

Color-stable aqueous mixture comprising recovered liquid caprolactam

The present invention relates to a process for preparing a highly pure liquid mixture which comprises ϵ -caprolactam and which is color-stable when stored at low temperatures, wherein
5 said mixture is prepared by subjecting a solid material which comprises polyamide 6 to hydrolytic depolymerization and purifying the resulting depolymerization mixture with respect to ϵ -caprolactam. Further, the present invention relates to a method of storing said mixture, and further relates to the respectively stored mixture. Still further, the present invention relates to the use of the optionally stored mixture for preparing polyamide 6, and thus to a full polyamide 6 (or
10 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
15 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. Once a respectively
20 purified mixture comprising ϵ -caprolactam is obtained from depolymerisation and downstream purification stages, such mixture is advantageously re-used as an educt for polymerization, in particular for preparing polyamide 6, thus realizing a recycle loop. However, it is not guaranteed that such a mixture 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
25 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. The APHA color scale, also referred to as the Hazen scale or as the Platinum Cobalt scale, is a color standard named for the American Public Health Association. Yet further, it is desirable that such storing can be carried out under economically advantageous
30 conditions, such as comparatively low temperatures.

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.
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Surprisingly, it was found that a highly pure mixture ϵ -caprolactam which is obtained from hydrolytic depolymerisation and subsequent purification and which exhibits a certain minimum content of water has the desired storing properties.

40 Therefore, the present invention relates to a process for preparing a liquid ϵ -caprolactam mixture M_F , the process comprising
(i) providing a stream S_M comprising a solid material M comprising polyamide 6;
(ii) preparing an aqueous depolymerization mixture based on S_M ;

- (iii) subjecting the depolymerization mixture prepared according to (ii) 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; and optionally 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 ;
- (iv) passing the stream S_R , optionally the stream S_L , into an ϵ -caprolactam purification unit U_P , and
- (iv.1) obtaining from the unit U_P the mixture M_F ; or
- (iv.2) obtaining from the unit U_P a mixture M_T having an ϵ -caprolactam purity $\Omega_{GC}(M_T)$ of at least 99 %, an APHA value $\Omega_{APHA}(M_T)$ of at most 20 and a water content $x_{H_2O}(M_T)$ of at most 0.05 weight-%, based on the total weight of the mixture M_T , and adding water to the mixture M_T , obtaining the mixture M_F ;
- wherein the mixture M_F has an ϵ -caprolactam purity $\Omega_{GC}(M_F)$ of at least 99 %, an APHA value $\Omega_{APHA}(M_F)$ of at most 20 and a water content $x_{H_2O}(M_F)$ of at least 0.1 weight-%, based on the total weight of the mixture M_F .

Preferably at least 99 weight-%, preferably at least 99.1 weight-%, more preferably at least 99.2 weight-%, more preferably at least 99.3 weight-%, more preferably at least 99.4 weight-%, more preferably at least 99.5 weight-%, more preferably at least 99.6 weight-%, more preferably at least 99.7 weight-%, more preferably at least 99.8 weight-%, more preferably at least 99.9 weight-% of the mixture M_F consist of ϵ -caprolactam and water.

It is preferred that $\Omega_{GC}(M_F)$ is at least 99.5 %, more preferably at least 99.6 %, more preferably at least 99.7 %, more preferably at least 99.8 %, more preferably at least 99.9 %. Further, it is preferred that $\Omega_{APHA}(M_F)$ is at most 15, more preferably at most 12.5, more preferably at most 10, more preferably at most 7.5, more preferably at most 5. Still further, it is preferred that $x_{H_2O}(M_F)$ is in the range of from 0.1 to 10 weight-%, more preferably in the range of from 0.15 to 9 weight-%, more preferably in the range of from 0.2 to 8 weight-%, more preferably in the range of from 0.35 to 7 weight-%, more preferably in the range of from 0.5 to 6 weight-%. Suitable ranges of $x_{H_2O}(M_F)$ may include from 0.5 to 2 weight-% and from 2 to 4 weight-% and from 4 to 6 weight-%. Therefore, mixtures M_F are more preferred for which $\Omega_{GC}(M_F)$ is at least 99.9 %, $\Omega_{APHA}(M_F)$ is at most 5, and $x_{H_2O}(M_F)$ is in the range of from 0.5 to 6 weight-%.

Preferably, the mixture M_F has a temperature in the range of from 20 to 80 °C, more preferably in the range of from 35 to 77 °C, more preferably in the range of from 50 to 75 °C.

Optionally or preferably, the mixture M_F is further characterized by one or more of a permanganate absorption number $\Omega_{PAN}(M_F)$ and an UV absorption $\Omega_{UV}(M_F)$. $\Omega_{PAN}(M_F)$ is preferably at most 20, more preferably at most 15, more preferably at most 10. $\Omega_{UV}(M_F)$ is preferably at most 0.75, more preferably at most 0.25, more preferably at most 0.1. Therefore, mixtures M_F are more preferred for which $\Omega_{PAN}(M_F)$ is at most 10 and $\Omega_{UV}(M_F)$ is at most 0.1.

Thus, more preferred are mixtures M_F for which $\Omega_{GC}(M_F)$ is at least 99.9 %, $\Omega_{APHA}(M_F)$ is at most 5, $x_{H_2O}(M_F)$ is in the range of from 0.5 to 6 weight-%, $\Omega_{PAN}(M_F)$ is at most 10 and $\Omega_{UV}(M_F)$ is at most 0.1.

- 5 Regarding the determination of the values of Ω_{GC} , Ω_{APHA} , Ω_{UV} and Ω_{PAN} , reference is made to the Reference Examples hereinbelow.

Preferably according to the present invention, the purification unit U_P according to (v) comprises a water separation unit U_{WS} and a distillation unit U_D , and the process preferably comprises feeding
 10 the stream S_R , optionally 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 U_D , obtaining from U_D the mixture M_F comprising ϵ -caprolactam at a concentration c_{MF} , wherein $c_{SR} < c_{UWS} \lll c_{MF}$, preferably wherein $c_{SL} < c_{UWS} \lll c_{MF}$.

- 15 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} .

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} ,
 20 wherein the stream S_R , optionally 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
 25 stream S_I , said impurities preferably comprising at least one impurity comprised in S_R according to (iii), 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.

With regard to the specific apparatus design of the sub-unit U_{WS1} and sub-unit U_{WS2} , it is preferred
 30 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 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.

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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) will contain certain compounds which, either prior to or after
 40 depolymerization of polyamide 6 according to (iii), 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 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 $c_{L0}(\Psi)$ of one or more compounds Ψ which have a higher boiling point than ϵ -caprolactam further have a concentration $c_{L0}(C)$ of monomeric ϵ -caprolactam;
- (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
 - (β.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 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} ;
 - (β.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 $c_{V1}(C) > c_{UWS1}(C)$ and $c_{V1}(\Psi) < c_{UWS1}(\Psi)$;
 - (β.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 $c_{L1}(\Psi) > c_{UWS1}(\Psi)$;
- (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
 - (γ.1) passing the stream S_{V1} removed from the evaporation unit U_{E1} according to (β.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;
 - (γ.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;
 - (γ.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 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 (γ.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 $c_{UWS1}(\Psi)$,
 5 $c_{UWS1}(C) + c_{UWS1}(\Psi)$, 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,
 10 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}
 15 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,
 20 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;
- 25 - 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;
- 30 - 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;
- 35 - 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.

40 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);

- 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-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;
- 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.

According to the present invention, it is further preferred that the purification unit U_P further comprises, downstream of the distillation unit U_D , one or more of a crystallization unit U_{CR} and a chemical treatment unit U_{OD} , and the process preferably comprises obtaining the mixture M_F from U_{CR} or from U_{OD} .

As far as the chemical treatment in the unit U_{OD} is concerned, the process of the present invention preferably comprises

- (a) providing a preferably liquid stream S_{UD} comprising ϵ -caprolactam from the distillation unit U_D or a preferably liquid stream S_{CR} comprising ϵ -caprolactam from the crystallization unit U_{CR} , said stream S_{UD} or said stream S_{CR} further comprising one or more oxidizable organic impurity compounds X, wherein the stream S_{UD} or the stream S_{CR} has an ϵ -caprolactam purity $\Omega_{GC}(S_C)$ of at least 99 % and exhibits a weight ratio r_{XC} of the one or more organic compounds X relative to ϵ -caprolactam;
- (b) providing a stream S_O comprising at least one permanganate;
- (c) preparing an oxidation reaction educt mixture M_{OE} from the stream S_{UD} and the stream S_O , or from the stream S_{SCR} 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 $0 \leq r_{XCP} < r_{XC}$ and further exhibits a weight ratio r_{YCP} of the one or more products Y relative to ϵ -caprolactam with $r_{YCP} > 0$;
- (d) 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 mixture M_F or the mixture M_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 $0 \leq r_{\text{XCT}} < r_{\text{XC}}$.

The at least one permanganate comprised in the stream S_O provided according to (b) 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, wherein it is more preferred that the oxidation reaction educt mixture M_{OE} prepared according to (c) 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 (c) 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} comprised in the chemical treatment unit U_{OD} , wherein the unit U_{OR} preferably comprises one or more of at least one continuous stirred tank reactor and at least one tube reactor.

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 (c) is prepared from the stream S_{UD} or the stream S_{CR} , and from 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 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, wherein it is more preferred that the oxidation reaction educt mixture M_{OE} prepared according to (c) 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-%.

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.

According to the present invention, it may be 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 (d) comprises subjecting the stream S_P obtained according to (c) to distillation in a distillation unit U_{DT} which is comprised in, i.e. is part of, the chemical treatment unit U_{OD} . 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 mixture M_F or the mixture M_T . Preferably, the unit
- 5 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;
 - 10 - 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
 - in one side-stream distillation column; or
 - 15 -- in two separate distillation columns; or
 - in one divided wall distillation column; or
 - 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
 - 20 --- one or more high boiling compounds
 - are separated from ϵ -caprolactam.

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.

25 According to the process of the present invention, the purification unit U_P may further comprise a crystallization unit U_{CR} , wherein the process comprises obtaining from the distillation unit U_D a stream S_{UD} comprising ϵ -caprolactam at a concentration c_{UD} , and feeding the stream S_{UD} to the crystallization unit U_{CR} , obtaining from U_{CR} the mixture M_F comprising ϵ -caprolactam at the

30 concentration c_{MF} .

Further according to the present invention, the purification unit U_P may further comprise a chemical treatment unit U_{OD} , wherein the process comprises obtaining from the distillation unit U_D a stream S_{UD} comprising ϵ -caprolactam at a concentration c_{UD} and feeding the stream S_{UD} to the

35 chemical treatment unit U_{OD} , obtaining from U_{OD} the mixture M_F comprising ϵ -caprolactam at the concentration c_{MF} .

Yet further according to the present invention, the purification unit U_P may further comprise a chemical treatment unit U_{OD} and a crystallization unit U_{CR} , wherein the crystallization unit U_{CR} is

40 located downstream of the distillation unit U_D and the chemical treatment unit U_{OD} is located downstream of the crystallization unit U_{CR} , wherein the process comprises obtaining from the distillation unit U_D a stream S_{UD} comprising ϵ -caprolactam at a concentration c_{UD} , feeding the stream S_{UD} to the crystallization unit U_{CR} , obtaining from the crystallization U_{CR} a stream S_{CR}

comprising ϵ -caprolactam at a concentration c_{CR} , and feeding the stream S_{CR} to the chemical treatment unit U_{OD} , obtaining from U_{OD} the mixture M_F comprising ϵ -caprolactam at the concentration c_{MF} .

- 5 Still further according to the present invention, the purification unit U_P may further comprise a chemical treatment unit U_{OD} and a crystallization unit U_{CR} , wherein the chemical treatment unit U_{OD} is located downstream of the distillation unit U_D and the crystallization unit U_{CR} is located downstream of the unit U_{CR} , wherein the process comprises obtaining from the distillation unit U_D a stream S_{UD} comprising ϵ -caprolactam at a concentration c_{UD} , feeding the stream S_{UD} to the
- 10 chemical treatment unit U_{OD} , obtaining from the chemical treatment unit U_{OD} a stream S_{OD} comprising ϵ -caprolactam at a concentration c_{OD} , and feeding the stream S_{OD} to the crystallization unit U_{CR} , obtaining from U_{CR} the mixture M_F comprising ϵ -caprolactam at the concentration c_{MF} .

- As described above, according to (iv.2), the process of the present invention may comprise
- 15 passing the stream S_R , optionally the stream S_L , into an ϵ -caprolactam purification unit U_P , and obtaining from the unit U_P a mixture M_T having an ϵ -caprolactam purity $\Omega_{GC}(M_T)$ of at least 99 %, an APHA value $\Omega_{APHA}(M_T)$ of at most 20 and a water content $x_{H_2O}(M_T)$ of at most 0.05 weight-%, based on the total weight of the mixture M_T . Preferably, $x_{H_2O}(M_T)$ is in the range of from 0 to 0.05 weight-%, more preferably in the range of from 0 to 0.01 weight-%, more preferably in the range
- 20 of from 0 to 0.001 weight-%. Further preferably, $\Omega_{GC}(M_T)$ is at least 99.5 %, more preferably at least 99.8 %, more preferably at least 99.9 %. Yet further preferably, $\Omega_{APHA}(M_T)$ is at most 20, more preferably at most 15, more preferably at most 10. Therefore, it is more preferred that $x_{H_2O}(M_T)$ is in the range of from 0 to 0.001 weight-%, $\Omega_{GC}(M_T)$ is at least 99.9 %, and $\Omega_{APHA}(M_T)$ is at most 10.

- 25 Optionally or preferably, the mixture M_T is further characterized by one or more of a permanganate absorption number $\Omega_{PAN}(M_T)$ and an UV absorption $\Omega_{UV}(M_T)$, wherein $\Omega_{PAN}(M_T)$ is at most 20, preferably at most 15, more preferably at most 10, and wherein $\Omega_{UV}(M_T)$ is at most 0.75, preferably at most 0.25, more preferably at most 0.1. Therefore, it is more preferred that
- 30 $x_{H_2O}(M_T)$ is in the range of from 0 to 0.001 weight-%, $\Omega_{GC}(M_T)$ is at least 99.9 %, $\Omega_{APHA}(M_T)$ is at most 10, $\Omega_{PAN}(M_T)$ is at most 10, and $\Omega_{UV}(M_T)$ is at most 0.1.

- As described above, according to (i), a stream S_M is provided which comprises a solid material M comprising polyamide 6. Preferably, the material M comprises, preferably consists of, waste
- 35 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
- 40 preferably from 50 to 98 weight-%, more preferably from 80 to 98 weight-% of the material M 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 elastane, 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.

5

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 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
10 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 subjected to a suitable metal removing step. If a metal removing step is carried out, ferrous
15 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.

Generally, the solid material M can be provided according to any suitable method. Preferably
20 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 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
25 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 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.

30

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 textile waste material sources and may be combined, and then the collected textile waste material can be suitably sorted as indicated above. The textile waste material may generally have
35 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
40 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:

- 5 - 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;
- 10 - 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 (ii) 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

- 20 $0.8 \leq T_{SF}/T_D \leq 1.05$ and $0.9 \leq p_{SF}/p_D \leq 1.05$;
- $0.6 \leq T_{SM}/T_{SF} \leq 1.2$ and $0.9 \leq p_{SM}/p_{SF} \leq 1.05$; and
- $0.8 \leq T_{SW}/T_{SF} \leq 1.2$ 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 .

25 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 30 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 .

35 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.

40 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 from 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.

According to the present invention, it is preferred that preparing the stream S_R according to (iii) 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
 5 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
 10 semicontinuous process, or a batch process.

As described hereinabove, the mixture M_F of the present invention having a certain minimum content of water is suitable to be stored and, after storing, still exhibits advantageous characteristics, in particular with respect to its APHA color. Therefore, the process of the present invention may further comprise

- 15 (v) storing the mixture M_F obtained according to (iv) at a temperature of the mixture of at most 80 °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.

Preferably according to (v), the mixture M_F is stored under exclusion of light. Further preferably
 20 according to (v), the storage time Δt_s is at least 7 d, more preferably at least 14 d, more preferably in the range of from 14 to 28 d. Still further preferably according to (v), the inert gas atmosphere comprises one or more of nitrogen and argon. Further according to the present invention, it is preferred that the mixture M_F is stored according to (v) at a storing temperature δ_s of the mixture M_F in the range of from 20 to 80 °C, preferably in the range of from 25 to 80 °C, more preferably
 25 in the range of from 35 to 77 °C, more preferably in the range of from 50 to 75 °C. Further according to the present invention, it is preferred that the mixture M_F is stored according to (v) 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. Further according to the present invention, it is preferred that the storing according to (v)
 30 comprises agitating, preferably mechanically agitating, more preferably stirring the mixture M_F for at least part of the storage time Δt_s , preferably for essentially the entire storage time Δt_s .

It was further found that it may be advantageous to carry out the storing according to (v) at a temperature which is in a specific functional relationship to the water content of the mixture M_F .
 35 Specifically, it may be preferred that during storing according to (v),

$$(\delta_s / ^\circ\text{C}) = -2.6 \cdot (x_{\text{H}_2\text{O}}(M_F) / \text{weight-\%}) + C_s$$

40 wherein $C_s = 77 \pm 10$, preferably $C_s = 77 \pm 5$.

Further, the present invention also relates to a method of storing a mixture M_F comprising ϵ -caprolactam and water and having a purity $\Omega_{\text{GC}}(M_F)$ of at least 99 %, an APHA value $\Omega_{\text{APHA}}(M_F)$ of at most 20 and a water content $x_{\text{H}_2\text{O}}(M_F)$ of at least 0.1 weight-%, based on the total weight of the

mixture M_F , wherein said method comprises storing the mixture M_F at a temperature of the mixture of at most 80 °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.

- 5 As far as said method of storing is concerned, it is preferred that at least 99 weight-%, preferably at least 99.1 weight-%, more preferably at least 99.2 weight-%, more preferably at least 99.3 weight-%, more preferably at least 99.4 weight-%, more preferably at least 99.5 weight-%, more preferably at least 99.6 weight-%, more preferably at least 99.7 weight-%, more preferably at least 99.8 weight-%, more preferably at least 99.9 weight-% of the mixture M_F consist of ϵ -
10 caprolactam and water.

- It is preferred that as far as the method of storing is concerned, $\Omega_{GC}(M_F)$ is at least 99.5 %, more preferably at least 99.6 %, more preferably at least 99.7 %, more preferably at least 99.8 %, more preferably at least 99.9 %. Further, it is preferred that $\Omega_{APHA}(M_F)$ is at most 15, more preferably at most 12.5, more preferably at most 10, more preferably at most 7.5, more preferably at most 5.
15 Still further, it is preferred that $x_{H_2O}(M_F)$ is in the range of from 0.1 to 10 weight-%, more preferably in the range of from 0.15 to 9 weight-%, more preferably in the range of from 0.2 to 8 weight-%, more preferably in the range of from 0.35 to 7 weight-%, more preferably in the range of from 0.5 to 6 weight-%. Suitable ranges of $x_{H_2O}(M_F)$ may include from 0.5 to 2 weight-% and from 2 to 4
20 weight-% and from 4 to 6 weight-%. Therefore, mixtures M_F are more preferred for which $\Omega_{GC}(M_F)$ is at least 99.9 %, $\Omega_{APHA}(M_F)$ is at most 5, and $x_{H_2O}(M_F)$ is in the range of from 0.5 to 6 weight-%.

- Optionally or preferably as far as the method of storing is concerned, the mixture M_F is further characterized by one or more of a permanganate absorption number $\Omega_{PAN}(M_F)$ and an UV
25 absorption $\Omega_{UV}(M_F)$. $\Omega_{PAN}(M_F)$ is preferably at most 20, more preferably at most 15, more preferably at most 10. $\Omega_{UV}(M_F)$ is preferably at most 0.75, more preferably at most 0.25, more preferably at most 0.1. Therefore, mixtures M_F are more preferred for which $\Omega_{PAN}(M_F)$ is at most 10 and $\Omega_{UV}(M_F)$ is at most 0.1. Thus, more preferred are mixtures M_F for which $\Omega_{GC}(M_F)$ is at least 99.9 %, $\Omega_{APHA}(M_F)$ is at most 5, $x_{H_2O}(M_F)$ is in the range of from 0.5 to 6 weight-%, $\Omega_{PAN}(M_F)$ is at
30 most 10 and $\Omega_{UV}(M_F)$ is at most 0.1.

Preferably, as far as the method of storing is concerned, the mixture M_F is obtainable or obtained by a process comprising the steps (i) to (iv) as described above,

- 35 Further regarding said method of storing, it is preferred that the mixture M_F is stored under exclusion of light. Further preferably regarding said method of storing, the storage time Δt_s is at least 7 d, more preferably at least 14 d, more preferably in the range of from 14 to 28 d. Still further regarding said method of storing, the inert gas atmosphere comprises one or more of nitrogen and argon. Further preferably regarding said method of storing, the mixture M_F is stored
40 at a storing temperature δ_s of the mixture M_F in the range of from 20 to 80 °C, preferably in the range of from 25 to 80 °C, more preferably in the range of from 35 to 77 °C, more preferably in the range of from 50 to 75 °C. Further preferably regarding said method of storing, the mixture M_F is stored according to (v) 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. Further preferably regarding said method of storing, it is preferred that the storing according to (v) comprises agitating, preferably mechanically agitating, more preferably stirring the mixture M_F for at least part of the storage time Δt_s , preferably for essentially the entire storage time Δt_s .

It was further found that it may be advantageous to carry out the method of storing at a storing temperature which is in a specific functional relationship to the water content of the mixture M_F . Specifically, it may be preferred that during storing,

$$(\delta_s / ^\circ\text{C}) = -2.6 \cdot (x_{\text{H}_2\text{O}}(M_F) / \text{weight-}\%) + C_s$$

wherein $C_s = 77 \pm 10$, preferably $C_s = 77 \pm 5$.

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

The present invention generally also relates to a liquid mixture M_F comprising ϵ -caprolactam and water and having a purity $\Omega_{GC}(M_F)$ of at least 99 %, an APHA value $\Omega_{APHA}(M_F)$ of at most 20 and a water content $x_{\text{H}_2\text{O}}(M_F)$ of at least 0.1 weight-%, based on the total weight of the mixture M_F , said mixture M_F preferably being obtainable or obtained by a process according to a process as described above comprising steps (i) to (iv), the mixture M_F exhibiting a storage stability $\Sigma_{\Delta t}$ after a storage time Δt , wherein $\Sigma_{\Delta t}$ is characterized by an APHA value $\Omega_{APHA}(\Delta t)$.

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

- if $\Omega_{APHA}(M_F)$ is less than 5, $\Omega_{APHA}(14) \leq 10$;
- if $\Omega_{APHA}(M_F)$ is in the range of from 5 to 8, $\Omega_{APHA}(14) \leq 2 \Omega_{APHA}(M_F)$;
- if $\Omega_{APHA}(M_F) > 8$, $\Omega_{APHA}(14) \leq 1.5 \Omega_{APHA}(M_F)$.

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

- if $\Omega_{APHA}(M_F)$ is less than 4, $\Omega_{APHA}(28) \leq 10$;
- if $\Omega_{APHA}(M_F)$ is in the range of from 4 to 8, $\Omega_{APHA}(28) \leq 3 \Omega_{APHA}(M_F)$;
- if $\Omega_{APHA}(M_F) > 8$, $\Omega_{APHA}(28) \leq 2 \Omega_{APHA}(M_F)$.

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 $\Omega_{PAN}(\Delta t)$ and an UV absorption $\Omega_{UV}(\Delta t)$.

If 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 $\Omega_{PAN}(14)$ and an UV absorption $\Omega_{UV}(14)$, it is preferred that

- if $\Omega_{PAN}(M_F)$ is less than 5, $\Omega_{PAN}(14) \leq 10$;

- if $\Omega_{\text{PAN}}(M_F)$ is in the range of from 5 to 8, $\Omega_{\text{PAN}}(14) \leq 1.5 \Omega_{\text{PAN}}(M_F)$;
 - if $\Omega_{\text{PAN}}(M_F) > 8$, $\Omega_{\text{PAN}}(14) \leq 1.25 \Omega_{\text{PAN}}(M_F)$;
- and
- if $\Omega_{\text{UV}}(M_F)$ is less than 0.02, $\Omega_{\text{UV}}(14) \leq 0.05$;
- 5 - if $\Omega_{\text{UV}}(M_F)$ is in the range of from 0.02 to 0.03, $\Omega_{\text{UV}}(14) \leq 3 \Omega_{\text{UV}}(M_F)$;
- if $\Omega_{\text{UV}}(M_F) > 0.03$, $\Omega_{\text{UV}}(14) \leq 1.25 \Omega_{\text{UV}}(M_F)$.

If 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

- 10 - if $\Omega_{\text{PAN}}(M_F)$ is less than 5, $\Omega_{\text{PAN}}(28) \leq 10$;
- if $\Omega_{\text{PAN}}(M_F)$ is in the range of from 5 to 8, $\Omega_{\text{PAN}}(28) \leq 3 \Omega_{\text{PAN}}(M_F)$;
 - if $\Omega_{\text{PAN}}(M_F) > 8$, $\Omega_{\text{PAN}}(28) \leq 2 \Omega_{\text{PAN}}(M_F)$;
- and
- if $\Omega_{\text{UV}}(M_F)$ is less than 0.025, $\Omega_{\text{UV}}(28) \leq 0.05$;
- 15 - if $\Omega_{\text{UV}}(M_F)$ is in the range of from 0.025 to 0.05, $\Omega_{\text{UV}}(28) \leq 3 \Omega_{\text{UV}}(M_F)$;
- if $\Omega_{\text{UV}}(M_F) > 0.05$, $\Omega_{\text{UV}}(28) \leq 2 \Omega_{\text{UV}}(M_F)$.

The present invention generally also relates to a stored liquid mixture M_s comprising ϵ -caprolactam and water, wherein the mixture M_s is obtainable or obtained by a process as described above comprising the step (v).

20

For said stored mixture M_s , it is preferred that it exhibits an APHA value $\Omega_{\text{APHA}}(14)$ after a storage time Δt of 14 d, wherein

- if $\Omega_{\text{APHA}}(M_F)$ is less than 4, $\Omega_{\text{APHA}}(14) \leq 10$;
- 25 - if $\Omega_{\text{APHA}}(M_F)$ is in the range of from 4 to 8, $\Omega_{\text{APHA}}(14) \leq 2 \Omega_{\text{APHA}}(M_F)$;
- if $\Omega_{\text{APHA}}(M_F) > 8$, $\Omega_{\text{APHA}}(14) \leq 1.5 \Omega_{\text{APHA}}(M_F)$.

For said stored mixture M_s , it is further preferred that it exhibits an APHA value $\Omega_{\text{APHA}}(28)$ after a storage time Δt of 28 d, wherein

- 30 - if $\Omega_{\text{APHA}}(M_F)$ is less than 4, $\Omega_{\text{APHA}}(28) \leq 10$;
- if $\Omega_{\text{APHA}}(M_F)$ is in the range of from 4 to 8, $\Omega_{\text{APHA}}(28) \leq 3 \Omega_{\text{APHA}}(M_F)$;
 - if $\Omega_{\text{APHA}}(M_F) > 8$, $\Omega_{\text{APHA}}(28) \leq 2 \Omega_{\text{APHA}}(M_F)$.

The said stored mixture M_s may be further characterized by one or more of a permanganate absorption number $\Omega_{\text{PAN}}(\Delta t)$ and an UV absorption $\Omega_{\text{UV}}(\Delta t)$.

35

If the storage time Δt is 14 d, it is preferred for the mixture M_s that

- if $\Omega_{\text{PAN}}(M_F)$ is less than 5, $\Omega_{\text{PAN}}(14) \leq 10$;
 - if $\Omega_{\text{PAN}}(M_F)$ is in the range of from 5 to 8, $\Omega_{\text{PAN}}(14) \leq 1.5 \Omega_{\text{PAN}}(M_F)$;
- 40 - if $\Omega_{\text{PAN}}(M_F) > 8$, $\Omega_{\text{PAN}}(14) \leq 1.25 \Omega_{\text{PAN}}(M_F)$;
- and
- if $\Omega_{\text{UV}}(M_F)$ is less than 0.01, $\Omega_{\text{UV}}(14) \leq 0.05$;
 - if $\Omega_{\text{UV}}(M_F)$ is in the range of from 0.01 to 0.03, $\Omega_{\text{UV}}(14) \leq 3 \Omega_{\text{UV}}(M_F)$;

- if $\Omega_{UV}(M_F) > 0.03$, $\Omega_{UV}(14) \leq 1.25 \Omega_{UV}(M_F)$.

If the storage time Δt is 28 d, it is preferred for the mixture M_s that

- if $\Omega_{PAN}(M_F)$ is less than 5, $\Omega_{PAN}(28) \leq 10$;
 - 5 - if $\Omega_{PAN}(M_F)$ is in the range of from 5 to 8, $\Omega_{PAN}(28) \leq 3 \Omega_{PAN}(M_F)$;
 - if $\Omega_{PAN}(M_F) > 8$, $\Omega_{PAN}(28) \leq 2 \Omega_{PAN}(M_F)$;
- and
- if $\Omega_{UV}(M_F)$ is less than 0.025, $\Omega_{UV}(28) \leq 0.05$;
 - if $\Omega_{UV}(M_F)$ is in the range of from 0.025 to 0.04, $\Omega_{UV}(28) \leq 1.5 \Omega_{UV}(M_F)$;
 - 10 - if $\Omega_{UV}(M_F) > 0.03$, $\Omega_{UV}(28) \leq 1.25 \Omega_{UV}(M_F)$.

The present invention further relates to the use of a mixture M_F as described hereinabove and/or a 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.

15

The present invention still further relates to a method for preparing polyamide 6, comprising

- (A) preparing a mixture M_F according to a process as described hereinabove comprising steps (i) to (iv), and/or providing a mixture M_F as described hereinabove;
- (B) optionally storing the mixture M_F at storage conditions as defined hereinabove in the
- 20 context of the process step (v), obtaining a stored mixture M_s ;
- (C) subjecting the mixture M_F prepared and/or provided according to (A) and/or the mixture M_s according to (B) to polyamide 6 polymerization conditions.

The present invention still further relates to polyamide 6 as such, obtainable or obtained by said method, wherein said polyamide has n APHA value of at most 10, preferably of at most 9, more

25 preferably of at most 8.

The present invention still further relates to a process as described above, which process comprises providing at least part of the mixture M_F , or of 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

30 feedstock to a textile material producing unit U_{TP} , from which unit U_{TP}

- (A) a textile material M_{TE} is obtained which is brought onto the market, wherein, after the lifetime T_{MTE} of said textile material M_{TE} , it is at least partially collected as textile waste material in a textile material collecting unit U_{TC} ;
- (B) remaining material M_{RE} is obtained as textile waste material;
- 35 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 as material M according to (i).

40 The present invention still further relates to a process as described above, which process comprises providing at least part of the mixture M_F , or of 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_{EP} is obtained which is brought onto the market, wherein, after the lifetime T_{MEP} of said engineering plastics material M_{EP} , it is at least partially collected as engineering plastics waste material in an engineering plastics material collecting unit U_{EC} ;

- 5 (B) remaining material M_{RE} 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 as material M according to (i).

10

The present invention still further relates to the use of the mixture M_F 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 mixture M_F 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 engineering plastics material, more preferably for preparing a textile material.

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The present invention still further relates to the use of the mixture M_F 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 mixture M_F 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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Further 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 from the mixture M_F 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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Further 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.

Further 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 mixture M_F 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 ϵ -caprolactam mixture M_F , the process comprising
 - (i) providing a stream S_M comprising a solid material M comprising polyamide 6;
 - (ii) preparing an aqueous depolymerization mixture based on S_M ;
 - (iii) subjecting the depolymerization mixture prepared according to (ii) 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; and optionally 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 ;
 - (iv) passing the stream S_R , optionally the stream S_L , into an ϵ -caprolactam purification unit U_P , and
 - (iv.1) obtaining from the unit U_P the mixture M_F ; or
 - (iv.2) obtaining from the unit U_P a mixture M_T having an ϵ -caprolactam purity $\Omega_{GC}(M_T)$ of at least 99 %, an APHA value $\Omega_{APHA}(M_T)$ of at most 20 and a water content $x_{H_2O}(M_T)$ of at most 0.05 weight-%, based on the total weight of the mixture M_T , and adding water to the mixture M_T , obtaining the mixture M_F ;

wherein the mixture M_F has an ϵ -caprolactam purity $\Omega_{GC}(M_F)$ of at least 99 %, an APHA value $\Omega_{APHA}(M_F)$ of at most 20 and a water content $x_{H_2O}(M_F)$ of at least 0.1 weight-%, based on the total weight of the mixture M_F .
2. The process of embodiment 1, wherein $\Omega_{GC}(M_F)$ is at least 99.5 %, more preferably at least 99.8 %, more preferably at least 99.9 %.
3. The process of embodiment 1 or 2, wherein $\Omega_{APHA}(M_F)$ is at most 15, preferably at most 10, more preferably at most 5.
4. The process of any one of embodiments 1 to 3, wherein the mixture M_F has a temperature in the range of from 20 to 80 °C, preferably in the range of from 35 to 77 °C, more preferably in the range of from 50 to 75 °C.

5. The process of any one of embodiments 1 to 4, wherein $x_{H_2O}(M_F)$ is in the range of from 0.1 to 10 weight-%, preferably in the range of from 0.2 to 8 weight-%, more preferably in the range of from 0.5 to 6 weight-%.
- 5 6. The process of any one of embodiments 1 to 5, wherein the mixture M_F is further characterized by one or more of a permanganate absorption number $\Omega_{PAN}(M_F)$ and an UV absorption $\Omega_{UV}(M_F)$, wherein $\Omega_{PAN}(M_F)$ is at most 20, preferably at most 15, more preferably at most 10, and wherein $\Omega_{UV}(M_F)$ is at most 0.75, preferably at most 0.25, more preferably at most 0.1.
- 10 7. The process of any one of embodiments 1 to 6, wherein the purification unit U_P according to (v) comprises a water separation unit U_{WS} and a distillation unit U_D , the process preferably comprising feeding the stream S_R , optionally 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 U_D , obtaining from U_D the mixture M_F comprising ϵ -caprolactam at a concentration c_{MF} , wherein $c_{SR} < c_{UWS} \ll c_{MF}$, preferably wherein $c_{SL} < c_{UWS} \ll c_{MF}$.
- 15 8. The process of embodiment 7, 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 , optionally 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 (iii), 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.
- 20 25 30 9. The process of embodiment 7 or 8, wherein the purification unit U_P further comprises, downstream of the unit U_D , one or more of a crystallization unit U_{CR} and a chemical treatment unit U_{OD} , the process comprising obtaining the mixture M_F from U_{CR} or from U_{OD} .
- 35 10. The process of embodiment 9, wherein the chemical treatment in the unit U_{OD} comprises
 - (a) providing a preferably liquid stream S_{UD} comprising ϵ -caprolactam from the distillation unit U_D or a preferably liquid stream S_{CR} comprising ϵ -caprolactam from the crystallization unit U_{CR} , said stream S_{UD} or said stream S_{CR} further comprising one or more oxidizable organic impurity compounds X , wherein the stream S_{UD} or the stream S_{CR} has an ϵ -caprolactam purity $\Omega_{GC}(S_C)$ of at least 99 % and exhibits a weight ratio r_{XC} of the one or more organic compounds X relative to ϵ -caprolactam;
 - 40 (b) providing a stream S_O comprising at least one permanganate;
 - (c) preparing an oxidation reaction educt mixture M_{OE} from the stream S_{UD} and the stream S_O , or from the stream S_{SCR} and the stream S_O , and subjecting the mixture

- 5 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 $0 \leq r_{XCP} < r_{XC}$ and further exhibits a weight ratio r_{YCP} of the one or more products Y relative to ϵ -caprolactam with $r_{YCP} > 0$;
- 10 (d) 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 mixture M_F or the mixture M_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 $0 \leq r_{XCT} < r_{XC}$.
- 15 11. The process of embodiment 10, wherein the at least one permanganate comprised in the stream S_O provided according to (b) 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.
- 20 12. The process of embodiment 10 or 11, wherein from 0.5 to 100 weight-% of the stream S_O provided according to (b) consist of permanganate.
- 25 13. The process of any one of embodiments 10 to 12, wherein the stream S_O provided according to (b) further comprises water.
- 30 14. The process of any one of embodiments 10 to 13, wherein the oxidation reaction educt mixture M_{OE} prepared according to (c) 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-%.
- 35 15. The process of any one of embodiments 10 to 14, wherein the oxidation reaction conditions according to (c) 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.
- 40 16. The process of any one of embodiments 10 to 15, wherein the mixture M_{OE} prepared according to (c) further comprises water.
17. The process of any one of embodiments 10 to 16, wherein subjecting the mixture M_{OE} to oxidation reaction conditions is carried out in an oxidation reaction unit U_{OR} comprised in the chemical treatment unit U_{OD} , wherein the unit U_{OR} preferably comprises one or more of at least one continuous stirred tank reactor and at least one tube reactor.

18. The process of any one of embodiments 10 to 17, further comprising providing a stream S_B comprising at least one hydroxide, wherein the oxidation reaction educt mixture M_{OE} according to (c) is prepared from the stream S_{UD} or the stream S_{CR} , and from the stream S_O and the stream S_B .
19. The process of embodiment 18, 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.
20. The process of embodiment 18 or 19, wherein from 0.5 to 100 weight-% of the stream S_B consist of hydroxide.
21. The process of any one of embodiments 18 to 20, wherein the stream S_B further comprises water.
22. The process of any one of embodiment 18 to 21, wherein the oxidation reaction educt mixture M_{OE} prepared according to (c) 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-%.
23. The process of any one of embodiments 10 to 22, 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 $^\circ\text{C}$.
24. The process of any one of embodiments 10 to 23, 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 (d) comprises subjecting the stream S_P obtained according to (c) to distillation in a distillation unit U_{DT} , comprised in the chemical treatment unit U_{OB} , obtaining from the distillation unit U_{DT} a stream S_{DT} comprising ϵ -caprolactam as the mixture M_F or the mixture M_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.
25. The process of any one of embodiments 10 to 24, wherein prior to being subjected to separating according to (d), the stream S_P obtained from (c) is subjected to filtration.
26. The process of any one of embodiments 9 to 25, wherein the purification unit U_P further comprises a crystallization unit U_{CR} , the process comprising obtaining from the distillation unit U_D a stream S_{UD} comprising ϵ -caprolactam at a concentration c_{UD} , and feeding the stream S_{UD} to the crystallization unit U_{CR} , obtaining from U_{CR} the mixture M_F comprising

ϵ -caprolactam at the concentration c_{MF} .

27. The process of any one of embodiments 9 to 25, wherein the purification unit U_P further comprises a chemical treatment unit U_{OD} , the process comprising obtaining from the distillation unit U_D a stream S_{UD} comprising ϵ -caprolactam at a concentration c_{UD} and feeding the stream S_{UD} to the chemical treatment unit U_{OD} , obtaining from U_{OD} the mixture M_F comprising ϵ -caprolactam at the concentration c_{MF} .
28. The process of any one of embodiments 9 to 25, wherein the purification unit U_P further comprises a chemical treatment unit U_{OD} and a crystallization unit U_{CR} , wherein the crystallization unit U_{CR} is located downstream of the distillation unit U_D and the chemical treatment unit U_{OD} is located downstream of the crystallization unit U_{CR} , the process comprising obtaining from the distillation unit U_D a stream S_{UD} comprising ϵ -caprolactam at a concentration c_{UD} , feeding the stream S_{UD} to the crystallization unit U_{CR} , obtaining from the crystallization U_{CR} a stream S_{CR} comprising ϵ -caprolactam at a concentration c_{CR} , and feeding the stream S_{CR} to the chemical treatment unit U_{OD} , obtaining from U_{OD} the mixture M_F comprising ϵ -caprolactam at the concentration c_{MF} .
29. The process of any one embodiment 9 to 25, wherein the purification unit U_P further comprises a chemical treatment unit U_{OD} and a crystallization unit U_{CR} , wherein the chemical treatment unit U_{OD} is located downstream of the distillation unit U_D and the crystallization unit U_{CR} is located downstream of the unit U_{CR} , the process comprising obtaining from the distillation unit U_D a stream S_{UD} comprising ϵ -caprolactam at a concentration c_{UD} , feeding the stream S_{UD} to the chemical treatment unit U_{OD} , obtaining from the chemical treatment unit U_{OD} a stream S_{OD} comprising ϵ -caprolactam at a concentration c_{OD} , and feeding the stream S_{OD} to the crystallization unit U_{CR} , obtaining from U_{CR} the mixture M_F comprising ϵ -caprolactam at the concentration c_{MF} .
30. The process of any one of embodiments 1 to 29, wherein $x_{H_2O}(M_T)$ is in the range of from 0 to 0.05 weight-%, preferably in the range of from 0 to 0.01 weight-%, more preferably in the range of from 0 to 0.001 weight-%.
31. The process of any one of embodiments 1 or 30, wherein $\Omega_{GC}(M_T)$ is at least 99.5 %, preferably at least 99.8 %, more preferably at least 99.9 %.
32. The process of any one of embodiments 1 to 31, wherein $\Omega_{APHA}(M_T)$ is at most 20, preferably at most 15, more preferably at most 10.
33. The process of any one of embodiments 1 to 32, wherein the mixture M_T is further characterized by one or more of a permanganate absorption number $\Omega_{PAN}(M_T)$ and an UV absorption $\Omega_{UV}(M_T)$, wherein $\Omega_{PAN}(M_T)$ is at most 20, preferably at most 15, more preferably at most 10, and wherein $\Omega_{UV}(M_T)$ is at most 0.75, preferably at most 0.25, more preferably at most 0.1.

34. The process of any one of embodiments 1 to 33, wherein the material M according to (i) 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 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 elastane, 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.
35. The process of any one of embodiments 1 to 34, further comprising
(v) storing the mixture M_F obtained according to (iv) at a temperature of the mixture of at most 80 °C under an inert gas atmosphere for a storage time Δt_z , obtaining a stored mixture M_s , wherein the storage time Δt_z is at least 1 d.
36. The process of any one of embodiments 1 to 35, wherein according to (v), the mixture M_F is stored under exclusion of light.
37. The process of any one of embodiments 1 to 36, wherein according to (v), the storage time Δt_z is at least 7 d, more preferably at least 14 d, more preferably in the range of from 14 to 28 d.
38. The process of any one of embodiments 1 to 37, wherein according to (v), the inert gas atmosphere comprises one or more of nitrogen and argon, preferably argon.
39. The process of any one of embodiments 1 to 38, wherein according to (v), the mixture M_F is stored at a storing temperature δ_s of the mixture M_F in the range of from 20 to 80 °C, preferably in the range of from 25 to 80 °C, more preferably in the range of from 35 to 77 °C, more preferably in the range of from 50 to 75 °C, 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.
40. The process of embodiment 39, wherein during storing according to (v),
- $$(\delta_s / ^\circ\text{C}) = -2.6 \cdot (x_{\text{H}_2\text{O}}(M_F) / \text{weight-\%}) + C_s$$
- wherein $C_s = 77 \pm 10$, preferably $C_s = 77 \pm 5$.

41. A method of storing a mixture M_F comprising ϵ -caprolactam and water and having a purity $\Omega_{GC}(M_F)$ of at least 99 %, an APHA value $\Omega_{APHA}(M_F)$ of at most 20 and a water content $x_{H_2O}(M_F)$ of at least 0.1 weight-%, based on the total weight of the mixture M_F , said mixture M_F being obtainable or obtained by a process according to any one of embodiments 1 to 34, said method comprising storing the mixture M_F at a temperature of the mixture of at most 80 °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.
42. The method of embodiment 41, wherein the mixture M_F is stored under exclusion of light.
43. The method of embodiment 41 or 42, wherein the storage time Δt_s is at least 7 d, more preferably at least 14 d, more preferably in the range of from 14 to 28 d.
44. The method of any one of embodiments 41 to 43, wherein the inert gas atmosphere comprises one or more of nitrogen and argon.
45. The method of any one of embodiments 41 to 44, wherein the mixture M_F is stored at a storing temperature δ_s of the mixture M_F in the range of from 20 to 80 °C, preferably in the range of from 25 to 80 °C, more preferably in the range of from 35 to 77 °C, more preferably in the range of from 50 to 75 °C 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.
46. The method of embodiment 45, wherein during storing,
- $$(\delta_s / ^\circ\text{C}) = -2.6 \cdot (x_{H_2O}(M_F) / \text{weight-\%}) + C_s$$
- wherein $C_s = 77 \pm 10$, preferably $C_s = 77 \pm 5$.
47. A liquid mixture M_F comprising ϵ -caprolactam and water and having a purity $\Omega_{GC}(M_F)$ of at least 99 %, an APHA value $\Omega_{APHA}(M_F)$ of at most 20 and a water content $x_{H_2O}(M_F)$ of at least 0.1 weight-%, based on the total weight of the mixture M_F , said mixture M_F preferably being obtainable or obtained by a process according to any one of embodiments 1 to 34, the mixture M_F exhibiting a storage stability $\Sigma_{\Delta t}$ after a storage time Δt , wherein $\Sigma_{\Delta t}$ is characterized by an APHA value $\Omega_{APHA}(\Delta t)$.
48. The mixture of embodiment 47, wherein Δt is 14 d and the storage stability Σ_{14} after said storage time is characterized by an APHA value $\Omega_{APHA}(14)$, wherein
- if $\Omega_{APHA}(M_F)$ is less than 5, $\Omega_{APHA}(14) \leq 10$;
 - if $\Omega_{APHA}(M_F)$ is in the range of from 5 to 8, $\Omega_{APHA}(14) \leq 2 \Omega_{APHA}(M_F)$;
 - if $\Omega_{APHA}(M_F) > 8$, $\Omega_{APHA}(14) \leq 1.5 \Omega_{APHA}(M_F)$.
49. The mixture of embodiment 47 or 48, wherein Δt is 28 d and the storage stability Σ_{28} after said storage time is characterized by an an APHA value $\Omega_{APHA}(28)$, wherein

- if $\Omega_{\text{APHA}}(\text{M}_\text{F})$ is less than 4, $\Omega_{\text{APHA}}(28) \leq 10$;
 - if $\Omega_{\text{APHA}}(\text{M}_\text{F})$ is in the range of from 4 to 8, $\Omega_{\text{APHA}}(28) \leq 3 \Omega_{\text{APHA}}(\text{M}_\text{F})$;
 - if $\Omega_{\text{APHA}}(\text{M}_\text{F}) > 8$, $\Omega_{\text{APHA}}(28) \leq 2 \Omega_{\text{APHA}}(\text{M}_\text{F})$.
- 5 50. The mixture of any one of embodiments 47 to 49, wherein the storage stability $\Sigma_{\Delta t}$ after a storage time Δt is further characterized by one or more of a permanganate absorption number $\Omega_{\text{PAN}}(\Delta t)$ and an UV absorption $\Omega_{\text{UV}}(\Delta t)$.
- 10 51. The mixture of embodiment 50, 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 $\Omega_{\text{PAN}}(14)$, wherein
- if $\Omega_{\text{PAN}}(\text{M}_\text{F})$ is less than 5, $\Omega_{\text{PAN}}(14) \leq 10$;
 - if $\Omega_{\text{PAN}}(\text{M}_\text{F})$ is in the range of from 5 to 8, $\Omega_{\text{PAN}}(14) \leq 1.5 \Omega_{\text{PAN}}(\text{M}_\text{F})$;
 - if $\Omega_{\text{PAN}}(\text{M}_\text{F}) > 8$, $\Omega_{\text{PAN}}(14) \leq 1.25 \Omega_{\text{PAN}}(\text{M}_\text{F})$;
- 15 and an UV absorption $\Omega_{\text{UV}}(14)$, wherein
- if $\Omega_{\text{UV}}(\text{M}_\text{F})$ is less than 0.02, $\Omega_{\text{UV}}(14) \leq 0.05$;
 - if $\Omega_{\text{UV}}(\text{M}_\text{F})$ is in the range of from 0.02 to 0.03, $\Omega_{\text{UV}}(14) \leq 3 \Omega_{\text{UV}}(\text{M}_\text{F})$;
 - if $\Omega_{\text{UV}}(\text{M}_\text{F}) > 0.03$, $\Omega_{\text{UV}}(14) \leq 1.25 \Omega_{\text{UV}}(\text{M}_\text{F})$.
- 20 52. The mixture of embodiment 50 or 51, 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 $\Omega_{\text{PAN}}(28)$, wherein
- if $\Omega_{\text{PAN}}(\text{M}_\text{F})$ is less than 5, $\Omega_{\text{PAN}}(28) \leq 10$;
 - if $\Omega_{\text{PAN}}(\text{M}_\text{F})$ is in the range of from 5 to 8, $\Omega_{\text{PAN}}(28) \leq 3 \Omega_{\text{PAN}}(\text{M}_\text{F})$;
- 25 - if $\Omega_{\text{PAN}}(\text{M}_\text{F}) > 8$, $\Omega_{\text{PAN}}(28) \leq 2 \Omega_{\text{PAN}}(\text{M}_\text{F})$;
- and an UV absorption $\Omega_{\text{UV}}(28)$, wherein
- if $\Omega_{\text{UV}}(\text{M}_\text{F})$ is less than 0.025, $\Omega_{\text{UV}}(28) \leq 0.05$;
 - if $\Omega_{\text{UV}}(\text{M}_\text{F})$ is in the range of from 0.025 to 0.05, $\Omega_{\text{UV}}(28) \leq 3 \Omega_{\text{UV}}(\text{M}_\text{F})$;
 - if $\Omega_{\text{UV}}(\text{M}_\text{F}) > 0.05$, $\Omega_{\text{UV}}(28) \leq 2 \Omega_{\text{UV}}(\text{M}_\text{F})$.
- 30 53. A liquid mixture M_S comprising ϵ -caprolactam and water, obtainable or obtained by a process according to any one of embodiments 35 to 40.
- 35 54. The mixture of embodiment 53, having an APHA value $\Omega_{\text{APHA}}(14)$ after a storage time Δt of 14 d, wherein
- if $\Omega_{\text{APHA}}(\text{M}_\text{F})$ is less than 4, $\Omega_{\text{APHA}}(14) \leq 10$;
 - if $\Omega_{\text{APHA}}(\text{M}_\text{F})$ is in the range of from 4 to 8, $\Omega_{\text{APHA}}(14) \leq 2 \Omega_{\text{APHA}}(\text{M}_\text{F})$;
 - if $\Omega_{\text{APHA}}(\text{M}_\text{F}) > 8$, $\Omega_{\text{APHA}}(14) \leq 1.5 \Omega_{\text{APHA}}(\text{M}_\text{F})$.
- 40 55. The mixture of embodiment 53 or 54, having an APHA value $\Omega_{\text{APHA}}(28)$ after a storage time Δt of 28 d, wherein
- if $\Omega_{\text{APHA}}(\text{M}_\text{F})$ is less than 4, $\Omega_{\text{APHA}}(28) \leq 10$;
 - if $\Omega_{\text{APHA}}(\text{M}_\text{F})$ is in the range of from 4 to 8, $\Omega_{\text{APHA}}(28) \leq 3 \Omega_{\text{APHA}}(\text{M}_\text{F})$;

- if $\Omega_{\text{APHA}}(\text{M}_\text{F}) > 8$, $\Omega_{\text{APHA}}(28) \leq 2 \Omega_{\text{APHA}}(\text{M}_\text{F})$.
56. The mixture of any one of embodiments 53 to 55, having one or more of a permanganate absorption number $\Omega_{\text{PAN}}(14)$ and an UV/Vis absorption $\Omega_{\text{UV}}(14)$ after a storage time Δt ,
 5 wherein
 - if $\Omega_{\text{PAN}}(\text{M}_\text{F})$ is less than 5, $\Omega_{\text{PAN}}(14) \leq 10$;
 - if $\Omega_{\text{PAN}}(\text{M}_\text{F})$ is in the range of from 5 to 8, $\Omega_{\text{PAN}}(14) \leq 1.5 \Omega_{\text{PAN}}(\text{M}_\text{F})$;
 - if $\Omega_{\text{PAN}}(\text{M}_\text{F}) > 8$, $\Omega_{\text{PAN}}(14) \leq 1.25 \Omega_{\text{PAN}}(\text{M}_\text{F})$;
 and wherein
 10 - if $\Omega_{\text{UV}}(\text{M}_\text{F})$ is less than 0.01, $\Omega_{\text{UV}}(14) \leq 0.05$;
 - if $\Omega_{\text{UV}}(\text{M}_\text{F})$ is in the range of from 0.01 to 0.03, $\Omega_{\text{UV}}(14) \leq 3 \Omega_{\text{UV}}(\text{M}_\text{F})$;
 - if $\Omega_{\text{UV}}(\text{M}_\text{F}) > 0.03$, $\Omega_{\text{UV}}(14) \leq 1.25 \Omega_{\text{UV}}(\text{M}_\text{F})$.
57. The mixture of any one of embodiments 53 to 56, having one or more of a permanganate
 15 absorption number $\Omega_{\text{PAN}}(28)$ and an UV/Vis absorption $\Omega_{\text{UV}}(28)$ after a storage time Δt ,
 wherein
 - if $\Omega_{\text{PAN}}(\text{M}_\text{F})$ is less than 5, $\Omega_{\text{PAN}}(28) \leq 10$;
 - if $\Omega_{\text{PAN}}(\text{M}_\text{F})$ is in the range of from 5 to 8, $\Omega_{\text{PAN}}(28) \leq 3 \Omega_{\text{PAN}}(\text{M}_\text{F})$;
 - if $\Omega_{\text{PAN}}(\text{M}_\text{F}) > 8$, $\Omega_{\text{PAN}}(28) \leq 2 \Omega_{\text{PAN}}(\text{M}_\text{F})$;
 20 and wherein
 - if $\Omega_{\text{UV}}(\text{M}_\text{F})$ is less than 0.025, $\Omega_{\text{UV}}(28) \leq 0.05$;
 - if $\Omega_{\text{UV}}(\text{M}_\text{F})$ is in the range of from 0.025 to 0.04, $\Omega_{\text{UV}}(28) \leq 1.5 \Omega_{\text{UV}}(\text{M}_\text{F})$;
 - if $\Omega_{\text{UV}}(\text{M}_\text{F}) > 0.04$, $\Omega_{\text{UV}}(28) \leq 1.25 \Omega_{\text{UV}}(\text{M}_\text{F})$.
- 25 58. Use of the mixture M_F according to any one of embodiments 47 to 52 or the mixture M_S
 according to any one of embodiments 53 to 57 as an educt material for a chemical process,
 preferably for a polymerization reaction, more preferably for preparing polyamide 6.
59. A method for preparing polyamide 6, comprising
 30 (A) preparing a mixture M_F according to a process according to any one of embodiments
 1 to 34, and/or providing a mixture M_F according to any one of embodiments 47 to 52;
 (B) optionally storing the mixture M_F at storage conditions as defined in any one of
 embodiments 35 to 40, obtaining a stored mixture M_S ;
 (C) subjecting the mixture M_F prepared and/or provided according to (A) and/or the
 35 mixture M_S according to (B) to polyamide 6 polymerization conditions.
60. Polyamide 6, obtainable or obtained by a method according to embodiment 59, having an
 APHA value of at most 10, preferably of at most 9, more preferably of at most 8.
- 40 61. The process of any one of embodiments 1 to 34, or 35 to 40, further comprising providing at
 least part of the mixture M_F , or of 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_{TE} is obtained which is brought onto the market, wherein, after the lifetime T_{MTE} of said textile material M_{TE} , it is at least partially collected as textile waste material in a textile material collecting unit U_{TC} ;
- (B) remaining material M_{RE} is obtained as textile waste material;
- 5 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 as material M according to (i).
- 10 62. The process of any one of embodiments 1 to 34, or 35 to 40, further comprising providing at least part of the mixture M_F , or of 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}
- 15 (A) an engineering plastics material M_{EP} is obtained which is brought onto the market, wherein, after the lifetime T_{MEP} of said engineering plastics material M_{EP} , it is at least partially collected as engineering plastics waste material in an engineering plastics material collecting unit U_{EC} ;
- (B) remaining material M_{RE} is obtained as engineering plastics waste material;
- 20 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 as material M according to (i).
- 25 63. Use of the mixture M_F according to any one of embodiments 47 to 52 or of the mixture M_S according to any one of embodiments 53 to 57 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.
- 30 64. A method for preparing polyamide 6, said method comprising employing the mixture M_F according to any one of embodiments 47 to 52 or the mixture M_S according to any one of embodiments 53 to 57 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
- 35 material.
- 40 65. Use of the mixture M_F according to any one of embodiments 47 to 52 or of the mixture M_S according to any one of embodiments 53 to 57 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 mixture M_F according to any one of embodiments 47 to 52 or the mixture M_S according to any one of embodiments 53 to 57 as a starting material.

66. The use or the method of embodiment 65, 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.
- 5
67. The use or the method of embodiment 65 or 66, 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 the mixture M_F according to any one of embodiments 47 to 52 or from the mixture M_S according to any one of embodiments 53 to 57, 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.
- 10
- 15
68. The use or the method of any one of embodiments 65 to 67, 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:
- 20
- 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;

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 - 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;

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 - 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

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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.

69. The use or the method of any one of embodiments 65 to 68, wherein the polymer, or the polymer product, or the polymer and the polymer product contains or contain polyamide 6, obtainable or obtained from the mixture M_F according to any one of embodiments 47 to 52 or from the mixture M_S according to any one of embodiments 53 to 57 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 69 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 65 to 69 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 techniques 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 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“.

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.

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 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 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 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 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.

Reference Example 1

1.1 Determination of the APHA color of ϵ -caprolactam

The APHA color was determined in accordance with ISO 8112. In principle, 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 density 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. A specific amount of ϵ -caprolactam, usually in the range of from 5 to 50 g, is dissolved in a 250 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

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

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

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

Reference Example 2

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 with a Teflon-coated magnetic stir bar at 250-500 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.

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:

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

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

The following specifications were observed after 28 days:

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

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 $\Omega_{\text{APHA}}(28)$ and $\Omega_{\text{PAN}}(28)$, 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

Depolymerized and purified ϵ -caprolactam (15.0 g) with the following specifications:

$\Omega_{\text{UV}}(M_T) = 0.03$; $\Omega_{\text{APHA}}(M_T) = 2$; $\Omega_{\text{PAN}}(M_T) = 7$; $\Omega_{\text{GC}}(M_T) = 99.9 \%$;

10 was stored under inert atmosphere and light exclusion for 14 and 28 days at 85 °C.

The following specifications were observed after 14 days:

$\Omega_{\text{UV}}(14) = 0.28$; $\Omega_{\text{APHA}}(14) = 5$; $\Omega_{\text{PAN}}(14) = 13$.

15 The following specifications were observed after 28 days:

$\Omega_{\text{UV}}(28) = 0.87$; $\Omega_{\text{APHA}}(28) = 23$; $\Omega_{\text{PAN}}(28) = 23$.

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 in the context of the present invention, leading to an ϵ -caprolactam mixture M_T . For this mixture M_T of recovered ϵ -caprolactam which exhibited the same characteristics Ω_{UV} , Ω_{APHA} , Ω_{PAN} , and Ω_{GC} as the ϵ -caprolactam according to Reference Example 3, it was found that the storage conditions of Reference Example 2 led to an insufficient stability, as can be seen, for example, from the huge relative increase of the Ω_{APHA} value with

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25 $\Omega_{\text{APHA}}(28) = 12.5 \Omega_{\text{APHA}}(M_T)$, or of the Ω_{UV} value with $\Omega_{\text{UV}}(28) = 29 \Omega_{\text{UV}}(M_T)$.

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

The ϵ -caprolactam according to Comparative Example 2 was not obtained from conventional synthesis but recovered via hydrolytic depolymerisation and subsequent purification as described in the context of the present invention, leading to an ϵ -caprolactam mixture M_T . This depolymerized and purified ϵ -caprolactam (15.0 g) had the following specifications:

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

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

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The following specifications were observed after 28 days:

$\Omega_{\text{UV}}(28) = 1.68$; $\Omega_{\text{APHA}}(28) = 54$; $\Omega_{\text{PAN}}(28) = 33$.

As for the material of Comparative Example 1, an insufficient storage stability was observed, for example in view of the relative increase in the Ω_{APHA} value with $\Omega_{\text{APHA}}(28) = 5.4 \Omega_{\text{APHA}}(M_T)$.

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Example 1: Storing stability of recovered ϵ -caprolactam

The same material as in Comparative Example 2 was used, where based on the recovered ϵ -caprolactam as obtained from hydrolytic depolymerisation and subsequent purification, an aqueous mixture M_F was prepared which was then stored at the storage conditions according to the present invention. In particular, the depolymerized and purified ϵ -caprolactam (15.0 g) employed had the following specifications:
 $\Omega_{UV}(M_F) = 0.73$; $\Omega_{APHA}(M_F) = 10$; $\Omega_{PAN}(M_F) = 21$; $\Omega_{GC}(M_F) = 99.9 \%$.
 This material was stored under inert argon atmosphere and light exclusion for 28 days at 70°C as a mixture comprising 2.0 weight -% of demineralized water.

The following specifications were observed after 28 days:
 $\Omega_{UV}(28) = 0.73$; $\Omega_{APHA}(28) = 19$; $\Omega_{PAN}(28) = 20$.

Compared to the respective specifications of Comparative Example 2, all values $\Omega_{UV}(28)$, $\Omega_{APHA}(28)$ and $\Omega_{PAN}(28)$ showed a significantly lower increase, if at all. In particular, it was found that $\Omega_{APHA}(28) = 1.9 \Omega_{APHA}(M_F)$; $\Omega_{UV}(28) = 1.0 \Omega_{UV}(M_F)$; $\Omega_{PAN}(28) = 0.95 \Omega_{PAN}(M_F)$.

Example 2 Storing stability of recovered ϵ -caprolactam

The ϵ -caprolactam which was employed was recovered via hydrolytic depolymerisation and subsequent purification as described in the context of the present invention, leading to an ϵ -caprolactam mixture M_F . The depolymerized and purified ϵ -caprolactam (15.0 g) had the following specifications:
 $\Omega_{APHA}(M_F) = 5$; $\Omega_{GC}(M_F) = 99.9 \%$.
 and was stored under inert atmosphere and light exclusion 28 days at 70°C as a mixture comprising 2.0 weight -% of demineralized water.

The following specification was observed after 28 days:
 $\Omega_{APHA}(28) = 11$.

It was found that, as can be seen from $\Omega_{APHA}(28) = 2.2 \Omega_{APHA}(M_F)$, the aqueous mixture of the present invention led to an advantageous storage stability of the recovered ϵ -caprolactam.

Example 3: Storing stability of recovered ϵ -caprolactam

The ϵ -caprolactam which was employed was recovered via hydrolytic depolymerisation and subsequent purification as described in the context of the present invention, leading to an ϵ -caprolactam mixture M_F . The depolymerized and purified ϵ -caprolactam (15.0 g) had the following specifications:
 $\Omega_{UV}(M_F) = 0.03$; $\Omega_{APHA}(M_F) = 1$; $\Omega_{PAN}(M_F) = 4$; $\Omega_{GC}(M_F) = 99.9 \%$;
 and was stored under inert atmosphere and light exclusion for 14 and 28 days at 70°C with 2.0 weight-% of demineralized water.

The following specifications were observed after 14 days:

$\Omega_{UV}(14) = 0.03$; $\Omega_{APHA}(14) = 1$; $\Omega_{PAN}(14) = 4$.

The following specifications were observed after 28 days:

$\Omega_{UV}(28) = 0.04$; $\Omega_{APHA}(28) = 3$; $\Omega_{PAN}(28) = 5$.

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It was found that, as can be seen from all values, the aqueous mixture of the present invention led to a very advantageous storage stability of the recovered ϵ -caprolactam.

Example 4: Storing stability of recovered ϵ -caprolactam

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The ϵ -caprolactam which was employed was the ϵ -caprolactam of Example 3, i.e. the material with the following specifications:

$\Omega_{UV}(M_F) = 0.03$; $\Omega_{APHA}(M_F) = 1$; $\Omega_{PAN}(M_F) = 4$; $\Omega_{GC}(M_F) = 99.9\%$.

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Compared to Example 3, the material which was subjected to storing for 28 d was a different aqueous mixture, namely a mixture comprising 5.0 weight-% of demineralized water. The storing was carried out at 60 °C at otherwise identical conditions as in Example 3.

The following specifications were observed after 28 days:

$\Omega_{UV}(28) = 0.04$; $\Omega_{APHA}(28) = 1$; $\Omega_{PAN}(28) = 3$.

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It was found that, as can be seen from all values, the aqueous mixture of the present invention led to a very advantageous storage stability of the recovered ϵ -caprolactam.

Claims

1. A process for preparing a liquid ϵ -caprolactam mixture M_F , the process comprising
 - (i) providing a stream S_M comprising a solid material M comprising polyamide 6;
 - 5 (ii) preparing an aqueous depolymerization mixture based on S_M ;
 - (iii) subjecting the depolymerization mixture prepared according to (ii) 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; and optionally 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 ;
 - 10 (iv) passing the stream S_R , optionally the stream S_L , into an ϵ -caprolactam purification unit U_P , and
 - 15 (iv.1) obtaining from the unit U_P the mixture M_F ; or
 - (iv.2) obtaining from the unit U_P a mixture M_T having an ϵ -caprolactam purity $\Omega_{GC}(M_T)$ of at least 99 %, an APHA value $\Omega_{APHA}(M_T)$ of at most 20 and a water content $x_{H_2O}(M_T)$ of at most 0.05 weight-%, based on the total weight of the mixture M_T , and adding water to the mixture M_T , obtaining the mixture M_F ;
 - 20 wherein the mixture M_F has an ϵ -caprolactam purity $\Omega_{GC}(M_F)$ of at least 99 %, an APHA value $\Omega_{APHA}(M_F)$ of at most 20 and a water content $x_{H_2O}(M_F)$ of at least 0.1 weight-%, based on the total weight of the mixture M_F .
- 25 2. The process of claim 1, wherein $\Omega_{GC}(M_F)$ is at least 99.5 %, more preferably at least 99.8 %, more preferably at least 99.9 % and $\Omega_{APHA}(M_F)$ is at most 15, preferably at most 10, more preferably at most 5.
- 30 3. The process of claim 1 or 2, wherein the mixture M_F has a temperature in the range of from 20 to 80 °C, preferably in the range of from 35 to 77 °C, more preferably in the range of from 50 to 75 °C.
- 35 4. The process of any one of claims 1 to 3, wherein $x_{H_2O}(M_F)$ is in the range of from 0.1 to 10 weight-%, preferably in the range of from 0.2 to 8 weight-%, more preferably in the range of from 0.5 to 6 weight-%.
- 40 5. The process of any one of claims 1 to 4, wherein the purification unit U_P according to (v) comprises a water separation unit U_{WS} and a distillation unit U_D , the process preferably comprising feeding the stream S_R , optionally 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 U_D , obtaining from U_D the mixture M_F comprising ϵ -caprolactam at a concentration c_{MF} , wherein $c_{SR} < c_{UWS} \ll c_{MF}$, preferably wherein $c_{SL} < c_{UWS} \ll c_{MF}$; 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 , optionally 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 preferably 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 (iii), 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;
- wherein the purification unit U_P preferably further comprises, downstream of the unit U_D , one or more of a crystallization unit U_{CR} and a chemical treatment unit U_{OD} , the process comprising obtaining the mixture M_F from U_{CR} or from U_{OD} .
6. The process of claim 5, wherein the chemical treatment in the unit U_{OD} comprises
- (a) providing a preferably liquid stream S_{UD} comprising ϵ -caprolactam from the distillation unit U_D or a preferably liquid stream S_{CR} comprising ϵ -caprolactam from the crystallization unit U_{CR} , said stream S_{UD} or said stream S_{CR} further comprising one or more oxidizable organic impurity compounds X , wherein the stream S_{UD} or the stream S_{CR} has an ϵ -caprolactam purity $\Omega_{GC}(S_C)$ of at least 99 % and exhibits a weight ratio r_{XC} of the one or more organic compounds X relative to ϵ -caprolactam;
 - (b) providing a stream S_O comprising at least one permanganate;
 - (c) preparing an oxidation reaction educt mixture M_{OE} from the stream S_{UD} and the stream S_O , or from the stream S_{SCR} 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 $0 \leq r_{XCP} < r_{XC}$ and further exhibits a weight ratio r_{YCP} of the one or more products Y relative to ϵ -caprolactam with $r_{YCP} > 0$;
 - (d) 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 mixture M_F or the mixture M_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 $0 \leq r_{XCT} < r_{XC}$;
7. The process of claim 6, wherein the at least one permanganate comprised in the stream S_O provided according to (b) 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, wherein preferably from 0.5 to 100 weight-% of the stream S_O provided according to (b) consist of permanganate and wherein the stream S_O provided according to (b) preferably further comprises water;

- wherein the oxidation reaction educt mixture M_{OE} prepared according to (c) exhibits a permanganate concentration, calculated as MnO_4 , preferably 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-%;
- 5 wherein the oxidation reaction conditions according to (c) comprise a temperature T_{OE} of the mixture M_{OE} preferably 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;
- wherein the mixture M_{OE} prepared according to (c) preferably further comprises water;
- 10 wherein subjecting the mixture M_{OE} to oxidation reaction conditions is carried out in an oxidation reaction unit U_{OR} comprised in the chemical treatment unit U_{OD} , wherein the unit U_{OR} preferably comprises one or more of at least one continuous stirred tank reactor and at least one tube reactor.
8. The process of claim 6 or 7, further comprising providing a stream S_B comprising at least one hydroxide, wherein the oxidation reaction educt mixture M_{OE} according to (c) is prepared from the stream S_{UD} or the stream S_{CR} , and from the stream S_O and the stream S_B , wherein the at least one hydroxide comprised in the stream S_B preferably comprises, more 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, wherein the stream S_B preferably further comprises water, wherein the oxidation reaction educt mixture M_{OE} prepared according to (c) exhibits a hydroxide concentration, calculated as OH, preferably 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-%.
- 25 9. The process of any one of claims 6 to 8, wherein the one or more oxidizable organic compounds X have a boiling point $\delta_X/^\circ C$ with $0.5 \leq (\delta_X / \delta_C) \leq 1.5$, $\delta_C/^\circ C$ being the boiling point of ϵ -caprolactam and wherein at least one of the one or more oxidation products Y has a boiling point $\delta_Y/^\circ C$ with $\delta_Y/^\circ C \neq \delta_C/^\circ C$, wherein the difference $\Delta\delta$ between the boiling points δ_Y and δ_C is preferably at least 1 °C, 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 (d) preferably comprises subjecting the stream S_P obtained according to (c) to distillation in a distillation unit U_{DT} , comprised in the chemical treatment unit U_{OD} , obtaining from the distillation unit U_{DT} a stream S_{DT} comprising ϵ -caprolactam as the mixture M_F or the mixture M_T , wherein the unit U_{DT} preferably comprises one or more distillation columns, more preferably one or two distillation columns, wherein at least one column is optionally configured as side stream column or as divided wall column.
- 35 10. The process of any one of claims 5 to 9, wherein the purification unit U_P further comprises a crystallization unit U_{CR} , the process comprising obtaining from the distillation unit U_D a stream S_{UD} comprising ϵ -caprolactam at a concentration c_{UD} , and feeding the stream S_{UD} to the crystallization unit U_{CR} , obtaining from U_{CR} the mixture M_F comprising ϵ -caprolactam at the concentration c_{MF} ;
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- or wherein the purification unit U_P further comprises a chemical treatment unit U_{OD} , the process comprising obtaining from the distillation unit U_D a stream S_{UD} comprising ϵ -caprolactam at a concentration c_{UD} and feeding the stream S_{UD} to the chemical treatment unit U_{OD} , obtaining from U_{OD} the mixture M_F comprising ϵ -caprolactam at the concentration c_{MF} ;
- 5 or wherein the purification unit U_P further comprises a chemical treatment unit U_{OD} and a crystallization unit U_{CR} , wherein the crystallization unit U_{CR} is located downstream of the distillation unit U_D and the chemical treatment unit U_{OD} is located downstream of the crystallization unit U_{CR} , the process comprising obtaining from the distillation unit U_D a stream S_{UD} comprising ϵ -caprolactam at a concentration c_{UD} , feeding the stream S_{UD} to the crystallization unit U_{CR} , obtaining from the crystallization U_{CR} a stream S_{CR} comprising ϵ -caprolactam at a concentration c_{CR} , and feeding the stream S_{CR} to the chemical treatment unit U_{OD} , obtaining from U_{OD} the mixture M_F comprising ϵ -caprolactam at the concentration c_{MF} ;
- 10 or wherein the purification unit U_P further comprises a chemical treatment unit U_{OD} and a crystallization unit U_{CR} , wherein the chemical treatment unit U_{OD} is located downstream of the distillation unit U_D and the crystallization unit U_{CR} is located downstream of the unit U_{OD} , the process comprising obtaining from the distillation unit U_D a stream S_{UD} comprising ϵ -caprolactam at a concentration c_{UD} , feeding the stream S_{UD} to the chemical treatment unit U_{OD} , obtaining from the chemical treatment unit U_{OD} a stream S_{OD} comprising ϵ -caprolactam at a concentration c_{OD} , and feeding the stream S_{OD} to the crystallization unit U_{CR} , obtaining from U_{CR} the mixture M_F comprising ϵ -caprolactam at the concentration c_{MF} .
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- 25 11. The process of any one of claims 1 to 10, wherein $x_{H_2O}(M_T)$ is in the range of from 0 to 0.05 weight-%, preferably in the range of from 0 to 0.01 weight-%, more preferably in the range of from 0 to 0.001 weight-%, wherein $\Omega_{GC}(M_T)$ is at least 99.5 %, preferably at least 99.8 %, more preferably at least 99.9 %, and wherein $\Omega_{APHA}(M_T)$ is at most 20, preferably at most 15, more preferably at most 10.
- 30 12. The process of any one of claims 1 to 11, wherein the material M according to (i) 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;
- 35 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 polyamide 6;
- 40 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 elastane, 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 any one of claims 1 to 12, further comprising
 (v) storing the mixture M_F obtained according to (iv) at a temperature of the mixture of at most 80 °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 mixture M_F is stored preferably under exclusion of light, the storage time Δt_s is preferably at least 7 d, more preferably at least 14 d, more preferably in the range of from 14 to 28 d, the inert gas atmosphere preferably comprises one or more of nitrogen and argon, and the mixture M_F is stored at a storing temperature δ_s of the mixture M_F preferably in the range of from 20 to 80 °C, preferably in the range of from 25 to 80 °C, more preferably in the range of from 35 to 77 °C, more preferably in the range of from 50 to 75 °C.
14. The process of claim 13, wherein during storing according to (v),

$$(\delta_s / ^\circ\text{C}) = -2.6 \cdot (x_{\text{H}_2\text{O}}(M_F) / \text{weight-}\%) + C_s$$
 wherein $C_s = 77 \pm 10$, preferably $C_s = 77 \pm 5$.
15. A method of storing a mixture M_F comprising ϵ -caprolactam and water and having a purity $\Omega_{\text{GC}}(M_F)$ of at least 99 %, an APHA value $\Omega_{\text{APHA}}(M_F)$ of at most 20 and a water content $x_{\text{H}_2\text{O}}(M_F)$ of at least 0.1 weight-%, based on the total weight of the mixture M_F , said mixture M_F preferably being obtainable or obtained by a process according to any one of claims 1 to 12, said method comprising storing the mixture M_F at a temperature of the mixture of at most 80 °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.
16. A liquid mixture M_F comprising ϵ -caprolactam and water and having a purity $\Omega_{\text{GC}}(M_F)$ of at least 99 %, an APHA value $\Omega_{\text{APHA}}(M_F)$ of at most 20 and a water content $x_{\text{H}_2\text{O}}(M_F)$ of at least 0.1 weight-%, based on the total weight of the mixture M_F , said mixture M_F preferably being obtainable or obtained by a process according to any one of claims 1 to 12, the mixture M_F exhibiting a storage stability $\Sigma_{\Delta t}$ after a storage time Δt , wherein $\Sigma_{\Delta t}$ is characterized by an APHA value $\Omega_{\text{APHA}}(\Delta t)$;
 wherein for Δt being 14 d and the storage stability Σ_{14} after said storage time being characterized by an APHA value $\Omega_{\text{APHA}}(14)$, it is preferred that
 - if $\Omega_{\text{APHA}}(M_F)$ is less than 5, $\Omega_{\text{APHA}}(14) \leq 10$;
 - if $\Omega_{\text{APHA}}(M_F)$ is prefin the range of from 5 to 8, $\Omega_{\text{APHA}}(14) \leq 2 \Omega_{\text{APHA}}(M_F)$;
 - if $\Omega_{\text{APHA}}(M_F) > 8$, $\Omega_{\text{APHA}}(14) \leq 1.5 \Omega_{\text{APHA}}(M_F)$;
 and wherein for Δt being 28 d and the storage stability Σ_{28} after said storage time being characterized by an an APHA value $\Omega_{\text{APHA}}(28)$, it is preferred that
 - if $\Omega_{\text{APHA}}(M_F)$ is less than 4, $\Omega_{\text{APHA}}(28) \leq 10$;
 - if $\Omega_{\text{APHA}}(M_F)$ is in the range of from 4 to 8, $\Omega_{\text{APHA}}(28) \leq 3 \Omega_{\text{APHA}}(M_F)$;
 - if $\Omega_{\text{APHA}}(M_F) > 8$, $\Omega_{\text{APHA}}(28) \leq 2 \Omega_{\text{APHA}}(M_F)$.

17. A liquid mixture M_S comprising ϵ -caprolactam and water, obtainable or obtained by a process according to claim 13 or 14, said mixture M_S having an APHA value $\Omega_{\text{APHA}}(14)$ after a storage time Δt of 14 d, wherein
- if $\Omega_{\text{APHA}}(M_F)$ is less than 4, $\Omega_{\text{APHA}}(14) \leq 10$;
 - 5 - if $\Omega_{\text{APHA}}(M_F)$ is in the range of from 4 to 8, $\Omega_{\text{APHA}}(14) \leq 2 \Omega_{\text{APHA}}(M_F)$;
 - if $\Omega_{\text{APHA}}(M_F) > 8$, $\Omega_{\text{APHA}}(14) \leq 1.5 \Omega_{\text{APHA}}(M_F)$;
- and further having an APHA value $\Omega_{\text{APHA}}(28)$ after a storage time Δt of 28 d, wherein
- if $\Omega_{\text{APHA}}(M_F)$ is less than 4, $\Omega_{\text{APHA}}(28) \leq 10$;
 - if $\Omega_{\text{APHA}}(M_F)$ is in the range of from 4 to 8, $\Omega_{\text{APHA}}(28) \leq 3 \Omega_{\text{APHA}}(M_F)$;
 - 10 - if $\Omega_{\text{APHA}}(M_F) > 8$, $\Omega_{\text{APHA}}(28) \leq 2 \Omega_{\text{APHA}}(M_F)$.
18. Use of the mixture M_F according to claim 16 or the mixture M_S according to claim 17 as an educt material for a chemical process, preferably for a polymerization reaction, more preferably for preparing polyamide 6; and/or a method for preparing polyamide 6, comprising
- 15 (A) preparing a mixture M_F according to a process according to any one of claims 1 to 12, and/or providing a mixture M_F according to claim 16;
 - (B) optionally storing the mixture M_F at storage conditions as defined in claim 13 or 14, obtaining a stored mixture M_S ;
 - 20 (C) subjecting the mixture M_F prepared and/or provided according to (A) and/or the mixture M_S according to (B) to polyamide 6 polymerization conditions;
- wherein said polyamide 6, obtainable or obtained by said use or said method has an APHA value of at most 10, preferably of at most 9, more preferably of at most 8.
19. The process of any one of claims 1 to 12, or 13 or 14, further comprising providing at least part of the mixture M_F , or of 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}
- 25 (A) a textile material M_{TE} is obtained which is brought onto the market, wherein, after the lifetime T_{MTE} of said textile material M_{TE} , it is at least partially collected as textile waste material in a textile material collecting unit U_{TC} ;
 - 30 (B) remaining material M_{RE} 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 as material M according to (i);
- 35 and/or further comprising providing at least part of the mixture M_F , or of 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}
- 40 (A) an engineering plastics material M_{EP} is obtained which is brought onto the market, wherein, after the lifetime T_{MEP} of said engineering plastics material M_{EP} , it is at least

partially collected as engineering plastics waste material in an engineering plastics material collecting unit U_{EC} ;

- (B) remaining material M_{RE} 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 as material M according to (i).
20. Use of the mixture M_F according to claim 16 or of the mixture M_S according to claim 17 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 mixture M_F according to claim 16 or the mixture M_S according to claim 17 as a starting material;
- wherein the polymer, or the polymer product, or the polymer and the polymer product preferably 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;
- 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 mixture M_F according to claim 16 or from the mixture M_S according to claim 17, 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 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;
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- 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;
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- 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;
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- 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 mixture M_F according to claim 16 or from the mixture M_S according to claim 17 in an amount of 1
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- weight-% or more, 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;
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- 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.