to an engineering plastics material producing unit U_{EP} , from which unit U_{EP}

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- (A) an engineering plastics material M_E is obtained which is brought onto the market, wherein, after the life-time T_{ME} of said engineering plastics material M_E it is at least partially collected as engineering plastics waste material in an engineering plastics material collecting unit U_{EC} ;

- (B) remaining material M_R is obtained as engineering plastics waste material;

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wherein at least part of the engineering plastics waste material according to (A), or at least part of the engineering plastics waste material according to (B), or at least part of the engineering plastics waste material according to (A) and at least part of the engineering plastics waste material according to (B) is suitably provided to U_R as S_M , as defined in embodiment 18.

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42. Use of S_T according to any one of embodiments 26 to 35 or of M_S according to embodiment 39 for preparing polyamide 6, said use preferably further comprising employing said polyamide 6 as a feedstock for preparing one or more of a textile material and an engineering plastics material, more preferably for preparing a textile material.

43. A method for preparing polyamide 6, said method comprising employing S_T according to any one of embodiments 26 to 35 or M_S according to embodiment 39 as a starting material, wherein said method preferably further comprises employing said polyamide 6 as a feedstock for preparing one or more of a textile material and an engineering plastics material, more preferably for preparing a textile material.
44. Use of S_T according to any one of embodiments 26 to 35 or of M_S according to embodiment 39 for preparing one or more of a polymer and a polymer product; or a method for preparing one or more of a polymer and a polymer product, said method comprising employing S_T according to any one of embodiments 26 to 35 or M_S according to embodiment 39 as a starting material.
45. The use or the method of embodiment 44, wherein the polymer, or the polymer product, or the polymer and the polymer product is or are in the form of at least one of a granulate, a strand, a rod, a plate, a pipe, a foil, a layer, a film, a sheet, a fiber, a filament, a coating, an extruded article, a molded article, a soft foam, a half-rigid foam and a rigid foam.
46. The use or the method of embodiment 44 or 45, wherein the polymer, or the polymer product, or the polymer and the polymer product comprises or comprise polyamide 6 and optionally at least one further polymeric compound, said polyamide 6 being at least partially obtainable or obtained from S_T according to any one of embodiments 26 to 35 or from M_S according to embodiment 39, wherein the at least one further polymeric compound preferably comprises one or more of at least one polyamide 6.6, at least one polyethylene terephthalate, at least one polyurethane, at least one polyester, at least one cellulose material, and at least one rubber material comprising one or more of at least one natural rubber material and at least one synthetic rubber material.
47. The use or the method of any one of embodiments 44 to 46, wherein the polymer, or the polymer product, or the polymer and the polymer product is or are one of the following or a part of one of the following:
- a part of a car, preferably a cylinder head cover, an engine cover, a housing for a charge air cooler, a charge air cooler flap, an intake pipe, an intake manifold, a connector, a gear wheel, a fan wheel, a cooling water box, a housing or a housing part for a heat exchanger, a coolant cooler, a charge air cooler, a thermostat, a water pump, a radiator, a fastening part or a part of a battery system for electromobility, a dashboard, a steering column switch, a seat, a headrest, a center console, a transmission component, a door module, a car exterior for an A, a B, a C or a D pillar cover, a spoiler, a door handle, an exterior mirror, a windscreen wiper, a windscreen wiper protection housing, a decorative grill, a cover strip, a roof rail, a window frame, a sunroof frame, an antenna panel, a headlight, a taillight, an airbag, a top mount, an oil pan, a fuel cell, a heat shield and/or a cushion;

- a cloth, an apparel, preferably a shirt, trousers, a pullover, a boot, a shoe, a shoe sole, a tight, a yarn, a fabric, and/or or jacket;
 - an electrical part, preferably an electrical component, an electronic passive component, an electronic active component, a printed circuit board, a housing component, a foil, a line, a switch such as a microswitch, a plug, a socket, a distributor, a relay, a resistor, a capacitor, an inductor, a bobbin, a lamp, a diode such as an LED, a transistor, a connector, a regulator, an integrated circuit (IC), a processor, a controller, a memory, a sensor, a microbutton, a semiconductor, a reflector housing for example for light-emitting diodes, a fastener for an electrical and/or an electronic component, a spacer, a bolt, a strip, a slide-in guide, a screw, a nut, a film hinge, a snap hook (snap-in), and/or a spring tongue;
 - a consumer and/or a pharmaceutical product, preferably a tennis string, a climbing rope, a bristle, a brush, an artificial grass, a 3D printing filament, a grass trimmer, a zipper, a hook and loop fastener, a paper machine clothing, an extrusion coating, a fishing line, a fishing net, an offshore line and rope, a vial, a syringe, an ampoule, a bottle, a sliding element, a spindle nut, a chain conveyor, a plain bearing, a roller, a wheel, a gear, a roller, a ring gear, a screw and spring damper, a hose, a pipeline, a cable sheathing, a socket, a switch, a cable tie, a fan wheel, a carpet, a box and/or a bottle for cosmetics, a mattress, a cushion, an insulation;
 - a packaging for the food industry, preferably a mono- and/or multi-layer blown film, a cast film (mono- and/or multi-layer), a biaxially stretched film, a laminating film.
48. The use or the method of any one of embodiments 44 to 47, wherein the polymer, or the polymer product, or the polymer and the polymer product contains or contain polyamide 6, obtainable or obtained from S_T according to any one of embodiments 26 to 35 or from M_S according to embodiment 39 in an amount of 1 weight-% or more, preferably 2 weight-% or more, more preferably 5 weight-% or more, more preferably 15 weight-% or more, more preferably 30 weight-% or more, more preferably 40 weight-% or more, more preferably 60 weight-% or more, more preferably 80 weight-% or more, more preferably 90 weight-% or more, more preferably 95 weight-% or more; and/or in an amount of 100 weight-% or less, preferably 95 weight-% or less, more preferably 90 weight-% or less, more preferably 50 weight-% or less, more preferably 25 weight-% or less, more preferably 10 weight-% or less.
- As far as the embodiment 48 is concerned, the respective amounts are preferably determined based on identity preservation and/or segregation and/or mass balance and/or book and claim chain of custody models, more preferably based on mass balance, more preferably the International Sustainability and Carbon Certification (ISCC) standard.
- As far as the embodiments 44 to 48 are concerned, preparing the polymer, the polymer product, or the polymer and the polymer product may comprise one or more synthesis steps and can be performed by conventional synthesis and technics well known to the person skilled in the art. Examples of the synthesis steps are described in "Industrial Organic Chemistry", 3rd volume,

Wiley-VCH, 1997; ISBN: 978-3-527-28838-0; „Kunststoffhandbuch“, 11 volumes in 17 sub-volumes, Carl Hanser Verlag, especially volume 6, „Polyamide“, 1st edition, 1966; “Injection Molding Reference Guide, 4th edition, CreateSpace Independent Publishing Platform, 2011, ISBN: 978-1466407824; WO 2008/155271 A1 and WO 2013/139827 A1, each of which is
 5 incorporated herein by reference.

The term „bar“ as used in the context of the present invention refers to the absolute pressure, also referred to as „bar(abs)“ or as “bara”.

- 10 The abbreviation „d“ as used in the context of the present invention in terms as a physical unit describes the time interval “day”, i.e. a time interval of (24 ± 1) h, preferably (24 ± 0.5) h. For example, a time period of 14 d refers to (336 ± 1) h, preferably (336 ± 0.5) h, and a time period of 28 d refers to (672 ± 1) h, preferably (672 ± 0.5) h.
- 15 The term “textile material” as used herein covers textile raw materials and non-textile raw materials that are processed by various methods into linear, planar and spatial structures. It concerns the linear textile structures produced from them, such as yarns, twisted yarns and ropes, the sheet-like textile structures, such as woven fabrics, knitted fabrics, braids, stitch-bonded fabrics, nonwovens and felts, and the three-dimensional textile structures, i.e. body
 20 structures, such as textile hoses, stockings or textile semi-finished products; and it further concerns those finished products which, using the aforementioned products, are brought into a saleable condition by making up, opening up and/or other operations for onward transmission to the processor, the trade or the end consumer. The term “textile waste material” as used herein covers a textile material as defined above, the inherent value of which has been consumed from
 25 the perspective of its current holder and, thus, is an end-of-life material for said holder.

- The term “engineering plastics” as used herein refers to high-performance plastics grades which possess physical properties enabling them to perform for prolonged use in structural applications, over a wide temperature range, under mechanical stress, and in difficult chemical and physical
 30 environments used for example to fabricate plastic parts replacing traditional engineering materials like metals and ceramics. Engineering plastics specifically apply in the fabrication of mechanical parts across several industries such as automotive, medical, electrical and electronics, aerospace, construction and consumer products. The term “engineering plastics waste material” as used herein covers an engineering plastics material as defined above, the
 35 inherent value of which has been consumed from the perspective of its current holder and, thus, is an end-of-life material for said holder.

The present invention is further illustrated by the following Reference Examples, Examples, and Comparative Examples.

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Reference Example 1

1.1 Determination of the APHA color of ϵ -caprolactam

The APHA color was determined in accordance with ISO 8112. In principal, the extinction E of a 50 % by weight aqueous ϵ -caprolactam solution is determined in a cuvette of length $l = 5$ cm at a wavelength $\lambda = 390$ nm and expressed in Hazen units (platinum-cobalt scale). For doing so, the measured extinction E is multiplied by the factor $f = 150$. The Hazen units (platinum-cobalt scale) are defined as the color of a solution containing, in 1 l water, 1 mg platinum in the form of hexachloroplatinum(IV) acid in the presence of 2 mg cobalt(II) chloride hexahydrate. The Hazen units correspond to the APHA units. A standard solution of 500 Hazen units as prepared as follows: 1.000 g cobalt(II) chloride hexahydrate ($\text{CoCl}_2 \cdot 6 \text{H}_2\text{O}$) and 1.245 g potassium hexachloroplatinate(IV) (K_2PtCl_6) are dissolved in 100 ml hydrochloric acid having a d of 1.19 g/ml. The solution is transferred into a 1000 ml volumetric flask which is filled to the calibration mark. This solution contains 500 mg platinum and corresponds to 500 Hazen units. $(5-50) \pm 0.1$ g ϵ -caprolactam are dissolved in a 250 ml Erlenmeyer flask in 50 ml distilled water. The solution is mixed and left until the air bubbles have disappeared. The 2 cuvettes of the spectrophotometer (which is suitable for measurements at a wavelength $\lambda = 390$ nm) are filled with distilled water, placed in the beam path, and the spectrophotometer is adjusted at $\lambda = 390$ nm to $E = 0$. Then, the distilled water is removed from the sample cuvette, followed by filling this cuvette with the ϵ -caprolactam solution. Then, the extinction E of this solution is determined at $\lambda = 390$ nm (E_{390}) against the comparative cuvette containing distilled water. The color number X (Hazen units, platinum-cobalt scale) is calculated as $X = E \cdot f = 150 \cdot E_{390}$. X is rounded to the next integer.

1.2 Determination of the purity of ϵ -caprolactam

The purity of ϵ -caprolactam and the respective amounts of impurities was determined via GC-FID/MS using GC (Agilent 7890A) coupled with two MSDs (Agilent 5975C) for electron impact ionisation and chemical ionisation. The respective area-% values obtained from the measurement represent the GC purity values Ω_{GC} according to the present invention.

1.3 Determination of the PAN of ϵ -caprolactam

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The PAN values were determined in accordance with DIN ISO 8660.

1.4 Determination of the UV-Vis absorption of ϵ -caprolactam

35 The UV/Vis absorption values were determined at a wavelength of 290 nm in accordance with DIN ISO 7059.

Reference Example 2

40 For determining a storage stability $\Sigma_{\Delta t}$ after a storage time Δt , 10-25 g of a given material were stored under exclusion of light in a glass vessel under an inert (argon) gas atmosphere for a pre-determined time Δt at constant temperature in the respective examples and comparative examples under constant stirring using a Teflon-coated, magnetic stir bar at 200-500 rpm. The

temperatures were kept constant in an oil bath using a contact thermometer. During the measurement, it was ensured that the respective material and never less than 15 % of the gas atmosphere were maintained at the respective temperature.

5 **Reference Example 3:** Storing stability of petrochemically derived ϵ -caprolactam

ϵ -caprolactam (15.0 g), which was prepared via the reaction sequence (i) cyclohexane oxidation with air (ii) oximation using hydroxylamine sulfate (iii) Beckmann rearrangement (oleum / sulphuric acid catalysed), with the following specifications:

10 $\Omega_{UV}(S_T) = 0.03$; $\Omega_{APHA}(S_T) = 2$; $\Omega_{PAN}(S_T) = 3$; $\Omega_{GC}(S_T) = 99.9 \%$;

was stored under inert atmosphere and light exclusion for 28 days at 85 °C.

The following specifications were observed after 28 days:

$\Omega_{UV}(28) = 0.16$; $\Omega_{APHA}(28) = 4$; $\Omega_{PAN}(28) = 8$.

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This Reference Example 3 shows that a (conventionally) synthesized ϵ -caprolactam can be stored for 28 d at 85 °C, and the specifications after 28 d, in particular $\Omega_{APHA}(28)$ and $\Omega_{PAN}(28)$, did not change much so that it can be concluded that the material exhibits a good storage stability Σ_{28} .

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Comparative Example 1: Insufficient storing stability of recovered ϵ -caprolactam

Compared to Reference Example 3, the ϵ -caprolactam according to Comparative Example 1 was not obtained from conventional synthesis but via hydrolytic depolymerisation and subsequent purification as described hereinabove, essentially in accordance with the process comprising steps (i) and (iv) as described above without a final crystallization, however without the chemical treatment according to the present invention, 99.9 weight-% of the ϵ -caprolactam fraction consisted of ϵ -caprolactam.

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30 This depolymerized and purified ϵ -caprolactam (15.0 g) with the following specifications:

$\Omega_{UV}(S_T) = 0.73$; $\Omega_{APHA}(S_T) = 10$; $\Omega_{PAN}(S_T) = 21$; $\Omega_{GC}(S_T) = 99.9 \%$;

was stored under inert atmosphere and light exclusion 28 days at 85 °C.

The following specifications were observed after 28 days:

35 $\Omega_{UV}(28) = 1.68$; $\Omega_{APHA}(28) = 75$; $\Omega_{PAN}(28) = 33$.

It was found that the material which was not subjected to the chemical treatment according to the present invention exhibited an insufficient storage stability, as can be seen, in particular, from the huge relative increase of the Ω_{APHA} value with $\Omega_{APHA}(28) = 7.5 \Omega_{APHA}(S_T)$.

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Comparative Example 2: Insufficient storing stability of recovered ϵ -caprolactam

As for Comparative Example 1 and compared to Reference Example 3, the ϵ -caprolactam according to Comparative Example 2 was not obtained from conventional synthesis but via hydrolytic depolymerisation and subsequent purification as described hereinabove, essentially in accordance with the process comprising steps (i) to (iv) as described above, without final crystallization. Further compared to Comparative Example 1, prior to the final purification in accordance with the process of the present invention, the material which exhibited a $\Omega_{GC} < 99\%$ (an aqueous stream comprising about 49 weight-% ϵ -caprolactam) was chemically treated according to the following method: The material (100 g) was heated to 75 °C under nitrogen atmosphere, and a 5.0 weight-% aqueous $KMnO_4$ solution (0.98 g) was added. After stirring the mixture for 30 min, an aqueous 8.0 weight-% (2 N) NaOH solution (0.234 g) was added, and the mixture was stirred for another 30 min. Thereafter, water was removed in vacuo, and ϵ -caprolactam was fine distilled (26 stages). 99.8 weight-% of the ϵ -caprolactam fraction consisted of ϵ -caprolactam.

This depolymerized and purified ϵ -caprolactam (15.0 g) with the following specifications: $\Omega_{UV}(S_T) = 0.17$; $\Omega_{APHA}(S_T) = 12$; $\Omega_{PAN}(S_T) = 26$ $\Omega_{GC}(S_T) = 99.8\%$; was stored under inert argon atmosphere and light exclusion for 14 days at 85 °C.

The following specifications were observed after 14 days:
 $\Omega_{APHA}(14) = 129$.

It was found that the material which exhibited a purity $< 99\%$ and which was chemically treated, exhibited, after the treatment, an insufficient storage stability, although highly pure after fine distillation, as can be seen from the huge relative increase of the Ω_{APHA} value already after 14 d with $\Omega_{APHA}(14) = 10.75 \Omega_{APHA}(S_T)$.

Comparative Example 3: Insufficient storing stability of recovered ϵ -caprolactam

As in Comparative Example 1, ϵ -caprolactam according to Comparative Example 3 was not obtained from conventional synthesis but via hydrolytic depolymerisation and subsequent purification as described hereinabove, essentially in accordance with the process of the present invention, without final crystallization. However, no chemical treatment according to step (iii) of the present invention was carried out; however, as final step, the separation according to step (iv) was carried out, i.e. ϵ -caprolactam was distilled overhead (0 stages). The expression "0 stage distillation" as used in the context of the present invention relates to a simple distillation at a temperature of 130 °C and a slow decrease of the vacuum applied to a value of 50 mbar, thereby removing water of which a portion goes to the vacuum system and a portion is collected in a first fraction, and wherein the vacuum is then further decreased to a value of 10 mbar, thereby obtaining an ϵ -caprolactam fraction which is condensed at 90 °C).

99.8 weight-% of the ϵ -caprolactam fraction consisted of ϵ -caprolactam. Prior to step (iv), the depolymerized and pre-purified ϵ -caprolactam (15.0 g) had the following specifications: $\Omega_{UV}(S_T) = 0.17$; $\Omega_{APHA}(S_T) = 12$; $\Omega_{PAN}(S_T) = 26$; $\Omega_{GC}(S_T) = 99.8\%$. After the step (iv) separation,

$\Omega_{\text{APHA}}(\text{S}_T)$ was 2.

After storing under inert argon atmosphere and light exclusion for 14 days at 85 °C, the following specifications were observed:

5 $\Omega_{\text{APHA}}(14) = 63$.

It was found that the material exhibited an insufficient storage stability, as can be seen from the huge relative increase of the Ω_{APHA} value already after 14 d with $\Omega_{\text{APHA}}(14) = 31.5 \Omega_{\text{APHA}}(\text{S}_T)$.

10 **Example 1:** Storing stability of recovered ϵ -caprolactam

As in Comparative Example 1, ϵ -caprolactam according to Example 1 was not obtained from conventional synthesis but via hydrolytic depolymerisation and subsequent purification as described hereinabove, essentially in accordance with the process according to the embodiments
15 18 to 22, without final crystallization. Thereafter, this material (45.0 g) was molten at 75 °C under nitrogen atmosphere and a 5.0 weight-% aqueous KMnO_4 solution (0.93 g) was added. After stirring the mixture for 30 min, an aqueous 8.0 weight-% (2 N) NaOH solution (0.23 g) was added, and the mixture was stirred for another 30 min. After the water was removed in vacuo, caprolactam was distilled overhead (0 stages).

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The obtained ϵ -caprolactam had the following improved specifications:

$\Omega_{\text{UV}}(\text{S}_T) = 0.12$; $\Omega_{\text{APHA}}(\text{S}_T) = 2$; $\Omega_{\text{PAN}}(\text{S}_T) = 11$; $\Omega_{\text{GC}}(\text{S}_T) = 99.9$ %;

After storing under inert argon atmosphere and light exclusion for 14 days at 85 °C, the following specifications were observed:

25 $\Omega_{\text{UV}}(14) = 0.29$; $\Omega_{\text{APHA}}(14) = 5$; $\Omega_{\text{PAN}}(14) = 13$.

In view of these specifications, it was found that ϵ -caprolactam chemically refined and further treated according to the present invention exhibited an advantageous storage stability.

30 **Example 2:** Storing stability of recovered ϵ -caprolactam

As in Comparative Example 1, ϵ -caprolactam according to Comparative Example 2 was not obtained from conventional synthesis but via hydrolytic depolymerisation and subsequent purification as described hereinabove, essentially in accordance with the process of the present
35 invention, without final crystallization. Thereafter, this material (3.85 kg) was molten at 80 °C under nitrogen atmosphere, a 5.0 weight-% aqueous KMnO_4 solution (77.03 g) was added. After stirring the mixture for 30 min, an aqueous 8.0 weight-% (2 N) NaOH solution (19.41 g) was added, and the mixture was stirred for another 30 min. After the water was removed in vacuo, caprolactam was distilled overhead (0 stages). 99.96 weight-% of the ϵ -caprolactam fraction
40 consisted of ϵ -caprolactam.

The obtained ϵ -caprolactam had the following improved specifications:

$\Omega_{\text{UV}}(\text{S}_T) = 0.33$; $\Omega_{\text{APHA}}(\text{S}_T) = 5$; $\Omega_{\text{PAN}}(\text{S}_T) = 23$; $\Omega_{\text{GC}}(\text{S}_T) = 99.96$ %;

After storing under inert argon atmosphere and light exclusion for 28 days at 85 °C, the following specifications were observed:

$\Omega_{UV}(28) = 0.38$; $\Omega_{APHA}(28) = 10$; $\Omega_{PAN}(14) = 22$.

- 5 In view of these specifications, it was found that ϵ -caprolactam chemically refined and further treated according to the present invention exhibited an advantageous storage stability.

Claims

1. A process for preparing a liquid high-purity ϵ -caprolactam stream S_T , the process comprising
 - 5 (i) preparing a liquid stream S_C comprising ϵ -caprolactam, said preparing comprising depolymerizing a material M comprising polyamide 6, said liquid stream S_C further comprising one or more oxidizable organic impurity compounds X , wherein the stream S_C has an ϵ -caprolactam purity $\Omega_{GC}(S_C)$ of at least 99 % and exhibits a weight ratio r_{XCC} of the one or more organic compounds X relative to ϵ -caprolactam;
 - 10 (ii) providing a stream S_O comprising at least one permanganate;
 - (iii) preparing an oxidation reaction educt mixture M_{OE} from the stream S_C and the stream S_O , and subjecting the mixture M_{OE} to oxidation reaction conditions, obtaining an oxidation reaction product stream S_P comprising ϵ -caprolactam, further comprising one or more oxidation products Y obtained from the oxidation of at least a part of the one or more compounds X , and optionally further comprising a part of the one or more organic compounds X , wherein the stream S_P exhibits a weight ratio r_{XCP} of organic compound X relative to ϵ -caprolactam with $0 \leq r_{XCP} < r_{XCC}$ and further exhibits a weight ratio r_{YCP} of the one or more products Y relative to ϵ -caprolactam with $r_{YCP} > 0$;
 - 20 (iv) separating at least a part of the one or more oxidation products Y and optionally at least a part of organic compound X from the stream S_P , obtaining the stream S_T exhibiting a weight ratio r_{YCT} of oxidation product Y relative to ϵ -caprolactam with $0 \leq r_{YCT} < r_{YCP}$, and further exhibiting a weight ratio r_{XCT} of organic compound X relative to ϵ -caprolactam with $0 \leq r_{XCT} \leq r_{XCP}$, wherein the stream S_T exhibits an ϵ -caprolactam purity $\Omega_{GC}(S_T)$ of at least 99.5 % with $\Omega_{GC}(S_T) > \Omega_{GC}(S_C)$, and an APHA value $\Omega_{GAPHA}(S_T)$ of at most 10.
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2. The process of claim 1, wherein the at least one permanganate comprised in the stream S_O provided according to (ii) comprises, preferably consists of, at least alkali metal
 - 30 permanganate, wherein more preferably, the at least one alkali metal permanganate comprises one or more of sodium permanganate and potassium permanganate, wherein preferably from 0.5 to 100 weight-% of the stream S_O provided according to (ii) consist of permanganate, the stream S_O provided according to (ii) preferably further comprises water.
3. The process of claim 1 or 2, wherein the oxidation reaction educt mixture M_{OE} prepared according to (iii) exhibits a permanganate concentration, calculated as MnO_4 , in the range of from 0.005 to 5 weight-%, preferably in the range of from 0.01 to 3 weight-%, more preferably in the range of from 0.05 to 1 weight-%.
4. The process of any one of claims 1 to 3, wherein the oxidation reaction conditions according to (iii) comprise a temperature T_{OE} of the mixture M_{OE} in the range of from 40 to 140 °C, preferably in the range of from 60 to 100 °C, more preferably in the range of from 70 to 90 °C.

5. The process of any one of claims 1 to 4, further comprising providing a stream S_B comprising at least one hydroxide, wherein the oxidation reaction educt mixture M_{OE} according to (iii) is prepared from the stream S_C , the stream S_O , and the stream S_B .
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6. The process of claim 5, wherein the at least one hydroxide comprised in the stream S_B comprises, preferably consists of, at least alkali metal hydroxide, wherein more preferably, the at least one alkali metal hydroxide comprises, more preferably consists of, sodium hydroxide, wherein preferably from 0.5 to 100 weight-% of the stream S_B consist of hydroxide, the stream S_B preferably further comprises water.
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7. The process of claim 5 or 6, wherein the oxidation reaction educt mixture M_{OE} prepared according to (iii) exhibits a hydroxide concentration, calculated as OH, in the range of from 0.005 to 0.75 weight-%, preferably in the range of from 0.01 to 0.5 weight-%, more preferably in the range of from 0.1 to 0.25 weight-%.
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8. The process of any one of claims 1 to 7, wherein the one or more oxidizable organic compounds X have a boiling point $\delta_X/^\circ\text{C}$ with $0.5 \leq (\delta_X / \delta_C) \leq 1.5$, $\delta_C/^\circ\text{C}$ being the boiling point of ϵ -caprolactam and wherein at least one of the one or more oxidation products Y has a boiling point $\delta_Y/^\circ\text{C}$ with $\delta_Y/^\circ\text{C} \neq \delta_C/^\circ\text{C}$, wherein the difference $\Delta\delta$ between the boiling points δ_Y and δ_C is preferably at least 1°C .
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9. The process of any one of claims 1 to 8, wherein separating at least a part of the one or more oxidation products Y and optionally at least a part of organic compound X from the stream S_P according to (iv) comprises subjecting the stream S_P obtained according to (iii) to distillation in a distillation unit U_{DT} , obtaining from the distillation unit U_{DT} a stream S_{DT} comprising ϵ -caprolactam as the stream S_T , wherein the unit U_{DT} comprises one or more distillation columns, preferably one or two distillation columns, wherein at least one column is optionally configured as side stream column or as divided wall column.
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10. The process of claim 9, wherein separating at least a part of the one or more oxidation products Y and optionally at least a part of organic compound X from the stream S_P according to (iv) further comprises subjecting the stream S_{DT} to crystallization in a crystallization unit U_{CR} , obtaining from the unit U_{CR} a stream S_{CR} comprising ϵ -caprolactam as the stream S_T .
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11. The process of any one of claims 1 to 10, wherein preparing the liquid stream S_C according to (i) comprises
 - (i.1) providing a stream S_M comprising a solid material M comprising polyamide 6;
 - (i.2) preparing an aqueous depolymerization mixture based on S_M ;
 - (i.3) subjecting the depolymerization mixture prepared according to (i.2) to polyamide 6 depolymerization conditions in a reaction unit U_R , obtaining a liquid aqueous stream
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- S_R comprising ϵ -caprolactam dissolved in water at a concentration c_{SR} , the stream S_R further comprising one or more impurities;
- (i.4) preferably passing the liquid aqueous stream S_R into an evaporation unit U_E , obtaining from S_R a liquid aqueous stream S_L comprising ϵ -caprolactam dissolved in water at a concentration c_{SL} with $c_{SL} > c_{SR}$, and further obtaining from S_R one or more aqueous vapor streams S_V ;
- (i.5) passing the stream S_R , preferably the stream S_L , into a purification unit U_P , obtaining from the stream S_R , preferably from the stream S_L , the stream S_C .
12. The process of any one of claims 1 to 11, preferably of claim 11, wherein the material M comprises, preferably consists of, waste material, wherein said waste material more preferably comprises, more preferably consists of, one or more of at least one textile waste material and at least one engineering plastics waste material, more preferably comprises, more preferably consists of at least one textile waste material;
- wherein preferably from 10 to 99 weight-%, more preferably from 30 to 98.5 weight-%, more preferably from 50 to 98 weight-%, more preferably from 80 to 98 weight-%, of the material M consist of the polyamide;
- wherein preferably, in addition to polyamide 6, the material M comprises one or more further organic polymeric compounds, more preferably including, but not limited to, one or more of at least one elastanes, at least one polyethylene terephthalate, at least one polytetrahydrofuran, at least one polyamide 6.6, at least one polyurethane, at least one polyester, at least one cellulose material, and at least one rubber material comprising one or more of at least one natural rubber material and at least one synthetic rubber material.
13. The process of claim 11 or 12, wherein the purification unit U_P according to (i.5) comprises a water separation unit U_{WS} and a distillation unit U_D , the process comprising feeding the stream S_R , preferably the stream S_L , to U_{WS} , obtaining from U_{WS} a stream U_{WS} comprising ϵ -caprolactam at a concentration c_{UWS} , feeding the stream S_{UWS} to the distillation unit U_D , obtaining from U_D the stream S_C comprising ϵ -caprolactam at a concentration c_{SC} , wherein $c_{SR} < c_{UWS} \ll c_{SC}$, preferably wherein $c_{SL} < c_{UWS} \ll c_{SC}$; wherein the water separation unit U_{WS} preferably comprises at least two water separation sub-units U_{WS1} and U_{WS2} , more preferably two serially coupled water separation sub-units U_{WS1} and U_{WS2} , wherein the stream S_R , preferably the stream S_L , is fed into U_{WS1} , wherein downstream of U_{WS1} and upstream of U_{WS2} , a separation unit U_I is preferably located, the process comprising obtaining from U_{WS1} an aqueous stream S_{UWS1} , feeding the stream S_{UWS1} into the separation unit U_I , obtaining from U_I an aqueous stream S_{UI} , and feeding the stream S_{UI} into the unit U_{WS2} , wherein in U_I , one or more of impurities are separated from S_{UWS1} , thereby obtaining from U_I an impurity stream S_I , said impurities preferably comprising at least one impurity comprised in S_R according to (i.3), wherein at least one of said impurities is an organic compound having a higher boiling point than ϵ -caprolactam, the separation unit U_I being a high boiler separation unit.

14. The process of claim 13, wherein the purification unit U_P further comprises a crystallization unit U_{SCR} , said unit U_{SCR} preferably being located downstream of the distillation unit U_D , the process preferably comprising obtaining a stream S_{UD} from the distillation unit U_D comprising ϵ -caprolactam at a concentration C_{UD} , and feeding the stream to the crystallization unit U_{SCR} , obtaining from U_{SCR} the stream S_C comprising ϵ -caprolactam at a concentration C_{SC} , wherein $C_{SR} < C_{UWS} \lll C_{UD} < C_{SC}$, preferably wherein $C_{SL} < C_{UWS} \lll C_{UD} < C_{SC}$.
15. The process of any one of claims 1 to 14, wherein the stream S_T has an ϵ -caprolactam purity $\Omega_{GC}(S_T)$ of at least 99.8 %, more preferably of at least 99.9 % and an APHA value $\Omega_{APHA}(S_T)$ of at most 9, preferably of at most 8.
16. A liquid high-purity ϵ -caprolactam stream S_T , obtainable or obtained by a process according to any one claims 1 to 15, exhibiting an ϵ -caprolactam purity $\Omega_{GC}(S_T)$ of at least 99.5 %, preferably of at least 99.8 %, more preferably of at least 99.9 %; and further exhibiting and an APHA value $\Omega_{GC}(S_T)$ of at most 10, preferably of at most 9, more preferably of at most 8.
17. The stream S_T of claim 16, exhibiting a storage stability $\Sigma_{\Delta t}$ after a storage time Δt , wherein $\Sigma_{\Delta t}$ is characterized by an APHA value $\Omega_{APHA}(\Delta t)$; wherein if Δt is 14 d and the storage stability Σ_{14} after said storage time is characterized by an APHA value $\Omega_{APHA}(14)$:
- if $\Omega_{APHA}(S_T) < 5$, $\Omega_{APHA}(14) \leq 10$;
 - if $\Omega_{APHA}(S_T)$ is in the range of from 5 to 8, $\Omega_{APHA}(14) \leq 1.5 \Omega_{APHA}(S_T)$;
 - if $\Omega_{APHA}(S_T) > 8$, $\Omega_{APHA}(14) \leq 1.25 \Omega_{APHA}(S_T)$.
- and wherein if Δt is 28 d and the storage stability Σ_{28} after said storage time is characterized by an APHA value $\Omega_{APHA}(28)$:
- if $\Omega_{APHA}(S_T) < 4$, $\Omega_{APHA}(28) \leq 10$;
 - if $\Omega_{APHA}(S_T)$ is in the range of from 4 to 10, $\Omega_{APHA}(28) \leq 3 \Omega_{APHA}(S_T)$;
 - if $\Omega_{APHA}(S_T) > 10$, $\Omega_{APHA}(28) \leq 2 \Omega_{APHA}(S_T)$.
18. A method for preparing polyamide 6, comprising
- (a) preparing a stream S_T according to a process according to any one of claims 1 to 15; and/or providing a stream S_T according to claim 16 or 17;
 - (b) optionally storing the material of the stream S_T under an inert gas atmosphere, preferably under exclusion of light, for a storage time Δt_s , obtaining a stored mixture M_s , wherein the material is preferably stored at a temperature of the material of at least 85 °C for a storage time Δt_s preferably of at least 1 d, more preferably of at least 7 d, more preferably of at least 14 d, more preferably in the range of from 14 to 28 d;
 - (c) subjecting the stream S_T prepared and/or provided according to (a) and/or the mixture M_s according to (b) to polyamide 6 polymerization conditions.
19. A mixture M_s comprising ϵ -caprolactam, obtainable or obtained according to step (b) as defined in claim 18.

20. Use of the stream S_T according to claim 16 or 17, or of the stored mixture M_S according to claim 19, for preparing one or more of a polymer and a polymer product; or a method for preparing one or more of a polymer and a polymer product, said method comprising employing the stream S_T or the mixture M_S as a starting material; wherein the polymer, or the polymer product, or the polymer and the polymer product is or are preferably in the form of at least one of a granulate, a strand, a rod, a plate, a pipe, a foil, a layer, a film, a sheet, a fiber, a filament, a coating, an extruded article, a molded article, a soft foam, a half-rigid foam and a rigid foam; wherein the polymer, or the polymer product, or the polymer and the polymer product preferably comprises or comprise polyamide 6 and optionally at least one further polymeric compound, said polyamide 6 being at least partially obtainable or obtained from the stream S_T or from the mixture M_S , wherein the at least one further polymeric compound preferably comprises one or more of at least one polyamide 6.6, at least one polyethylene terephthalate, at least one polyurethane, at least one polyester, at least one cellulose material, and at least one rubber material comprising one or more of at least one natural rubber material and at least one synthetic rubber material; wherein the polymer, or the polymer product, or the polymer and the polymer product preferably is or are one of the following or a part of one of the following:
- a part of a car, preferably a cylinder head cover, an engine cover, a housing for a charge air cooler, a charge air cooler flap, an intake pipe, an intake manifold, a connector, a gear wheel, a fan wheel, a cooling water box, a housing or a housing part for a heat exchanger, a coolant cooler, a charge air cooler, a thermostat, a water pump, a radiator, a fastening part or a part of a battery system for electromobility, a dashboard, a steering column switch, a seat, a headrest, a center console, a transmission component, a door module, a car exterior for an A, a B, a C or a D pillar cover, a spoiler, a door handle, an exterior mirror, a windscreen wiper, a windscreen wiper protection housing, a decorative grill, a cover strip, a roof rail, a window frame, a sunroof frame, an antenna panel, a headlight, a taillight, an airbag, a top mount, an oil pan, a fuel cell, a heat shield and/or a cushion;
 - a cloth, an apparel, preferably a shirt, trousers, a pullover, a boot, a shoe, a shoe sole, a tight, a yarn, a fabric, and/or or jacket;
 - an electrical part, preferably an electrical component, an electronic passive component, an electronic active component, a printed circuit board, a housing component, a foil, a line, a switch such as a microswitch, a plug, a socket, a distributor, a relay, a resistor, a capacitor, an inductor, a bobbin, a lamp, a diode such as an LED, a transistor, a connector, a regulator, an integrated circuit (IC), a processor, a controller, a memory, a sensor, a microbutton, a semiconductor, a reflector housing for example for light-emitting diodes, a fastener for an electrical and/or an electronic component, a spacer, a bolt, a strip, a slide-in guide, a screw, a nut, a film hinge, a snap hook (snap-in), and/or a spring tongue;
 - a consumer and/or a pharmaceutical product, preferably a tennis string, a climbing rope, a bristle, a brush, an artificial grass, a 3D printing filament, a grass trimmer, a zipper, a

- hook and loop fastener, a paper machine clothing, an extrusion coating, a fishing line, a fishing net, an offshore line and rope, a vial, a syringe, an ampoule, a bottle, a sliding element, a spindle nut, a chain conveyor, a plain bearing, a roller, a wheel, a gear, a roller, a ring gear, a screw and spring damper, a hose, a pipeline, a cable sheathing, a socket, a switch, a cable tie, a fan wheel, a carpet, a box and/or a bottle for cosmetics, a mattress, a cushion, an insulation;
- 5 - a packaging for the food industry, preferably a mono- and/or multi-layer blown film, a cast film (mono- and/or multi-layer), a biaxially stretched film, a laminating film;
- 10 wherein the polymer, or the polymer product, or the polymer and the polymer product preferably contains or contain polyamide 6, obtainable or obtained from the stream S_T or from the mixture M_S in an amount of 1 weight-% or more, preferably 2 weight-% or more, more preferably 5 weight-% or more, more preferably 15 weight-% or more, more preferably 30 weight-% or more, more preferably 40 weight-% or more, more preferably 60 weight-% or more, more preferably 80 weight-% or more, more preferably 90 weight-% or more, more
- 15 preferably 95 weight-% or more; and/or in an amount of 100 weight-% or less, preferably 95 weight-% or less, more preferably 90 weight-% or less, more preferably 50 weight-% or less, more preferably 25 weight-% or less, more preferably 10 weight-% or less.