

Highly heat-integrated process for preparing purified epsilon-caprolactam from polyamide 6

The present invention relates to a process for preparing purified ϵ -caprolactam from polyamide 6 comprising hydrolytically depolymerizing polyamide 6 contained in a solid material, wherein
 5 downstream of the depolymerization stage, heat contained in the stream obtained from depolymerization is highly efficiently used within the overall process to obtain purified ϵ -caprolactam.

Polyamide, and in particular polyamide 6 being characterized by the formula $(-\text{NH}-(\text{CH}_2)_5-\text{CO}-)_n$,
 10 can be found in numerous materials, such as packaging, engineering plastics from automotive and textile filaments. The latter represents about 40 % of the polyamide 6 global market. At present, only a very small part of the textile filaments is recycled while it represents a significant percentage of the global CO_2 emissions. There is thus a need to recycle polyamide 6 from such materials. Processes for alkaline depolymerizing a polyamide exists. Further, the processes in
 15 the art are energy-intensive processes. Thus, there is a constant need to provide an improved process for depolymerizing a polyamide able to overcome these issues.

Surprisingly, it was found that the process of the present invention according to which polyamide is hydrolytically depolymerized, wherein the stream obtained from depolymerization is suitably
 20 processed so as to obtain aqueous vapor streams having different pressures and wherein these aqueous vapor streams are further used as tailor-made heat sources in different depolymerization downstream stages ultimately leading to purified ϵ -caprolactam, is a robust and, at the same time, a highly heat-effective process. Thus, the process of the present invention permits to reduce the overall energy consumption compared to known processes for
 25 depolymerization of a polyamide. Further, using the inventive heat-integrated process permits to reduce the CO_2 footprint, an essential feature of any up-to-date industrial-scale process.

In particular, the present invention relates to a process for preparing purified ϵ -caprolactam from polyamide 6 contained in a solid material M, the process comprising

- 30 (i) preparing an aqueous liquid stream S_R comprising ϵ -caprolactam dissolved in water, comprising
 - (i.1) providing the solid material M comprising the polyamide 6, and providing an aqueous liquid stream S_W ;
 - 35 (i.2) preparing an aqueous depolymerization mixture based on the solid material M and the aqueous liquid stream S_W provided according to (i.1);
 - (i.3) subjecting the aqueous depolymerization mixture prepared according to (i.2) to depolymerization conditions in a chemical reaction unit U_R , said depolymerization conditions comprising a depolymerization temperature T_D at a depolymerization pressure p_D , obtaining in U_R a liquid aqueous reaction mixture M_R comprising ϵ -
 40 caprolactam dissolved in water;
 - (i.4) removing the aqueous liquid stream S_R from U_R , wherein S_R comprises ϵ -caprolactam at an ϵ -caprolactam concentration c_{SR} and wherein S_R has a pressure p_{SR} with $0.95 p_D \leq p_{SR} \leq p_D$ and a temperature T_{SR} with $0.95 T_D \leq T_{SR} \leq T_D$;

- (ii) subjecting the liquid aqueous stream S_R obtained according to (i.4) to depressurization in an evaporation unit U_E , obtaining from U_E aqueous vapor streams S_{EV1} , S_{EV2} and S_{EV3} , wherein S_{EV1} has a pressure p_{EV1} and a temperature T_{EV1} , wherein S_{EV2} has a pressure p_{EV2} and a temperature T_{EV2} , and wherein S_{EV3} has a pressure p_{EV3} and a temperature T_{EV3} , wherein $p_{EV1} > p_{EV2} > p_{EV3}$; and further obtaining from U_E an aqueous liquid stream S_L comprising ϵ -caprolactam at an ϵ -caprolactam concentration c_{SL} with $c_{SL} > c_{SR}$;
- (iii) passing the aqueous liquid stream S_L obtained according to (ii) through a heat-consuming purification unit U_P comprising at least two heat-consuming purification sub-units U_{P1} and U_{P2} , obtaining from U_P a stream S_{CPL} comprising ϵ -caprolactam at an ϵ -caprolactam concentration c_{SCPL} with $c_{SCPL} \gg c_{SL}$;
- (iv) providing at least part of the heat consumed in U_{P1} by S_{EV3} or a part stream thereof, thereby obtaining from S_{EV3} or the part stream thereof an at least partially condensed aqueous stream S_{EL3} having a pressure p_{EL3} and a temperature T_{EL3} with $T_{EL3} \leq T_{EV3}$; and providing at least part of the heat consumed in U_{P2} by S_{EV2} or a part stream thereof, thereby obtaining from S_{EV2} or the part stream thereof an at least partially condensed aqueous stream S_{EL2} having a pressure p_{EL2} and a temperature T_{EL2} with $T_{EL2} \leq T_{EV2}$;
- (v) subjecting at least part of the aqueous stream S_{EL3} and at least part of the aqueous stream S_{EL2} to heat exchange in a heat exchange unit U_H , wherein at least part of the heat transferred in U_H is provided by the aqueous vapor stream S_{EV1} or a part stream thereof, thereby obtaining from S_{EL3} and S_{EL2} an aqueous liquid stream S_{RW} having a temperature T_{RW} with $T_{RW} > T_{EL3}$ and $T_{RW} > T_{EL2}$, and obtaining from S_{EV1} or the part stream thereof an at least partially condensed aqueous stream S_{EL1} having a temperature T_{EL1} with $T_{EL1} \leq T_{EV1}$;
- (vi) recycling at least part of the stream S_{RW} and at least part of the stream S_{EL1} into the reaction unit U_R .

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No specific limitations exist how the aqueous depolymerization mixture according to (i.2) is provided. Preferably, preparing the aqueous depolymerization mixture according to (i.2) comprises

- (i.2.1) melting in a melting unit U_M the solid material M provided according to (i.1), obtaining a liquid stream S_M having a temperature T_{SM} at a pressure p_{SM} ;
- (i.2.2) admixing in a pre-reaction unit U_{PR} the stream S_M obtained according to (i.2.1) with the stream S_W provided according to (i.1) and 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} ;
- (i.2.3) feeding the stream S_F obtained according to (i.2.2) as the depolymerization mixture into the chemical reaction unit U_R .

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Regarding the temperatures according to (i.2.1), (i.2.2) and (i.2.3) above, it is preferred that at least one of the following relations, more preferably at least two of the following relations, more preferably at least all of the following relations apply:

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$$0.8 \leq T_{SF}/T_D \leq 1.05;$$

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

$$0.8 \leq T_{SW}/T_{SF} \leq 1.2.$$

Regarding the pressures according to (i.2.1), (i.2.2) and (i.2.3) above, it is preferred that at least one of the following relations, preferably at least two of the following relations, more preferably at least all of the following relations apply:

- 0.9 $\leq$ $p_{SF}/p_D \leq 1.05$;
 5 0.9 $\leq$ $p_{SM}/p_{SF} \leq 1.05$; and
 0.9 $\leq$ $p_{SW}/p_{SF} \leq 1.05$.

Regarding the temperatures and pressures according to (i.2.1), (i.2.2) and (i.2.3) above, it is more preferred that at least one of the following combinations of temperature and pressure relations,
 10 more preferably at least two of the following combinations of temperature and pressure relations,
 more preferably all of the following combinations of temperature and pressure relations apply:

- 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
 15 0.8 $\leq$ $T_{SW}/T_{SF} \leq 1.2$ and 0.9 $\leq$ $p_{SW}/p_{SF} \leq 1.05$.

Regarding the pre-reaction unit U_{PR} according to (i.2.2), it is preferred that it is a mixing unit comprising a dynamic mixing unit, or a static mixing unit, or a dynamic mixing unit and a static mixing unit. Preferably, the pre-reaction unit U_{PR} according to (i.2.2) comprises more preferably consists of a static mixing unit.

Regarding the melting unit U_M according to (i.2.2), it is preferred that it comprises, more preferably consists of an extruder, i.e. a melt extruder. Generally, said extruder can be designed according to the specific needs of the process, preferably, for example, as a single-screw extruder or a twin-screw extruder. Therefore, it is preferred that the pre-reaction unit U_{PR}
 20 according to (i.2.2) comprises, preferably consists of, a mixing unit, preferably a static mixing unit, and the melting unit U_M comprises, preferably consists of an extruder, preferably a single-screw extruder or a twin-screw extruder. More preferably, the melting unit U_M is equipped with a degassing system, wherein the process further comprises removing a gas stream S_{GM} from U_M during melting in U_M . Preferably, the gas stream S_{GM} has a temperature T_{GM} at a pressure p_{GM} ,
 25 wherein 0.95 $\leq$ $T_{GM}/T_{SM} \leq 1.05$. Still more preferably, the gas stream S_{GM} removed from U_M is subjected to scrubbing in a scrubbing unit U_S , preferably to one or more of wet scrubbing and dry scrubbing, more preferably to wet scrubbing, wherein said wet scrubbing preferably comprises passing the gas stream S_{GM} into a scrubbing column, preferably a packed scrubbing column.

Preferably, between the melting unit U_M and the pre-reaction unit U_{PR} , a melt pump unit is arranged, in particular in case the pressure of the stream leaving the U_M is lower than the pressure desired for the stream to exhibit when entering the pre-reaction unit U_{PR} . In this case, the melt pump unit may serve for bringing the stream leaving the U_M to its desired pressure. More preferably, between the melting unit and the melt pump unit, a filtration unit U_F is arranged
 35 through which the stream leaving the melting unit U_M is passed, preferably for ensuring safe operation of the downstream melt pump unit. More preferably, said filtration unit U_F is designed for separating particles having a particle size in the range of from 100 to 500 micrometer,

preferably in the range of from 200 to 400 micrometer, from the stream leaving the melting unit U_M .

Regarding the mixing ratio of streams S_W and S_M according to (i.2.1), no specific restrictions exist.

- 5 Preferably, according to (i.2.1), S_W and S_M are admixed in U_{PR} at a mixing ratio $(m_W/kg) / (m_P/kg)$ in the range of from 1:1 to 20:1, more preferably in the range of from 2:1 to 15:1, more preferably in the range of from 5:1 to 10:1, wherein m_W is the amount of water comprised in S_W and m_P is the amount of polyamide 6 comprised in S_M .

- 10 According to (i.3), the aqueous depolymerization mixture prepared according to (i.2) is subjected to depolymerization conditions in a chemical reaction unit U_R , said depolymerization conditions comprising a depolymerization temperature T_D at a depolymerization pressure p_D . Preferably, T_D is in the range of from 230 to 335 °C and p_D is in the range of from 40 to 140 bar, more preferably T_D is in the range of from 250 to 320 °C and p_D is in the range of from 40 to 125 bar, more
15 preferably T_D is in the range of from 270 to 310 °C and p_D is in the range of from 40 to 110 bar.

Preferably according to the present invention, the reaction unit U_R according to (i.3) 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. More
20 preferably, 2 or 3, more preferably 3 chemical reactors R_i , are used. If $z > 1$, it is preferred that at least 2 reactors R_i , preferably 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
25 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 .

- According to the present invention, 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
30 range of from 230 to 335 °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.

- Further according to the present invention, if $z > 1$, the z reactors R_i are vertically arranged, with R_1 being the top-most reactor and R_z being the bottom-most reactor. In this case, it is preferred
35 that a stream S_i obtained from a reactor R_i is transferred to the following downstream reactor R_{i+1} by gravity, preferably by gravity only.

- Regarding the specific design of the one or more reactors used according to the process of the present invention, it is preferred that at least one, preferably z reactors R_i , are stirred tank
40 reactors. More preferably, at least one, more preferably every stirred tank reactor R_i has, independently from each other, from 2 to 6 compartments, preferably from 2 to 5 compartments, more preferably from 2 to 4 compartments. More preferably, said compartments are serially arranged, more preferably serially and vertically arranged, wherein 2 adjacent compartments are

preferably separated by a divider which comprises at least one flow-through opening. More preferably, wherein 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, wherein 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. Generally, the polyamide 6 depolymerization conditions in the chemical reaction unit U_R according to (i.3) 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 stirred tank reactors R_i . According to the present invention, it is preferred that at least 85 weight-%, more 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. In particular in the preferred case as described above according to which stirred tank reactors exhibiting the said compartments are used with $z > 1$, it is preferred that the residence time of an aqueous depolymerization mixture in a reactor R_i is t_{Di} , wherein $0.90 \leq (t_{Di} / t_{Di+1}) \leq 1.10$, preferably $0.95 \leq (t_{Di} / t_{Di+1}) \leq 1.05$. Thus, according to the present invention, a very narrow residence time distribution can be achieved.

Preferably according to the present invention, no polyamide 6 depolymerization catalyst such as a mineral acid and/or a zinc salt such as zinc chloride, zinc acetate or zinc triflate is added for preparing the stream S_F to be subjected to hydrolytic polyamide 6 depolymerisation conditions in the reaction unit U_R .

Further according to the present invention, the process preferably comprises removing from at least one reactor R_i , preferably from all z reactors R_i , a respective gas stream S_{Gi} , wherein a given gas stream S_{Gi} has a temperature T_{Gi} at a pressure p_{Gi} , and wherein $0.95 \leq T_{Gi}/T_{Di} \leq 1.05$. More preferably, the process of the present invention further comprises combining at least one of the gas streams S_{Gi} , preferably all streams S_{Gi} , with the gas stream S_{GM} obtained from the melting unit U_M and as described above, prior to subjecting the gas stream S_{GM} to scrubbing as defined above.

According to the present invention, it is possible to provide the solid material M according to (i.1) according to any suitable method. According to a preferred method, (i.1) comprises

- (i.1.1) 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;
- (i.1.2) passing the solid material M provided according to (i.1.1) 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 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} ;
- (i.1.3) 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.

Preferably, the first connecting line according to (i.1.2) comprises at least one unit U_{MRD} , more preferably at least one hopper, more preferably at least one one-zone hopper, and further comprises at least one unit U_{FMF} , preferably at least one rotary feeder, and preferably further
 5 comprises at least particle separation unit U_{FMPS} , more preferably at least one filter, more preferably at least one mesh filter. Preferably, for passing the solid material M via a first connecting line from the unit U_{MD} to the unit U_{MC} , at least one gas stream S_G is passed through the first connecting line, said at least one gas stream preferably comprising, more preferably consisting of air or lean air, wherein prior to being passed through the first connecting line, the at
 10 least one gas stream is preferably pre-treated by at least one of filtrating, compressing and cooling, more preferably by filtrating, compressing and cooling. Preferably, the second connecting line according to (i.1.3) comprises at least two units U_{SMF} , preferably comprising a rotary feeder and a loss-in-weight feeder, wherein more preferably, the rotary feeder is arranged upstream of the loss-in-weight feeder, and further comprises a unit U_{SMPS} , preferably a vibrating screen.

15 Preferably according to the present invention, according to (i.1), the solid material M is provided, preferably provided to U_M , 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, more preferably by two or more of the following pairs of values, more preferably by the following three
 20 pairs of values:

- a D10 value of the particle width in the range of from 0.1 to 15 mm and a D10 value of the particle length in the range of from 0.3 to 15 mm;
- a D50 value of the particle width in the range of from 0.2 to 20 mm and a D50 value of the particle length in the range of from 0.5 to 20 mm;
- 25 - 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.

Regarding the composition of the solid material M, it is preferred that from 10 to 100 weight-%, more preferably from 30 to 100 weight-%, more preferably from 50 to 100 weight-%, more
 30 preferably from 80 to 100 weight-%, of the solid material M consist of the polyamide 6. Also 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 solid material M consist of polyamide 6. In addition to polyamide 6, the solid material M preferably comprises one or more further organic polymeric compounds, more preferably including, but not limited to, one or more
 35 of at least one elastane; at least one polyamide 6.6; at least one semiaromatic polyamide including one or more of polyamide 6T and polyamide 6I; at least one polyethylene terephthalate; at least one polyurethane; at least one polyester; at least one polyether; at least one polyvinyl chloride; at least one natural fiber material such as wool and cotton; at least one cellulose material; at least one natural elastomer; at least one synthetic elastomer; at least one copolymer
 40 of two or more of said polymeric compounds including statistical copolymers, gradient copolymers, alternating copolymers, block copolymers, and graft copolymers; and at least one rubber material comprising one or more of at least one natural rubber material and at least one synthetic rubber material.

Preferably according to the present invention, the solid material M provided according to (i.1) comprises, preferably consists of, a waste material, preferably one or more of a textile waste material and an engineering plastics waste material, more preferably of a textile waste material.

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Regarding the evaporation unit U_E according to (ii), it is preferred that it comprises two evaporation sub-units U_{E1} and U_{E2} , wherein more preferably, U_{E1} and U_{E2} are serially coupled. While there is no specific restriction regarding the respective design, it is preferred that at least one evaporation sub-unit comprises, preferably consists of a flash drum, wherein it is more preferred that the evaporation sub-unit U_{E1} comprises, preferably consists of a flash drum and that the evaporation sub-unit U_{E2} comprises, preferably consists of a flash drum.

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Preferably according to the present invention, (ii) comprises

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(ii.1) subjecting the liquid aqueous stream S_R obtained according to (i.4) to depressurization in the evaporation sub-unit U_{E1} , obtaining from U_{E1} an aqueous vapor stream S_{EV1A} having the pressure p_{EV1} , and further obtaining an at least partially aqueous liquid stream S_{LU1} ;

(ii.2) dividing the stream S_{EV1A} , obtaining the stream S_{EV1} and a stream S_{EV1B} having the pressure p_{EV1} ;

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(ii.3) subjecting the stream S_{EV1B} to depressurization in a unit U_{V1} , U_{V1} preferably comprising a valve, more preferably a pressure relief valve, obtaining the stream S_{EV2} ;

(ii.4) subjecting the stream S_{LU1} obtained according to (ii.1) to depressurization in U_{E2} , obtaining from U_{E2} an aqueous vapor stream S_{EV3A} and the liquid stream S_L .

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Preferably, the aqueous vapor stream S_{EV3A} obtained according to (ii.4) is the aqueous vapor stream S_{EV3} .

Further preferably according to the present invention, obtaining the stream S_{EV3} further comprises one or more of (ii.5.1) and (ii.5.2):

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(ii.5.1) separating a stream S_{EV1C} from the stream S_{EV1A} , obtained according to (ii.1), the stream S_{EV1C} having the pressure p_{EV1} ; subjecting the stream S_{EV1C} to depressurization in a unit U_{V2} , U_{V2} preferably comprising a valve, more preferably a pressure relief valve, obtaining a stream S_{EV3B} having the pressure p_{EV3} ;

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(ii.5.2) separating a stream S_{EV2A} from the stream S_{EV2} obtained according to (ii.3), the stream S_{EV2A} having the pressure p_{EV2} ; subjecting the stream S_{EV2A} to depressurization in a unit U_{V3} , U_{V3} preferably comprising a valve, more preferably a pressure relief valve, obtaining a stream S_{EV3C} having the pressure p_{EV3} ;

and further comprises

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(ii.6) admixing one or more of the streams S_{EV3B} obtained according to (ii.5.1) and the stream S_{EV3C} obtained according to (ii.5.2) to the stream S_{EV3A} obtained according to (ii.4), obtaining the stream S_{EV3} .

Preferably according to the process of the present invention, the following pressures and temperatures are realized:

- p_D is preferably 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
 T_D is preferably 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;
- 5 - p_{EV1} is preferably in the range of from 13 to 19 bar, more preferably in the range of from 14 to 18 bar, more preferably in the range of from 15 to 17 bar; and
 T_{EV1} is preferably in the range of from 170 to 230 °C, more preferably in the range of from 180 to 220 °C, more preferably in the range of from 190 to 210 °C;
- 10 - p_{EV2} is preferably in the range of from 5 to 11 bar, more preferably in the range of from 6 to 10 bar, more preferably in the range of from 7 to 9 bar; and
 T_{EV2} is preferably in the range of from 150 to 210 °C, more preferably in the range of from 160 to 200 °C, more preferably in the range of from 170 to 190 °C;
- p_{EV3} is preferably in the range of from 0.95 to 1.5 bar, more preferably in the range of from 1.0 to 1.4 bar, more preferably in the range of from 1.1 to 1.3 bar; and
15 T_{EV3} is preferably in the range of from 90 to 140 °C, more preferably in the range of from 100 to 130 °C, more preferably in the range of from 110 to 120 °C.

Further preferably according to the process of the present invention, the following is realized as far as the pressures of the at least partially condensed aqueous streams relative to the pressures of the respective aqueous vapour streams, and as far as the temperature differences between the aqueous vapor streams and the respective at least partially condensed aqueous streams at these pressures is concerned:

- $0.95 p_{EV1} \leq p_{EL1} \leq p_{EV1}$; and
 $\Delta T_{VL1} = T_{EV1} - T_{EL1}$ is in the range of from 2 to 10 °C, preferably in the range of from 3 to 8 °C, more preferably in the range of from 4 to 6 °C;
- 25 - $0.95 p_{EV2} \leq p_{EL2} \leq p_{EV2}$; and
 $\Delta T_{VL2} = T_{EV2} - T_{EL2}$ is in the range of from 15 to 40 °C, preferably in the range of from 18 to 32 °C, more preferably in the range of from 20 to 30 °C;
- $0.95 p_{EV3} \leq p_{EL3} \leq p_{EV3}$; and
30 $\Delta T_{VL3} = T_{EV3} - T_{EL3}$ is in the range of from 10 to 30 °C, preferably in the range of from 12.5 to 27.5 °C, more preferably in the range of from 15 to 25 °C.

In case of latent heat comprised in the aqueous vapour streams, the temperature differences ΔT_{VL1} , ΔT_{VL2} , ΔT_{VL3} may become zero, and the following is realized:

- 35 - $0.95 p_{EV1} \leq p_{EL1} \leq p_{EV1}$; and
 $\Delta T_{VL1} = T_{EV1} - T_{EL1}$ is in the range of from 0 to 10 °C, preferably in the range of from 0 to 8 °C, more preferably in the range of from 0 to 6 °C;
- $0.95 p_{EV2} \leq p_{EL2} \leq p_{EV2}$; and
 $\Delta T_{VL2} = T_{EV2} - T_{EL2}$ is in the range of from 0 to 40 °C, preferably in the range of from 0 to 32 °C, more preferably in the range of from 0 to 30 °C;
- 40 - $0.95 p_{EV3} \leq p_{EL3} \leq p_{EV3}$; and
 $\Delta T_{VL3} = T_{EV3} - T_{EL3}$ is in the range of from 0 to 30 °C, preferably in the range of from 0 to 27.5 °C, more preferably in the range of from 0 to 25 °C.

- According to a preferred process of the present invention, at least part of the at least partially condensed stream S_{EL2} and at least part of the at least partially condensed stream S_{EL3} are suitably combined, and the respectively combined stream is subjected to heating prior to being
- 5 suitably recycled to the reaction unit U_R . According to this preferred process, the respective heat for heating said combined stream is at least partially provided by the aqueous vapor stream S_{EV1} or a part stream thereof. Therefore, the present invention also relates to the above-described process, wherein (v) and (vi) comprise
- (v) combining at least part of the stream S_{EL2} and at least part of the stream S_{EL3} in a unit U_C ,
 10 obtaining a combined aqueous liquid stream S_C , and subjecting at least part of the aqueous liquid stream S_C to heat exchange in a heat exchange unit U_H , wherein at least part of the heat transferred in U_H is provided by the aqueous vapor stream S_{EV1} or a part stream thereof, thereby obtaining from S_C an aqueous liquid stream S_{RW} having a temperature $T_{RW} > T_C$, and obtaining from S_{EV1} or the part stream thereof an at least
- 15 partially condensed aqueous stream S_{EL1} having a temperature T_{EL1} with $T_{EL1} < T_{EV1}$, the process further comprising combining at least part of the stream S_{EL1} in U_C with S_{EL2} or the part stream thereof and the stream S_{EL3} or the part stream thereof;
- (vi) recycling at least part of the stream S_{RW} into the reaction unit U_R .
- 20 Generally, according to the present invention, the heat-consuming purification unit U_P comprises two or more heat-consuming purification sub-units U_{P1} and U_{P2} for different ϵ -caprolactam purification tasks downstream of the hydrolytic depolymerization stage. Each of the heat-consuming purification sub-units U_{P1} and U_{P2} may consist of one single purification sub-unit or of two or more purification sub-units. According to a preferred design of the process of the present
- 25 invention, the heat-consuming purification sub-units U_{P1} comprises two or more purification sub-units $U_{P1(j)}$, $j=1..m$, $m \geq 2$, and the heat-consuming purification sub-units U_{P2} comprises two or more purification sub-units $U_{P2(k)}$, $k=1..n$, $n \geq 2$. More preferably according to the present invention, the two or more purification sub-units $U_{P1(j)}$ comprise a water separation unit U_{WS} and a crystallization unit U_{CR} , and the two or more purification sub-units $U_{P2(k)}$ comprise at least one
- 30 distillation column. More preferably according to the present invention, the two or more purification sub-units $U_{P1(j)}$ comprise a water separation unit U_{WS} and a crystallization unit U_{CR} , and the two or more purification sub-units $U_{P2(k)}$ comprise a distillation unit U_{DI} and one or more of a high-boiler separation unit U_{HS} and a chemical treatment unit U_{CT} . More preferably according to the present invention, the two or more purification sub-units $U_{P1(j)}$ comprise a water separation
- 35 unit U_{WS} and a crystallization unit U_{CR} , and the two or more purification sub-units $U_{P2(k)}$ comprise a distillation unit U_{DI} , a high-boiler separation unit U_{HS} and a chemical treatment unit U_{CT} . Accordingly, it is preferred according to the present invention to prepare different aqueous vapor streams from the streams S_{EV2} and S_{EV3} , and use these different streams as suitable heat sources for said different heat-consuming purification sub-units.
- 40 Therefore, the present invention also relates to the above-described process, comprising
- (iii) passing the aqueous liquid stream S_L obtained according to (ii) through a heat-consuming purification unit U_P at least comprising m heat-consuming purification sub-units $U_{P1(j)}$,

- $j=1..m$, $m \geq 2$, and n heat-consuming purification sub-units $U_{P2}(k)$, $k=1..n$, $n \geq 2$ obtaining from U_P a stream S_{CPL} comprising ϵ -caprolactam at an ϵ -caprolactam concentration C_{SCPL} with $C_{SCPL} \gg C_{SL}$;
- (iv) dividing the stream S_{EV3} in at least m part streams $S_{EV3}(j)$ having a temperature $T_{EV3}(j) = T_{EV3}$ and a pressure $p_{EV3}(j) = p_{EV3}$, and dividing the stream S_{EV2} in at least n part streams $S_{EV2}(k)$ having a temperature $T_{EV2}(j) = T_{EV2}$ and a pressure $p_{EV2}(j) = p_{EV2}$; and providing at least part of the heat consumed in $U_{P1}(j)$ by $S_{EV3}(j)$, thereby obtaining from $S_{EV3}(j)$ an at least partially condensed aqueous stream $S_{EL3}(j)$ having a pressure $p_{EL3}(j)$ and a temperature $T_{EL3}(j)$ with $T_{EL3}(j) < T_{EV3}(j)$; and providing at least part of the heat consumed in $U_{P2}(k)$ by $S_{EV2}(k)$, thereby obtaining from $S_{EV2}(k)$ an at least partially condensed aqueous stream $S_{EL2}(k)$ having a pressure $p_{EL2}(k)$ and a temperature $T_{EL2}(k)$ with $T_{EL2}(k) < T_{EV2}(k)$;
- (v) subjecting at least parts of the aqueous streams $S_{EL3}(j)$ and $S_{EL2}(k)$ to heat exchange in a heat exchange unit U_H , wherein at least part of the heat transferred in U_H is provided by the aqueous vapor stream S_{EV1} or a part stream thereof, thereby obtaining from the streams $S_{EL3}(j)$ and the streams $S_{EL2}(k)$ an aqueous liquid stream S_{RW} having a temperature T_{RW} with $T_{RW} > T_{EL3}(j)$ and $T_{RW} > T_{EL2}(k)$, and obtaining from S_{EV1} or the part stream thereof an at least partially condensed aqueous stream S_{EL1} having a temperature T_{EL1} with $T_{EL1} < T_{EV1}$;
- (vi) recycling at least part of the stream S_{RW} and at least part of the stream S_{EL1} into the reaction unit U_R .

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According to the process of the present invention, it is preferred that according to (iii), the m heat-consuming purification sub-units $U_{P1}(j)$ comprise one or more of a water separation unit U_{WS} and a crystallization unit U_{CR} , wherein the water separation unit U_{WS} preferably comprises one or more of an evaporator arranged upstream of a flash tank and a film evaporator, more preferably one or more of an evaporator arranged upstream of a flash tank and a falling film evaporator, and wherein the crystallization unit U_{CR} preferably comprises at least one heat exchanger preferably for providing a heating medium used for crystallization purposes. More preferably, a stream $S_{EV3}(j)$ is used for providing at least part of the heat consumed by the evaporator arranged upstream of the flash tank comprised in the water separation unit U_{WS} , thereby obtaining a stream $S_{EL3}(j)$. Further, more preferably, another stream $S_{EV3}(j)$ is used for providing at least part of the heat consumed in the water separation unit U_{WS} , thereby obtaining a stream $S_{EL3}(j)$. Yet further more preferably, a stream $S_{EV3}(j)$ is used for providing at least part of the heat consumed by the at least one heat exchanger of the crystallization unit U_{CR} , thereby obtaining a stream $S_{EL3}(j)$. This heat exchanger, for example, may be used for providing hot water for the crystallization unit U_{CR} .

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Further according to the process of the present invention, it is preferred that according to (iii), the n heat-consuming purification sub-units $U_{P2}(k)$ comprise a distillation unit U_{DI} , wherein U_{DI} preferably comprises at least one distillation column, preferably at least two distillation columns, more preferably at least three distillation columns, more preferably at least three serially arranged distillation columns. More preferably, in at least one of the distillation columns, preferably in each distillation column, a first stream $S_{EV2}(k_1)$ is passed as a direct heating medium through a heating jacket of said distillation column, thereby obtaining a first stream $S_{EL2}(k_1)$, and second stream $S_{EV2}(k_2)$ is passed as an indirect heating medium through a heat exchanger, preferably a heat

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exchanger used for sump evaporation of said distillation column, thereby obtaining a second stream $S_{EL2}(k_2)$. More preferably, the distillation in at least one distillation column is carried out as a vacuum distillation, and the process further comprises operating at least one vacuum generating means, preferably at least one vacuum ejector, with at least one stream $S_{EV2}(k)$.

- 5 According to the present, it may be conceivable that, prior to using a stream $S_{EV2}(k)$ as heating medium in one or more of said distillation columns and depending on the specific configuration of the respective distillation column, the pressure of $S_{EV2}(k)$ is suitably reduced, preferably for example to a range of from 3 to 4 bar. As indicated above, it is preferred according to the process of the present invention that the purification unit U_P comprises a heat-consuming water
- 10 separation unit U_{WS} , a heat-consuming distillation unit U_{DI} and a heat-consuming crystallization unit U_{CR} . According to this preferred design, the process preferably comprises feeding the stream S_L comprising ϵ -caprolactam at a concentration c_{SL} to U_{WS} , obtaining from U_{WS} a stream S_{UWS} comprising ϵ -caprolactam at a concentration c_{SUWS} , feeding the stream S_{UWS} to the distillation unit U_{DI} , obtaining from U_{DI} a stream S_{UDI} comprising ϵ -caprolactam at a concentration c_{SUDI} , and
- 15 feeding the stream S_{UDI} into the crystallization unit U_{CR} , obtaining from U_{CR} the stream S_{CPL} comprising ϵ -caprolactam at the concentration c_{SCPL} , wherein $c_{SL} < c_{SUWS} < c_{SUDI} < c_{SCPL}$.

Further according to the process of the present invention, it is preferred that according to (iii), the n heat-consuming purification sub-units $U_{P2}(k)$ further comprise a high-boiler separation unit U_{HS} .

20 In said high-boiler separation unit U_{HS} , one or more compounds X are separated from the stream fed into U_{HS} wherein said one or more compounds have a boiling point higher than the boiling point of ϵ -caprolactam. Preferably according to the present invention, the high-boiler separation carried out in U_{HS} comprises

- (a) providing the stream S_{UWS} , having a temperature T_{SUWS} and exhibiting a total concentration $c_{SUWS}(X)$ of the one or more compounds X and a concentration $c_{SUWS}(C)$ of monomeric ϵ -caprolactam;
- 25 (b) producing in an evaporation unit U_{E1} from the stream S_{UWS} an aqueous at least partially vaporous stream S_{V1} and a liquid stream S_{L1} , comprising
- (b.1) passing the stream S_{UWS} provided according to (a) into the unit U_{E1} , preparing in the
- 30 unit U_{E1} from the stream S_{UWS} an evaporation mixture M_{E1} having an evaporation temperature T_{E1} at an evaporation pressure p_{E1} with $T_{E1} > T_{SUWS}$, wherein the one or more one organic compounds X 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} ;
- (b.2) removing the stream S_{V1} from the evaporation unit U_{E1} , the stream S_{V1} having a
- 35 temperature T_{V1} with $T_{V1} \leq T_{E1}$ and exhibiting a total concentration $c_{V1}(X)$ of one or more compounds X and a concentration $c_{V1}(C)$ of monomeric ϵ -caprolactam with $c_{V1}(C) > c_{SUWS}(C)$ and $c_{V1}(X) < c_{SUWS}(X)$;
- (b.3) removing the stream S_{L1} from the evaporation unit U_{E1} , the stream S_{L1} having a
- 40 temperature T_{L1} with $T_{L1} = T_{E1}$ and exhibiting a total concentration $c_{L1}(X)$ of one or more compounds X and a concentration $c_{L1}(C)$ of monomeric ϵ -caprolactam with $c_{L1}(C) < c_{E1}(C)$ and $c_{L1}(X) > c_{SUWS}(X)$;
- (c) 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

- (c.1) passing the stream S_{V1} removed from the evaporation unit U_{E1} according to (b.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;
- 5 (c.2) removing the stream S_{V2} from the separation unit U_{S1} , the stream S_{V2} having a temperature T_{V2} with $T_{L0} < T_{V2} \leq T_{V1}$ and exhibiting a total concentration $c_{V2}(X)$ of one or more compounds X and a concentration $c_{V2}(C)$ of monomeric ϵ -caprolactam;
- 10 (c.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 $c_{L2}(X)$ of one or more compounds X and a concentration $c_{L2}(C)$ of monomeric ϵ -caprolactam with $c_{L2}(X) > c_{V2}(X)$ and $c_{L2}(C) < c_{V2}(C)$;
- (d) passing the aqueous stream S_{V2} obtained from the separation unit U_{S1} according to (c.2) as stream S_{UHS} to the unit U_{DI} .

According to the present invention, the separation unit U_{S1} according to (c) is a heat-consuming unit, wherein at least part of the heat consumed in U_{S1} is provided by a stream $S_{EV2}(k)$ according to the present invention, obtaining a respective stream $S_{EL2}(k)$. Preferably, the separation unit U_{S1} comprises, more preferably consists of, a droplet separator, preferably selected from the group consisting of a hydrocyclone, a demister plate, and an absorption tower, wherein more preferably, U_{S1} is a hydrocyclone. According to this preferred design, the process preferably comprises feeding the stream S_L comprising ϵ -caprolactam at a concentration c_{SL} to U_{WS} , obtaining from U_{WS} a stream S_{UWS} comprising ϵ -caprolactam at a concentration c_{SUWS} , feeding the stream S_{UWS} to the high-boiler separation unit U_{HS} , obtaining from U_{HS} a stream S_{UHS} comprising ϵ -caprolactam at a concentration c_{SUHS} , feeding the stream S_{UHS} to the distillation unit U_{DI} , obtaining from U_{DI} a stream S_{UDI} comprising ϵ -caprolactam at a concentration c_{SUDI} , and feeding the stream S_{UDI} into the crystallization unit U_{CR} , obtaining from U_{CR} the stream S_{CPL} comprising ϵ -caprolactam at the concentration c_{SCPL} , wherein $c_{SL} < c_{SUWS} < c_{SUHS} < c_{SUDI} < c_{SCPL}$.

Further according to the process of the present invention, it is preferred that according to (iii), the n heat-consuming purification sub-units $U_{P2}(k)$ further comprise, preferably in addition to the high-boiler separation unit U_{HS} as described herein, a chemical treatment unit U_{CT} . According to the present invention, it is preferred that U_{CT} is suitably integrated in the distillation unit U_{DI} . In the preferred case where U_{DI} comprises three serially arranged distillation columns as described above, with the upstream-most column D_1 , the column D_2 in the middle and the downstream-most column D_3 , it is preferred that U_{CT} is arranged downstream of D_1 and upstream of D_2 . With regard to this preferred arrangement of three serially arranged distillation columns D_1 , D_2 , and D_3 , the distillation carried out in U_{DI} preferably comprises

35 (α) providing the feed stream to the first distillation column D_1 , the stream S_{UWS} , the stream S_{UWS} comprising ϵ -caprolactam at a concentration $c_{SUWS}(C)$, one or more organic compounds X at a total concentration $c_{SUWS}(X)$, one or more organic compounds Y at a total concentration $c_{SUWS}(Y)$, and water at a concentration $c_{SUWS}(W)$, wherein water has a boiling point T_W , ϵ -caprolactam has a boiling temperature T_C , the one or more organic compounds X have a boiling temperature T_X , and the one or more organic compounds Y have a boiling temperature T_Y , with $T_Y < T_C < T_X$;

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- (β) separating water from the stream S_{UWS} , comprising a distillation in a first distillation column D_1 , obtaining from D_1 a vapour top stream S_{T1} comprising water at a concentration $c_{ST1}(W) > c_{SUWS}(W)$, and further obtaining from D_1 a liquid bottoms stream S_{B1} comprising ϵ -caprolactam at a concentration $c_{SB1}(C) > c_{SUWS}(C)$, the one or more organic compounds X at a total concentration $c_{SB1}(X) > c_{SUWS}(X)$, and the one or more organic compounds Y at a total concentration $c_{SB1}(Y) > c_{SUWS}(Y)$;
- (γ) separating the one or more compounds X from at least a part of the stream S_{B1} , comprising a distillation in a second distillation column D_2 , obtaining from D_2 a top stream S_T comprising ϵ -caprolactam at a concentration $c_{ST2}(C) < c_{SB1}(C)$ and the one or more organic compounds Y at a total concentration $c_{ST2}(Y) > c_{SB1}(Y)$, further obtaining from D_2 a bottom stream S_{B2} comprising the one or more organic compounds X at a total concentration $c_{SB2}(X) > c_{SB1}(X)$ and optionally ϵ -caprolactam at a concentration $c_{SB2}(C) < c_{SB1}(C)$, and obtaining from D_2 a side stream S_{S2} comprising ϵ -caprolactam at a concentration $c_{SS2}(C) > c_{SB1}(C)$;
- (δ) separating the one or more compounds Y from at least a part of the stream S_{T2} , comprising a distillation in a third distillation column D_3 , obtaining from D_3 a top stream S_{T3} comprising the one or more compounds Y at a total concentration $c_{ST3}(Y) > c_{ST2}(Y)$, and obtaining from D_3 a bottom stream S_{B3} comprising ϵ -caprolactam at a concentration $c_{SB3}(C) > c_{ST2}(C)$;
- wherein either the stream S_{S2} and/or the stream S_{B3} is/are passed to a downstream treatment as the stream S_{UDI} . According to another design of the process of the present invention, the chemical treatment unit is arranged downstream of the distillation unit U_{DI} and upstream of the crystallization unit U_{CR} . Preferably according to the present invention, the chemical treatment carried out in U_{CT} comprises
- (a) providing a stream S_{OX} comprising at least one oxidizing agent preferably comprising a permanganate;
- (b) preparing an oxidation reaction educt mixture M_{OE} from the stream S_{OX} and the ϵ -caprolactam feed stream passed into U_{CT} , preferably the ϵ -caprolactam feed stream obtained from the distillation column D_1 as described below or the ϵ -caprolactam feed stream S_{UDI} as described below, comprising one or more oxidizable organic compounds A , and subjecting the mixture M_{OE} to oxidation reaction conditions, obtaining an oxidation reaction product stream S_{OP} comprising ϵ -caprolactam, further comprising one or more oxidation reaction products A_P obtained from the oxidation of at least a part of the one or more compounds A , and optionally further comprising a part of the one or more organic compounds A ;
- (c) providing a stream S_{OB} comprising at least one hydroxide, wherein the at least one hydroxide comprised in the stream S_{OB} 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;
- (d) admixing the stream S_{OB} provided according to (c) with the stream S_{OP} obtained according to (b) and subjecting the resulting mixture to basic treatment conditions, obtaining a chemically treated stream S_{UCT} ;
- (e) passing the stream S_{UCT} to either the column D_2 or to U_{CR} .

According to the present invention, one or more of the apparatus used for subjecting the mixture M_{OE} to oxidation reaction conditions according to (b) and the apparatus used for the basic treatment according to (d), preferably the apparatus used for the basic treatment according to (d), is a heat-consuming unit, wherein at least part of the heat consumed therein is provided by a stream $S_{EV2}(k)$ according to the present invention, obtaining a respective stream $S_{EL2}(k)$.
 5 Preferably, said apparatus used for the basic treatment according to (d) comprises, more preferably consists of, a reactor, preferably a stirred reactor, more preferably a continuous stirred tank reactor (CSTR). According to the preferred design wherein U_{CT} is arranged downstream of U_{DI} and upstream of U_{CR} , the process preferably comprises feeding the stream S_L comprising
 10 ϵ -caprolactam at a concentration c_{SL} to U_{WS} , obtaining from U_{WS} a stream S_{UWS} comprising ϵ -caprolactam at a concentration c_{SUWS} , feeding the stream S_{UWS} to the distillation unit U_{DI} , obtaining from U_{DI} a stream S_{UDI} comprising ϵ -caprolactam at a concentration c_{SUDI} , feeding the stream S_{UDI} into the chemical treatment unit U_{CT} , obtaining from U_{CT} a stream S_{UCT} comprising ϵ -caprolactam at a concentration c_{SUCT} , and feeding the stream S_{UCT} into the crystallization unit
 15 U_{CR} , obtaining from U_{CR} the stream S_{CPL} comprising ϵ -caprolactam at the concentration c_{SCPL} , wherein $c_{SL} < c_{SUWS} < c_{SUDI} < c_{SUCT} < c_{SCPL}$.

Regarding the preferred process of the present invention according to which at least m at least partially condensed aqueous streams $S_{EL3}(j)$ and at least n at least partially condensed aqueous
 20 streams $S_{EL2}(k)$ are obtained, it is preferred that (v) and (vi) comprise
 (v) combining at least one of the streams $S_{EL2}(k)$ or a part stream thereof, preferably all streams $S_{EL2}(k)$ or part streams thereof, and at least one of the streams $S_{EL3}(j)$ or a part stream thereof, preferably all streams $S_{EL3}(j)$ or part streams thereof, in a unit U_C , obtaining a combined aqueous liquid stream S_C , and subjecting at least a part of the aqueous liquid
 25 stream S_C to heat exchange in a heat exchange unit U_H , wherein at least part of the heat transferred in U_H is provided by the aqueous vapor stream S_{EV1} or a part stream thereof, thereby obtaining from S_C an aqueous liquid stream S_{RW} having a temperature $T_{RW} > T_C$, and obtaining from S_{EV1} or the part stream thereof an at least partially condensed aqueous stream S_{EL1} having a temperature T_{EL1} with $T_{EL1} < T_{EV1}$, the process further comprising
 30 combining at least a part of the stream S_{EL1} in U_C with S_{EL2} and S_{EL3} ;
 (vi) recycling at least part of the stream S_{RW} into the reaction unit U_R .

According to the process of the present invention, it may be preferred to further feed, in addition to at least one of the streams $S_{EL2}(k)$ or a part stream thereof, preferably all streams $S_{EL2}(k)$ or
 35 part streams thereof, and at least one of the streams $S_{EL3}(j)$ or a part stream thereof, preferably all streams $S_{EL3}(j)$ or part streams thereof, as indicated above, at least one liquid aqueous stream S_P into U_C . This at least one aqueous stream S_P can be, for example, an aqueous stream obtained from processing the stream S_L in the purification unit U_P . By way of example, at least one liquid aqueous stream S_P may be obtained in the water separation unit U_{WS} as described
 40 above and /or at least one liquid aqueous stream S_P may be obtained in the distillation unit U_{DI} as described above, i.e. these liquid aqueous streams are obtained in the course of the overall ϵ -caprolactam purification process wherein water is separated from the aqueous stream S_L in order to ultimately obtain purified crystalline ϵ -caprolactam. Further, in addition to the at least one liquid

aqueous stream S_P , at least one further liquid aqueous stream S_E can be fed into U_C , wherein at least one further liquid aqueous stream S_E can be a fresh water stream, such as a fresh water make-up stream intended to at least partially compensate for a loss of water realized in the course of the overall process.

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Therefore, the present invention also relates to a process which further comprises feeding at least one liquid aqueous stream S_P and optionally at least one liquid aqueous stream S_E into U_C and combining S_P and optionally S_E in U_C with the streams S_{EL2} and S_{EL3} , and the streams $S_{EL2}(k)$ and $S_{EL3}(j)$, respectively, wherein S_P is an aqueous stream obtained from the purification unit U_P and wherein S_E is a fresh water stream. Preferably, the aqueous stream S_P is obtained as optionally combined stream of at least one or more of the water separation unit U_{WS} as described above and the distillation unit U_{DI} as described above.

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According to the process of the present invention, it may be preferred to pass the stream S_{RW} , prior to recycling at least part of S_{RW} into the reaction unit U_R , through a heat exchange unit U_{H2} , obtaining a heated stream S_W having a temperature in the range of from $0.95 T_D$ to $1.05 T_D$. By way of example, the heat used for heating at least part of S_{RW} in U_H to the described temperature may be provided by hot oil. In this case, the process preferably further comprises (vi) recycling at least part of the stream S_{RW} as part of the stream S_W into the reaction unit U_R .

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In the course of the overall process of the present invention, it may be preferred to pass one or more streams through respective filtration units. By way of preferred examples, the process of the present may comprise one or more of

- passing the stream S_R , upstream of U_E , through a filtration unit U_{F1} ;
- 25 - passing the stream S_L , upstream of U_P , through a filtration unit U_{F2} ;
- passing the stream S_{LU1} , upstream of U_{E2} , through a filtration unit U_{F3} .

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Generally, the process of the present invention is a continuous process, a semicontinuous process or a batch process. It is conceivable that one or more stages of the process are carried out in a continuous manner, and one or more stages are carried out in a suitable semi-continuous and/or in a suitable batch-type manner so that the overall process can be classified as a continuous process.

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The process of the present invention represents a highly heat-integrated, economically and ecologically superior process for recovering ϵ -caprolactam, in particular from polyamide 6 containing waste material. Preferably, the heat efficiency η_{EFF} of the process of the present invention is at least 80 %, preferably in the range of from 80 to 100 %, more preferably in the range of from 90 to 100 %, with $\eta_{EFF} = (\Delta H_{UP1} + \Delta H_{UP2} + \Delta H_{UH}) / \Delta H_{SR}$ wherein

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- 40 ΔH_{UP1} is the total heat demand of the purification sub-unit U_{P1} according to (iii);
- ΔH_{UP2} is the total heat demand of the purification sub-unit U_{P2} according to (iii);
- ΔH_{UH} is the total heat transferred in the heat exchange unit U_H according to (v);
- ΔH_{SR} is the amount of usable energy contained in the stream S_R obtained according to (i.4).

More preferred ranges of η_{EFF} may be from 97 to 100 % or from 98 to 100 % or from 99 to 100 %.

Preferably according to the present invention, at least one of, more preferably at least two of,

5 more preferably the three following relative quantities are realized:

- $\Delta H_{\text{UP1}}(\text{rel}) = \Delta H_{\text{UP1}} / (\Delta H_{\text{UP1}} + \Delta H_{\text{UP2}} + \Delta H_{\text{UH}})$ is preferably in the range of from 30 to 50 %, more preferably in the range of from 35 to 45 %;

- $\Delta H_{\text{UP2}}(\text{rel}) = \Delta H_{\text{UP2}} / (\Delta H_{\text{UP1}} + \Delta H_{\text{UP2}} + \Delta H_{\text{UH}})$ is preferably in the range of from 15 to 30 %, more preferably in the range of from 20 to 25 %;

10 - $\Delta H_{\text{UH}}(\text{rel}) = \Delta H_{\text{UH}} / (\Delta H_{\text{UP1}} + \Delta H_{\text{UP2}} + \Delta H_{\text{UH}})$ is preferably in the range of from 30 to 45 %, more preferably in the range of from 35 to 40 %;

with the proviso that $\Delta H_{\text{UP1}}(\text{rel}) + \Delta H_{\text{UP2}}(\text{rel}) + \Delta H_{\text{UH}}(\text{rel}) = 1$.

15 Generally, the stream S_{CPL} obtained according to (iii), i.e. the purified ϵ -caprolactam stream, can be used for any suitable purpose.

According to a preferred use of the stream S_{CPL} , the process of the present invention further comprises providing at least part of the stream S_{CPL} obtained according to (iii) 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}

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

(B) remaining material M_{R} is obtained as textile waste material;

25 wherein at least part of the textile waste material according to (A), or at least part of the textile waste material according to (B), or at least part of the textile waste material according to (A) and at least part of the textile waste material according to (B) is suitably provided to U_{R} as S_{M} , preferably via U_{M} .

30 According to a preferred use of the stream S_{CPL} , the process of the present invention further comprises providing at least part of the stream S_{CPL} obtained according to (iii) 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}

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

(B) remaining material M_{R} is obtained as engineering plastics waste material;

40 wherein at least part of the engineering plastics waste material according to (A), or at least part of the engineering plastics waste material according to (B), or at least part of the engineering plastics waste material according to (A) and at least part of the engineering plastics waste material according to (B) is suitably provided to U_{R} as S_{M} , preferably via U_{M} .

Thus, the present invention also relates to the use of the stream S_{CPL} , obtainable or obtained by a process as described above, 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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Accordingly, the present invention also relates to a method for preparing polyamide 6, said method comprising employing S_{CPL} , obtainable or obtained by a process as described above, 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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Generally, the present invention also relates to the use of the stream S_{CPL} , obtainable or obtained by a process as described above, for preparing one or more of a polymer and a polymer product; or to a method for preparing one or more of a polymer and a polymer product, said method comprising employing the stream S_{CPL} , obtainable or obtained by a process as described above, as a starting material.

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Accordingly, the present invention also relates to the use or the method as described above, 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.

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Accordingly, the present invention also relates to the use or the method as described above, wherein the polymer, or the polymer product, or the polymer and the polymer product comprises or comprise polyamide 6 and optionally at least one further polymeric compound, said polyamide 6 being at least partially obtainable or obtained from S_{CPL} , said S_{CPL} being obtainable or obtained by a process as described above, 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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Accordingly, the present invention also relates to the use or the method as described above, 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:

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- 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

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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 a 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.

Accordingly, the present invention also relates to the use or the method as described above, wherein the polymer, or the polymer product, or the polymer and the polymer product contains or contain polyamide 6, obtainable or obtained from S_{CPL} , said S_{CPL} being obtainable or obtained by a process as described above, 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 purified ϵ -caprolactam from polyamide 6 contained in a solid material M, the process comprising
 - (i) preparing an aqueous liquid stream S_R comprising ϵ -caprolactam dissolved in water, comprising
 - (i.1) providing the solid material M comprising the polyamide 6, and providing an aqueous liquid stream S_W ;
 - (i.2) preparing an aqueous depolymerization mixture based on the solid material M and the aqueous liquid stream S_W provided according to (i.1);
 - (i.3) subjecting the aqueous depolymerization mixture prepared according to (i.2) to depolymerization conditions in a chemical reaction unit U_R , said depolymerization conditions comprising a depolymerization temperature T_D at a depolymerization pressure p_D , obtaining in U_R a liquid aqueous reaction mixture M_R comprising ϵ -caprolactam dissolved in water;
 - (i.4) removing the aqueous liquid stream S_R from U_R , wherein S_R comprises ϵ -caprolactam at an ϵ -caprolactam concentration c_{SR} and wherein S_R has a pressure p_{SR} with $0.95 p_D \leq p_{SR} \leq p_D$ and a temperature T_{SR} with $0.95 T_D \leq T_{SR} \leq T_D$;
 - (ii) subjecting the liquid aqueous stream S_R obtained according to (i.4) to depressurization in an evaporation unit U_E , obtaining from U_E aqueous vapor streams S_{EV1} , S_{EV2} and S_{EV3} , wherein S_{EV1} has a pressure p_{EV1} and a temperature T_{EV1} , wherein S_{EV2} has a pressure p_{EV2} and a temperature T_{EV2} , and wherein S_{EV3} has a pressure p_{EV3} and a temperature T_{EV3} , wherein $p_{EV1} > p_{EV2} > p_{EV3}$; and further obtaining from U_E an aqueous liquid stream S_L comprising ϵ -caprolactam at an ϵ -caprolactam concentration c_{SL} with $c_{SL} > c_{SR}$;
 - (iii) passing the aqueous liquid stream S_L obtained according to (ii) through a heat-consuming purification unit U_P comprising at least two heat-consuming purification sub-units U_{P1} and U_{P2} , obtaining from U_P a stream S_{CPL} comprising ϵ -caprolactam at an ϵ -caprolactam concentration c_{SCPL} with $c_{SCPL} \gg c_{SL}$;
 - (iv) providing at least part of the heat consumed in U_{P1} by S_{EV3} or a part stream thereof, thereby obtaining from S_{EV3} or the part stream thereof an at least partially condensed aqueous stream S_{EL3} having a pressure p_{EL3} and a temperature T_{EL3} with $T_{EL3} \leq T_{EV3}$; and providing at least part of the heat consumed in U_{P2} by S_{EV2} or a part stream thereof, thereby obtaining from S_{EV2} or the part stream thereof an at least partially condensed aqueous stream S_{EL2} having a pressure p_{EL2} and a temperature T_{EL2} with $T_{EL2} \leq T_{EV2}$;
 - (v) subjecting at least part of the aqueous stream S_{EL3} and at least part of the aqueous stream S_{EL2} to heat exchange in a heat exchange unit U_H , wherein at least part of the heat transferred in U_H is provided by the aqueous vapor stream S_{EV1} or a part stream thereof, thereby obtaining from S_{EL3} and S_{EL2} an aqueous liquid stream S_{RW} having a temperature T_{RW} with $T_{RW} > T_{EL3}$ and $T_{RW} > T_{EL2}$, and obtaining from S_{EV1} or the part

stream thereof an at least partially condensed aqueous stream S_{EL1} having a temperature T_{EL1} with $T_{EL1} \leq T_{EV1}$;

- (vi) recycling at least part of the stream S_{RW} and at least part of the stream S_{EL1} into the reaction unit U_R .

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2. The process of embodiment 1, wherein preparing the aqueous depolymerization mixture according to (i.2) comprises

(i.2.1) melting in a melting unit U_M the solid material M provided according to (i.1), obtaining a liquid stream S_M having a temperature T_{SM} at a pressure p_{SM} ;

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(i.2.2) admixing in a pre-reaction unit U_{PR} the stream S_M obtained according to (i.2.1) with the stream S_W provided according to (i.1) and 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} ;

(i.2.3) feeding the stream S_F obtained according to (i.2.2) as the depolymerization mixture into the chemical reaction unit U_R ;

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wherein

$0.8 \leq T_{SF}/T_D \leq 1.05$ 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 $0.9 \leq p_{SW}/p_{SF} \leq 1.05$.

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3. The process of embodiment 2, wherein the pre-reaction unit U_{PR} according to (i.2.2) comprises, 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.

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4. The process of embodiment 2 or 3, wherein according to (i.2.1), S_W and S_M are admixed in U_{PR} at a mixing ratio $(m_W/kg) / (m_P/kg)$ in the range of from 1:1 to 20:1, 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 .

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5. The process of any one of embodiments 1 to 4, wherein the reaction unit U_R according to (i.3) 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.

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6. The process of embodiment 5, wherein at least 1, preferably z reactors R_i , are stirred tank reactors.

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7. The process of any one of embodiments 1 to 6, wherein providing the solid material M according to (i.1) comprises

- (i.1.1) 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;
- 5 (i.1.2) passing the solid material M provided according to (i.1.1) 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 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} ;
- 10 (i.1.3) 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.
8. The process of any one of embodiments 1 to 7, wherein according to (i.1), the solid material M is provided, preferably provided to U_M , 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:
- 15 - 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;
- 20 - a D50 value of the particle width in the range of from 0.2 to 20 mm and a D50 value of the particle length in the range of from 0.5 to 20 mm;
- a D90 value of the particle width in the range of from 0.3 to 30 mm and a D90 value of the particle length in the range of from 0.8 to 30 mm.
- 25 9. The process of any one of embodiments 1 to 8, wherein from 10 to 100 weight-%, preferably from 30 to 100 weight-%, more preferably from 50 to 100 weight-%, more preferably from 80 to 100 weight-%, of the solid material M consist of the polyamide 6.
- 30 10. The process of any one of embodiments 1 to 9, wherein the solid material M provided according to (i.1) comprises, preferably consists of, a waste material, preferably one or more of a textile waste material and an engineering plastics waste material, more preferably of a textile waste material.
- 35 11. The process of any one of embodiments 1 to 10, wherein the evaporation unit U_E according to (ii) comprises two evaporation sub-units U_{E1} and U_{E2} , wherein U_{E1} and U_{E2} are preferably serially coupled.
- 40 12. The process of embodiment 11, wherein at least one evaporation sub-unit, preferably the two evaporation sub-units U_{E1} and U_{E2} comprise, preferably consist of a flash drum.
13. The process of embodiment 11 or 12, wherein (ii) comprises

- (ii.1) subjecting the liquid aqueous stream S_R obtained according to (i.4) to depressurization in the evaporation sub-unit U_{E1} , obtaining from U_{E1} an aqueous vapor stream S_{EV1A} having the pressure p_{EV1} , and further obtaining an at least partially aqueous liquid stream S_{LU1} ;
- 5 (ii.2) dividing the stream S_{EV1A} , obtaining the stream S_{EV1} and a stream S_{EV1B} having the pressure p_{EV1} ;
- (ii.3) subjecting the stream S_{EV1B} to depressurization in a unit U_{V1} , U_{V1} preferably comprising a valve, more preferably a pressure relief valve, obtaining the stream S_{EV2} ;
- 10 (ii.4) subjecting the stream S_{LU1} obtained according to (ii.1) to depressurization in U_{E2} , obtaining from U_{E2} an aqueous vapor stream S_{EV3A} and the liquid stream S_L .
14. The process of embodiment 13, wherein the aqueous vapor stream S_{EV3A} is the aqueous vapor stream S_{EV3} .
- 15 15. The process of embodiment 13, wherein obtaining the stream S_{EV3} further comprises one or more of (ii.5.1) and (ii.5.2):
- (ii.5.1) separating a stream S_{EV1C} from the stream S_{EV1A} , obtained according to (ii.1), the stream S_{EV1C} having the pressure p_{EV1} ; subjecting the stream S_{EV1C} to depressurization in a unit U_{V2} , U_{V2} preferably comprising a valve, more preferably a pressure relief valve, obtaining a stream S_{EV3B} having the pressure p_{EV3} ;
- 20 (ii.5.2) separating a stream S_{EV2A} from the stream S_{EV2} obtained according to (ii.3), the stream S_{EV2A} having the pressure p_{EV2} ; subjecting the stream S_{EV2A} to depressurization in a unit U_{V3} , U_{V3} preferably comprising a valve, more preferably a pressure relief valve, obtaining a stream S_{EV3C} having the pressure p_{EV3} ;
- 25 and further comprises
- (ii.6) admixing one or more of the streams S_{EV3B} obtained according to (ii.5.1) and the stream S_{EV3C} obtained according to (ii.5.2) to the stream S_{EV3A} obtained according to (ii.4), obtaining the stream S_{EV3} .
- 30 16. The process of any one of embodiments 1 to 15, wherein
- p_D is in the range of from 40 to 140 bar, preferably in the range of from 40 to 125 bar, more preferably in the range of from 40 to 110 bar; and T_D is in the range of from 230 to 335 °C, preferably in the range of from 250 to 320 °C, more preferably in the range of from 270 to 310 °C;
 - 35 - p_{EV1} is in the range of from 13 to 19 bar, preferably in the range of from 14 to 18 bar, more preferably in the range of from 15 to 17 bar; and T_{EV1} is in the range of from 170 to 230 °C, preferably in the range of from 180 to 220 °C, more preferably in the range of from 190 to 210 °C;
 - p_{EV2} is in the range of from 5 to 11 bar, preferably in the range of from 6 to 10 bar, more preferably in the range of from 7 to 9 bar; and
 - 40 T_{EV2} is in the range of from 150 to 210 °C, preferably in the range of from 160 to 200 °C, more preferably in the range of from 170 to 190 °C;

- p_{EV3} is in the range of from 0.95 to 1.5 bar, preferably in the range of from 1.0 to 1.4 bar, more preferably in the range of from 1.1 to 1.3 bar; and
 T_{EV3} is in the range of from 90 to 140 °C, preferably in the range of from 100 to 130 °C, more preferably in the range of from 110 to 120 °C.
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17. The process of any one of embodiments 1 to 16, wherein
- $0.95 p_{EV1} \leq p_{EL1} \leq p_{EV1}$; and
 $\Delta T_{VL1} = T_{EV1} - T_{EL1}$ is in the range of from 2 to 10 °C, preferably in the range of from 3 to 8 °C, more preferably in the range of from 4 to 6 °C;
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- $0.95 p_{EV2} \leq p_{EL2} \leq p_{EV2}$; and
 $\Delta T_{VL2} = T_{EV2} - T_{EL2}$ is in the range of from 15 to 40 °C, preferably in the range of from 18 to 32 °C, more preferably in the range of from 20 to 30 °C;
- $0.95 p_{EV3} \leq p_{EL3} \leq p_{EV3}$; and
 $\Delta T_{VL3} = T_{EV3} - T_{EL3}$ is in the range of from 10 to 30 °C, preferably in the range of from 12.5 to 27.5 °C, more preferably in the range of from 15 to 25 °C.
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18. The process of any one of embodiments 1 to 17, wherein (v) and (vi) comprise
- (v) combining at least part of the stream S_{EL2} and at least part of the stream S_{EL3} in a unit U_C , obtaining a combined aqueous liquid stream S_C , and subjecting at least part of
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- the aqueous liquid stream S_C to heat exchange in a heat exchange unit U_H , wherein at least part of the heat transferred in U_H is provided by the aqueous vapor stream S_{EV1} or a part stream thereof, thereby obtaining from S_C an aqueous liquid stream S_{RW} having a temperature $T_{RW} > T_C$, and obtaining from S_{EV1} or the part stream thereof an at least partially condensed aqueous stream S_{EL1} having a temperature T_{EL1} with T_{EL1}
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- $< T_{EV1}$, the process further comprising combining at least part of the stream S_{EL1} in U_C with S_{EL2} or the part stream thereof and the stream S_{EL3} or the part stream thereof;
- (vi) recycling at least part of the stream S_{RW} into the reaction unit U_R .
19. The process of any one of embodiments 1 to 18, comprising
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- (iii) passing the aqueous liquid stream S_L obtained according to (ii) through a heat-consuming purification unit U_P at least comprising m heat-consuming purification sub-units $U_{P1}(j)$, $j=1..m$, $m \geq 2$, and n heat-consuming purification sub-units $U_{P2}(k)$, $k=1..n$, $n \geq 2$ obtaining from U_P a stream S_{CPL} comprising ϵ -caprolactam at an ϵ -caprolactam concentration C_{SCPL} with $C_{SCPL} \gg C_{SL}$;
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- (iv) dividing the stream S_{EV3} in at least m part streams $S_{EV3}(j)$ having a temperature $T_{EV3}(j) = T_{EV3}$ and a pressure $p_{EV3}(j) = p_{EV3}$, and dividing the stream S_{EV2} in at least n part streams $S_{EV2}(k)$ having a temperature $T_{EV2}(j) = T_{EV2}$ and a pressure $p_{EV2}(j) = p_{EV2}$; and providing at least part of the heat consumed in $U_{P1}(j)$ by $S_{EV3}(j)$, thereby obtaining from $S_{EV3}(j)$ an at least partially condensed aqueous stream $S_{EL3}(j)$ having a pressure $p_{EL3}(j)$ and a temperature $T_{EL3}(j)$ with $T_{EL3}(j) < T_{EV3}(j)$; and providing at least part of the
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- heat consumed in $U_{P2}(k)$ by $S_{EV2}(k)$, thereby obtaining from $S_{EV2}(k)$ an at least partially condensed aqueous stream $S_{EL2}(k)$ having a pressure $p_{EL2}(k)$ and a temperature $T_{EL2}(k)$ with $T_{EL2}(k) < T_{EV2}(k)$;

- (v) subjecting at least parts of the aqueous streams $S_{EL3}(j)$ and $S_{EL2}(k)$ to heat exchange in a heat exchange unit U_H , wherein at least part of the heat transferred in U_H is provided by the aqueous vapor stream S_{EV1} or a part stream thereof, thereby obtaining from the streams $S_{EL3}(j)$ and the streams $S_{EL2}(k)$ an aqueous liquid stream S_{RW} having a temperature T_{RW} with $T_{RW} > T_{EL3}(j)$ and $T_{RW} > T_{EL2}(k)$, and obtaining from S_{EV1} or the part stream thereof an at least partially condensed aqueous stream S_{EL1} having a temperature T_{EL1} with $T_{EL1} < T_{EV1}$;
- (vi) recycling at least part of the stream S_{RW} and at least part of the stream S_{EL1} into the reaction unit U_R .
20. The process of embodiment 19, wherein according to (iii), the m heat-consuming purification sub-units $U_{P1}(j)$ comprise one or more of a water separation unit U_{WS} and a crystallization unit U_{CR} , wherein the water separation unit U_{WS} preferably comprises one or more of an evaporator arranged upstream of a flash tank and a film evaporator, more preferably one or more of an evaporator arranged upstream of a flash tank and a falling film evaporator, and wherein the crystallization unit U_{CR} preferably comprises at least one heat exchanger preferably for providing a heating medium used for crystallization purposes.
21. The process of embodiment 20, wherein a stream $S_{EV3}(j)$ is used for providing at least part of the heat consumed by the evaporator arranged upstream of the flash tank comprised in the water separation unit U_{WS} , thereby obtaining a stream $S_{EL3}(j)$.
22. The process of embodiment 20 or 21, wherein a stream $S_{EV3}(j)$ is used for providing at least part of the heat consumed in the water separation unit U_{WS} , thereby obtaining a stream $S_{EL3}(j)$.
23. The process of any one of embodiments 20 to 22, wherein a stream $S_{EV3}(j)$ is used for providing at least part of the heat consumed by the at least one heat exchanger of the crystallization unit U_{CR} , thereby obtaining a stream $S_{EL3}(j)$.
24. The process of any one of embodiments 20 to 23, wherein according to (iii), the n heat-consuming purification sub-units $U_{P2}(k)$ comprise a distillation unit U_{DI} , wherein U_{DI} preferably comprises at least one distillation column, preferably at least two distillation columns, more preferably at least three distillation columns, more preferably at least three serially arranged distillation columns, and wherein the n heat-consuming purification sub-units $U_{P2}(k)$ preferably further comprise one or more of a high-boiler separation unit U_{HS} and a chemical treatment unit U_{CT} , more preferably a high-boiler separation unit U_{HS} and a chemical treatment unit U_{CT} .
25. The process of embodiment 24, wherein in at least one of the distillation columns, preferably in each distillation column, a first stream $S_{EV2}(k_1)$ is passed as a direct heating medium through a heating jacket of said distillation column, thereby obtaining a first stream $S_{EL2}(k_1)$, and second stream $S_{EV2}(k_2)$ is passed as an indirect heating medium through a

heat exchanger, preferably a heat exchanger used for sump evaporation of said distillation column, thereby obtaining a second stream $S_{EL2}(k_2)$.

26. The process of embodiment 24 or 25, wherein the distillation in at least one distillation column is carried out as a vacuum distillation, wherein the process further comprises operating at least one vacuum generating means, preferably at least one vacuum ejector, with at least one stream $S_{EV2}(k)$.
27. The process of any one of embodiments 24 to 26, wherein the purification unit U_P comprises a heat-consuming water separation unit U_{WS} , a heat-consuming distillation unit U_{DI} and a heat-consuming crystallization unit U_{CR} , the process comprising feeding the stream S_L comprising ϵ -caprolactam at a concentration c_{SL} to U_{WS} , obtaining from U_{WS} a stream S_{UWS} comprising ϵ -caprolactam at a concentration c_{SUWS} , feeding the stream S_{UWS} to the distillation unit U_{DI} , obtaining from U_{DI} a stream S_{UDI} comprising ϵ -caprolactam at a concentration c_{SUDI} , and feeding the stream S_{UDI} into the crystallization unit U_{CR} , obtaining from U_{CR} the stream S_{CPL} comprising ϵ -caprolactam at the concentration c_{SCPL} , wherein $c_{SL} < c_{SUWS} < c_{SUDI} < c_{SCPL}$;
wherein the purification unit U_P preferably further comprises a heat-consuming high-boiler separation unit U_{HS} , the process preferably comprising feeding the stream S_L comprising ϵ -caprolactam at a concentration c_{SL} to U_{WS} , obtaining from U_{WS} a stream S_{UWS} comprising ϵ -caprolactam at a concentration c_{SUWS} , feeding the stream S_{UWS} to the high-boiler separation unit U_{HS} , obtaining from U_{HS} a stream S_{UHS} comprising ϵ -caprolactam at a concentration c_{SUHS} , feeding the stream S_{UHS} to the distillation unit U_{DI} , obtaining from U_{DI} a stream S_{UDI} comprising ϵ -caprolactam at a concentration c_{SUDI} , and feeding the stream S_{UDI} into the crystallization unit U_{CR} , obtaining from U_{CR} the stream S_{CPL} comprising ϵ -caprolactam at the concentration c_{SCPL} , wherein $c_{SL} < c_{SUWS} < c_{SUHS} < c_{SUDI} < c_{SCPL}$.
28. The process of any one of embodiments 19 to 27, wherein (v) and (vi) comprise
 - (v) combining at least one of the streams $S_{EL2}(k)$ or a part stream thereof, preferably all streams $S_{EL2}(k)$ or part streams thereof, and at least one of the streams $S_{EL3}(j)$ or a part stream thereof, preferably all streams $S_{EL3}(j)$ or part streams thereof, in a unit U_C , obtaining a combined aqueous liquid stream S_C , and subjecting at least a part of the aqueous liquid stream S_C to heat exchange in a heat exchange unit U_H , wherein at least part of the heat transferred in U_H is provided by the aqueous vapor stream S_{EV1} or a part stream thereof, thereby obtaining from S_C an aqueous liquid stream S_{RW} having a temperature $T_{RW} > T_C$, and obtaining from S_{EV1} or the part stream thereof an at least partially condensed aqueous stream S_{EL1} having a temperature T_{EL1} with $T_{EL1} < T_{EV1}$, the process further comprising combining at least a part of the stream S_{EL1} in U_C with S_{EL2} and S_{EL3} ;
 - (vi) recycling at least part of the stream S_{RW} into the reaction unit U_R .
29. The process of embodiment 28, further comprising feeding at least one liquid aqueous stream S_P and optionally at least one liquid aqueous stream S_E into U_C and combining S_P

and optionally S_E in U_C with the streams S_{EL2} and S_{EL3} , and the streams $S_{EL2}(k)$ and $S_{EL3}(j)$, respectively, wherein S_P is an aqueous stream obtained from the purification unit U_P and wherein S_E is a fresh water stream.

- 5 30. The process of embodiment 29, wherein the aqueous stream S_P is obtained as optionally combined stream of at least one or more of the water separation unit U_{WS} as defined in embodiment 20 and the distillation unit U_{DI} as defined in embodiment 24.
- 10 31. The process of any one of embodiments 1 to 30, comprising passing the stream S_{RW} , prior to recycling at least part of S_{RW} into the reaction unit U_R , through a heat exchange unit U_{H2} , obtaining a heated stream S_W having a temperature in the range of from $0.95 T_D$ to $1.05 T_D$.
- 15 32. The process of any one of embodiments 1 to 31, wherein (vi) comprises
(vi) recycling at least part of the stream S_{RW} as part of the stream S_W into the reaction unit U_R .
- 20 33. The process of any one of embodiments 1 to 32, preferably as far as being dependent on embodiment 13, comprising one or more of
- passing the stream S_R , upstream of U_E , through a filtration unit U_{F1} ;
- passing the stream S_L , upstream of U_P , through a filtration unit U_{F2} ;
- passing the stream S_{LU1} , upstream of U_{E2} , through a filtration unit U_{F3} .
- 25 34. The process of any one of embodiments 1 to 33, exhibiting a heat efficiency ΔH_{EFF} of at least 80 %, preferably in the range of from 80 to 100 %, more preferably in the range of from 90 to 100 %, with $\eta_{EFF} = (\Delta H_{UP1} + \Delta H_{UP2} + \Delta H_{UH}) / \Delta H_{SR}$
wherein
 ΔH_{UP1} is the total heat demand of the purification sub-unit U_{P1} according to (iii);
 ΔH_{UP2} is the total heat demand of the purification sub-unit U_{P2} according to (iii);
 ΔH_{UH} is the total heat transferred in the heat exchange unit U_H according to (v);
30 ΔH_{SR} is the amount of usable energy contained in the stream S_R obtained according to (i.4).
- 35 35. The process of embodiment 34, wherein at least one of, more preferably at least two of, more preferably the three following relative quantities are realized:
- $\Delta H_{UP1}(rel) = \Delta H_{UP1} / (\Delta H_{UP1} + \Delta H_{UP2} + \Delta H_{UH})$ is preferably in the range of from 30 to 50 %, more preferably in the range of from 35 to 45 %;
- $\Delta H_{UP2}(rel) = \Delta H_{UP2} / (\Delta H_{UP1} + \Delta H_{UP2} + \Delta H_{UH})$ is preferably in the range of from 15 to 30 %, more preferably in the range of from 20 to 25 %;
- $\Delta H_{UH}(rel) = \Delta H_{UH} / (\Delta H_{UP1} + \Delta H_{UP2} + \Delta H_{UH})$ is preferably in the range of from 30 to 45
40 %, more preferably in the range of from 35 to 40 %;
with the proviso that $\Delta H_{UP1}(rel) + \Delta H_{UP2}(rel) + \Delta H_{UH}(rel) = 1$.

36. The process of any one of embodiments 1 to 35, being a continuous process, a semicontinuous process or a batch process.
37. The process of any one of embodiments 1 to 36, further comprising providing at least part of the stream S_{CPL} obtained according to (iii) to a polyamide 6 production unit U_{PP} , wherein the polyamide 6 produced in U_{PP} is preferably provided as a feedstock to a textile material producing unit U_{TP} , from which unit U_{TP}
- (A) a textile material M_T is obtained which is brought onto the market, wherein, after the life-time T_{MT} of said textile material M_T it is at least partially collected as textile waste material in a textile material collecting unit U_{TC} ;
- (B) remaining material M_R is obtained as textile waste material; wherein at least part of the textile waste material according to (A), or at least part of the textile waste material according to (B), or at least part of the textile waste material according to (A) and at least part of the textile waste material according to (B) is suitably provided to U_R as S_M , preferably via U_M .
38. The process of any one of embodiments 1 to 37, further comprising providing at least part of the stream S_{CPL} obtained according to (iii) to a polyamide 6 production unit U_{PP} , wherein the polyamide 6 produced in U_{PP} is preferably provided as a feedstock to an engineering plastics material producing unit U_{EP} , from which unit U_{EP}
- (A) an engineering plastics material M_E is obtained which is brought onto the market, wherein, after the life-time T_{ME} of said engineering plastics material M_E it is at least partially collected as engineering plastics waste material in an engineering plastics material collecting unit U_{EC} ;
- (B) remaining material M_R is obtained as engineering plastics waste material; wherein at least part of the engineering plastics waste material according to (A), or at least part of the engineering plastics waste material according to (B), or at least part of the engineering plastics waste material according to (A) and at least part of the engineering plastics waste material according to (B) is suitably provided to U_R as S_M , preferably via U_M .
39. Use of S_{CPL} , obtainable or obtained by a process according to any one of embodiments 1 to 38, 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.
40. A method for preparing polyamide 6, said method comprising employing S_{CPL} , obtainable or obtained by a process according to any one of embodiments 1 to 38, 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.
41. Use of S_{CPL} , obtainable or obtained by a process according to any one of embodiments 1 to 38, for preparing one or more of a polymer and a polymer product; or

a method for preparing one or more of a polymer and a polymer product, said method comprising employing S_{CPL}, obtainable or obtained by a process according to any one of embodiments 1 to 38, as a starting material.

- 5 42. The use or the method of embodiment 41, 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.
- 10 43. The use or the method of embodiment 41 or 42, wherein the polymer, or the polymer product, or the polymer and the polymer product comprises or comprise polyamide 6 and optionally at least one further polymeric compound, said polyamide 6 being at least partially obtainable or obtained from S_{CPL}, said S_{CPL} being obtainable or obtained by a process according to any one of embodiments 1 to 36, 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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- 20 44. The use or the method of any one of embodiments 41 to 42, wherein the polymer, or the polymer product, or the polymer and the polymer product is or are one of the following or a part of one of the following:
- a part of a car, preferably a cylinder head cover, an engine cover, a housing for a charge air cooler, a charge air cooler flap, an intake pipe, an intake manifold, a connector, a gear wheel, a fan wheel, a cooling water box, a housing or a housing part for a heat exchanger, a coolant cooler, a charge air cooler, a thermostat, a water pump, a radiator, a fastening part or a part of a battery system for electromobility, a dashboard, a steering column switch, a seat, a headrest, a center console, a transmission component, a door module, a car exterior for an A, a B, a C or a D pillar cover, a spoiler, a door handle, an exterior mirror, a windscreen wiper, a windscreen wiper protection housing, a decorative grill, a cover strip, a roof rail, a window frame, a sunroof frame, an antenna panel, a headlight, a taillight, an airbag, a top mount, an oil pan, a fuel cell, a heat shield and/or a cushion;
 - a cloth, an apparel, preferably a shirt, trousers, a pullover, a boot, a shoe, a shoe sole, a tight, a yarn, a fabric, and/or or jacket;
 - an electrical part, preferably an electrical component, an electronic passive component, an electronic active component, a printed circuit board, a housing component, a foil, a line, a switch such as a microswitch, a plug, a socket, a distributor, a relay, a resistor, a capacitor, an inductor, a bobbin, a lamp, a diode such as an LED, a transistor, a connector, a regulator, an integrated circuit (IC), a processor, a controller, a memory, a sensor, a microbutton, a semiconductor, a reflector housing for example for light-emitting diodes, a fastener for an electrical and/or an electronic component, a spacer, a bolt, a
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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.

45. The use or the method of any one of embodiments 41 to 44, wherein the polymer, or the polymer product, or the polymer and the polymer product contains or contain polyamide 6, obtainable or obtained from S_{CPL} , said S_{CPL} being obtainable or obtained by a process according to any one of embodiments 1 to 36, 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 45 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 41 to 45 are concerned, preparing the polymer, the polymer product, or the polymer and the polymer product may comprise one or more synthesis steps and can be performed by conventional synthesis and technics well known to the person skilled in the art. Examples of the synthesis steps are described in "Industrial Organic Chemistry", 3rd volume, Wiley-VCH, 1997; ISBN: 978-3-527-28838-0; „Kunststoffhandbuch“, 11 volumes in 17 sub-volumes, Carl Hanser Verlag, especially volume 6, „Polyamide“, 1st edition, 1966; "Injection Molding Reference Guide, 4th edition, CreateSpace Independent Publishing Platform, 2011, ISBN: 978-1466407824; WO 2008/155271 A1 and WO 2013/139827 A1, each of which is 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 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.

Preferred aspects of the present invention are further illustrated in the Figures 1 to 12 as described hereinunder.

Description of the figures

Fig. 1 illustrates a process according to the present invention. In a reaction unit U_R , a depolymerization mixture (not shown) which is based on an a solid material M and an aqueous liquid stream is subjected to polyamide 6 depolymerization conditions, and from the reaction unit U_R , an aqueous liquid stream S_R comprising ϵ -caprolactam dissolved in water is obtained. This stream S_R is then subjected to depressurization conditions in an evaporation unit U_E from which aqueous vapor streams S_{EV1} , S_{EV2} and S_{EV3} are obtained, as well as an aqueous liquid stream S_L . The liquid stream S_L is then passed to a purification unit U_P where it is purified with respect to the oligomeric compound ϵ -caprolactam. From U_P , a respectively purified stream S_{CPL} is obtained. The unit U_P comprises at least two heat-consuming purification sub-units U_{P1} and U_{P2} (not shown), and at least part the heat consumed in U_{P1} is provided by S_{EV3} and at least part the heat consumed in U_{P2} is provided by S_{EV2} . Due to this heat transfer, condensation takes place, and from the vapor streams S_{EV2} and S_{EV3} , liquid streams S_{EL2} and S_{EL3} are obtained which are passed the a heat exchange unit U_H from which, based on the streams S_{EL2} and S_{EL3} , a respectively heated liquid aqueous stream S_{RW} is obtained which is recycled to the reaction unit

U_R as a source of water for the hydrolytic polyamide 6 depolymerization reaction. The heat for obtaining the stream S_{RW} based on S_{EL1} and S_{EL2} is provided by the aqueous vapor stream S_{EV1} which, after heat transfer in U_H , is obtained as (condensed) liquid stream S_{EL1} which, as S_{RW} , is recycled to the reaction unit U_R as a source of water for the hydrolytic polyamide 6
 5 depolymerization reaction.

Fig. 2 illustrates a process according to the present invention. In this figure, and further to Fig. 1, the two (different) heat-consuming purification sub-units U_{P1} and U_{P2} (not shown in Fig. 1) comprised in U_P are shown wherein the heat consumed in U_{P1} is at least partially provided by the stream S_{EV3} (from which, due to the heat transfer, the liquid stream S_{EL1} is obtained), and wherein
 10 the heat consumed in U_{P2} is at least partially provided by the stream S_{EV2} (from which, due to the heat transfer, the liquid stream S_{EL2} is obtained).

Fig. 3 illustrates a process according to the present invention. In this figure, and further to Figs. 1 and 2, a preferred way of preparing the depolymerization mixture in the reaction unit U_R is shown. A solid material M comprising polyamide 6 and a liquid aqueous stream S_W are provided. The solid material M is melted in a melting unit U_M from which a melt stream S_M is obtained. This stream S_M is admixed with the stream S_W in a pre-reaction U_{PR} , and resulting mixed stream is then passed to the reaction unit U_R where it is subjected, as depolymerization mixture, to
 15 polyamide 6 depolymerization conditions.

Fig. 4 illustrates a process according to the present invention. In this figure, and further to Figs. 1 to 3, a preferred way of treating the stream S_{EL1} is shown. The stream S_{EL1} , obtained from S_{EV1} used for heating purposes in U_H , is not directly recycled back to U_R as shown in Figs. 1 and 3, but
 25 first fed into a unit U_C where it is combined with the liquid streams S_{EL2} and S_{EL3} obtained from the purification unit U_P . The respectively combined liquid stream S_C is then passed through U_H and thereby heated. From U_H , the liquid aqueous stream S_{RW} is obtained which is then recycled to the reaction unit U_R (via U_{PR}) as a source of water for the hydrolytic polyamide 6 depolymerization reaction.

Fig. 5 illustrates a process according to the present invention. In this figure, and further to Fig. 4, a preferred way of recycling the stream S_{RW} is shown. The liquid aqueous stream S_{RW} obtained from U_H , prior to being recycled to U_R , is admixed with a fresh water stream S_W , and the resulting aqueous liquid stream, also referred to S_W , is then passed into U_R (via U_{PR}) as a source of water
 35 for the hydrolytic polyamide 6 depolymerization reaction.

Fig. 6 illustrates a process according to the present invention. In this figure, it is shown that prior to being recycled to U_R , the liquid aqueous stream S_{RW} is further heated in the heat exchange unit U_{H2} . A fresh water stream (not shown) can be admixed, either, for example, to the stream S_C prior to being fed into U_C , and/or can be admixed with S_{EL1} prior to being passed into U_C , and/or can be fed directly into U_C , and/or can be admixed to S_{RW} prior to being fed into U_{H2} , and/or to S_W according to this Fig. 6 prior to being fed into U_{PR} . Further in this figure, it is shown that an aqueous stream S_P which is obtained from the purification unit U_P is additionally passed into
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U_C. By way of example, the stream S_P can be obtained from one or more distillation columns comprised in U_P or from one or more other evaporation devices comprised in U_P. The stream S_P can also be a combined stream of two or more aqueous streams obtained from U_P, wherein it is also possible that two or more of these aqueous streams obtained from U_P are fed separately into U_C.

Fig. 7 illustrates a process according to the present invention. In this figure, a preferred way of providing the aqueous vapor streams S_{EV1}, S_{EV2} and S_{EV3} in U_E is shown. First, the stream aqueous liquid S_R obtained from the reaction unit U_R (not shown) is fed into a first evaporation unit U_{E1} from which a first aqueous vapor stream S_{EV1A} (having a pressure p_{EV1}) and an aqueous liquid stream S_{LU1} are obtained. S_{LU1} is then passed to a first evaporation unit U_{E2}. The stream S_{EV1A} is divided, and one of the respectively obtained vapor streams is the stream S_{EV1} which is used according to the present invention preferably for heating purposes in the heat exchange unit U_H. The other part of the stream, S_{EV1B}, is passed to depressurization in the unit U_{V1} from which the stream S_{EV2} is obtained which has the pressure p_{EV2} which is lower than the p_{EV1}. Further, from the evaporation unit U_{E2}, the stream S_{EV3A} is obtained which, if not treated further, is the stream S_{EV3} having the pressure p_{EV3} which in turn is lower than p_{EV2}. Further from U_{E2}, the liquid stream S_L is obtained which is then passed to the purification unit U_P.

Fig. 8 illustrates a process according to the present invention. In this figure, further to figure 7, a further preferred way of providing the aqueous vapor streams S_{EV1}, S_{EV2} and S_{EV3} in U_E is shown. Further to what is described in the context of figure 7, the stream S_{EV1A}, prior to being divided in the streams S_{EV1B} and S_{EV1}, is divided to obtain the stream S_{EV1C} having the pressure p_{EV1}. S_{EV1C} is subjected to depressurization in the unit U_{V2} from which the stream S_{EV3B} is obtained, having the pressure p_{EV3}. Further, the stream S_{EV2} obtained from U_{V1} having the pressure p_{EV2} is divided, obtaining the stream S_{EV2A} (and the remaining stream S_{EV2}), wherein S_{EV2A} has the pressure p_{EV2}. S_{EV2A} is subjected to depressurization in the unit U_{V3} from which the stream S_{EV3C} is obtained, having the pressure p_{EV3}. The streams S_{EV3B} and S_{EV3C} can then be used for heating purposes as such. In this figure 8, it is shown that both streams are combined with the stream S_{EV3A}, resulting in the combined stream S_{EV3}. The streams S_{EV1}, S_{EV2} and S_{EV3} according to the present invention can, irrespective how they are prepared in U_E, fed in respective steam pipe systems and passed to the respective units where part streams of S_{EV1}, S_{EV2} and S_{EV3} are taken from the respective pipe systems and fed into the individual heat-consuming units.

Fig. 9 illustrates a process according to the present invention. In this figure, a preferred arrangement of heat-consuming purification sub-units comprised in U_P is shown. According to this arrangement, the liquid stream S_L is first passed to a water separation unit U_{WS}. It is noted that one or more water streams (not shown) obtained by this water separation together may form at least a part of the stream S_P described herein. The heat consumed in U_{WS} for water separation purposes is at least partially provided by the aqueous vapor stream S_{EV3(1)} which is a part stream of S_{EV1} obtained from U_E. From U_{WS}, a stream S_{UWS} is obtained which is sent to further purification in a distillation unit U_{DI}. In this figure 9, it is assumed, for example, that U_{DI} comprises two

- distillation columns. For each of these distillation columns, an individual vapor stream is provided by dividing the stream S_{EV2} obtained from U_E . From U_{DI} , a stream S_{UDI} is obtained which is sent to a crystallization unit U_{CR} for further purification and from which the (final) stream S_{CPL} is obtained containing the purified ϵ -caprolactam. The heat consumed in U_{CR} for crystallization purposes is at least partially provided by the stream $S_{EV3}(2)$, a part stream of S_{EV3} . From these heat-consuming purification sub-units, the respective (condensed) liquid streams $S_{EL3}(1)$, $S_{EL3}(2)$, $S_{EL2}(1)$ and $S_{EL2}(2)$ are obtained which are then preferably combined (not shown) and suitably recycled according to the present invention to U_R (not shown).
- Fig. 10** illustrates a process according to the present invention. In this figure, a preferred arrangement of heat-consuming purification sub-units comprised in U_P is shown. According to this arrangement, the liquid stream S_L is first passed to a water separation unit U_{WS} . It is noted that one or more water streams (not shown) obtained by this water separation together may form at least a part of the stream S_P described herein. The heat consumed in U_{WS} for water separation purposes is at least partially provided by the aqueous vapor stream $S_{EV3}(1)$ which is a part stream of S_{EV1} obtained from U_E . From U_{WS} , a stream S_{UWS} is obtained which is sent to further purification in a high-boiler separation unit U_{HS} . In this high-boiler separation unit U_{HS} , a hydrocyclone, for example, is present for the operation of which a vapor stream $S_{EV2}(3)$ is provided by dividing the stream S_{EV2} obtained from U_E . From U_{HS} , a stream S_{UHS} is obtained which is sent to further purification in a distillation unit U_{DI} . In this figure 10, as in figure 9, it is assumed, for example, that U_{DI} comprises two distillation columns. For each of these distillation columns, an individual vapor stream is provided by (further) dividing the stream S_{EV2} obtained from U_E . From U_{DI} , a stream S_{UDI} is obtained which is sent to a crystallization unit U_{CR} for further purification and from which the (final) stream S_{CPL} is obtained containing the purified ϵ -caprolactam. The heat consumed in U_{CR} for crystallization purposes is at least partially provided by the stream $S_{EV3}(2)$, a part stream of S_{EV3} . From these heat-consuming purification sub-units, the respective (condensed) liquid streams $S_{EL3}(1)$, $S_{EL3}(2)$, $S_{EL2}(1)$, $S_{EL2}(2)$ and $S_{EL2}(3)$ are obtained which are then preferably combined (not shown) and suitably recycled according to the present invention to U_R (not shown).
- Fig. 11** illustrates a process according to the present invention. In this figure, compared with what is shown in figure 10, a preferred arrangement of the distillation unit U_{DI} comprised in U_P is shown. According to this preferred arrangement, the distillation unit U_{DI} comprises three (serially arranged) distillation columns D_1 , D_2 and D_3 . For each of these distillation columns, an individual vapor stream (streams $S_{EV2}(1)$, $S_{EV2}(2)$ and $S_{EV2}(3)$) is provided by (further) dividing the stream S_{EV2} obtained from U_E . In addition to the three distillation columns, the distillation unit U_{DI} further comprises a chemical treatment unit U_{CT} arranged downstream of D_1 and upstream of D_2 . In this chemical treatment unit U_{CT} , a reactor such as a stirred reactor, for example, is present for the operation of which a vapor stream $S_{EV2}(4)$ is provided by dividing the stream S_{EV2} obtained from U_E . From these heat-consuming purification sub-units, the respective (condensed) liquid streams $S_{EL3}(1)$, $S_{EL3}(2)$, $S_{EL2}(1)$, $S_{EL2}(2)$, $S_{EL2}(3)$, $S_{EL2}(4)$ and $S_{EL2}(5)$ are obtained which are then preferably combined (not shown) and suitably recycled according to the present invention to U_R (not shown).

Fig. 12 illustrates a process according to the present invention. In this figure, compared with what is shown in figure 11, the chemical treatment unit U_{CT} is arranged downstream of the distillation unit U_{DI} and upstream of the crystallization unit U_{CR} . According to this process, the stream S_{UDI} which is obtained from U_{DI} is passed to U_{CT} from which a stream S_{UCT} is obtained which is then passed to U_{CR} . From these heat-consuming purification sub-units, the respective (condensed) liquid streams $S_{EL3}(1)$, $S_{EL3}(2)$, $S_{EL2}(1)$, $S_{EL2}(2)$, $S_{EL2}(3)$, $S_{EL2}(4)$ and $S_{EL2}(4)$ are obtained which are then preferably combined (not shown) and suitably recycled according to the present invention to U_R (not shown).

Claims

1. A process for preparing purified ϵ -caprolactam from polyamide 6 contained in a solid material M, the process comprising
 - 5 (i) preparing an aqueous liquid stream S_R comprising ϵ -caprolactam dissolved in water, comprising
 - (i.1) providing the solid material M comprising the polyamide 6, and providing an aqueous liquid stream S_W ;
 - 10 (i.2) preparing an aqueous depolymerization mixture based on the solid material M and the aqueous liquid stream S_W provided according to (i.1);
 - (i.3) subjecting the aqueous depolymerization mixture prepared according to (i.2) to depolymerization conditions in a chemical reaction unit U_R , said depolymerization conditions comprising a depolymerization temperature T_D at a depolymerization pressure p_D , obtaining in U_R a liquid aqueous reaction mixture M_R comprising ϵ -caprolactam dissolved in water;
 - 15 (i.4) removing the aqueous liquid stream S_R from U_R , wherein S_R comprises ϵ -caprolactam at an ϵ -caprolactam concentration c_{SR} and wherein S_R has a pressure p_{SR} with $0.95 p_D \leq p_{SR} \leq p_D$ and a temperature T_{SR} with $0.95 T_D \leq T_{SR} \leq T_D$;
 - 20 (ii) subjecting the liquid aqueous stream S_R obtained according to (i.4) to depressurization in an evaporation unit U_E , obtaining from U_E aqueous vapor streams S_{EV1} , S_{EV2} and S_{EV3} , wherein S_{EV1} has a pressure p_{EV1} and a temperature T_{EV1} , wherein S_{EV2} has a pressure p_{EV2} and a temperature T_{EV2} , and wherein S_{EV3} has a pressure p_{EV3} and a temperature T_{EV3} , wherein $p_{EV1} > p_{EV2} > p_{EV3}$; and further obtaining from U_E an aqueous liquid stream S_L comprising ϵ -caprolactam at an ϵ -caprolactam concentration c_{SL} with $c_{SL} > c_{SR}$;
 - 25 (iii) passing the aqueous liquid stream S_L obtained according to (ii) through a heat-consuming purification unit U_P comprising at least two heat-consuming purification sub-units U_{P1} and U_{P2} , obtaining from U_P a stream S_{CPL} comprising ϵ -caprolactam at an ϵ -caprolactam concentration c_{SCPL} with $c_{SCPL} \gg c_{SL}$;
 - 30 (iv) providing at least part of the heat consumed in U_{P1} by S_{EV3} or a part stream thereof, thereby obtaining from S_{EV3} or the part stream thereof an at least partially condensed aqueous stream S_{EL3} having a pressure p_{EL3} and a temperature T_{EL3} with $T_{EL3} \leq T_{EV3}$; and providing at least part of the heat consumed in U_{P2} by S_{EV2} or a part stream thereof, thereby obtaining from S_{EV2} or the part stream thereof an at least partially condensed aqueous stream S_{EL2} having a pressure p_{EL2} and a temperature T_{EL2} with $T_{EL2} \leq T_{EV2}$;
 - 35 (v) subjecting at least part of the aqueous stream S_{EL3} and at least part of the aqueous stream S_{EL2} to heat exchange in a heat exchange unit U_H , wherein at least part of the heat transferred in U_H is provided by the aqueous vapor stream S_{EV1} or a part stream thereof, thereby obtaining from S_{EL3} and S_{EL2} an aqueous liquid stream S_{RW} having a temperature T_{RW} with $T_{RW} > T_{EL3}$ and $T_{RW} > T_{EL2}$, and obtaining from S_{EV1} or the part
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stream thereof an at least partially condensed aqueous stream S_{EL1} having a temperature T_{EL1} with $T_{EL1} \leq T_{EV1}$;

- (vi) recycling at least part of the stream S_{RW} and at least part of the stream S_{EL1} into the reaction unit U_R .

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2. The process of claim 1, wherein from 10 to 100 weight-%, preferably from 30 to 100 weight-%, more preferably from 50 to 100 weight-%, more preferably from 80 to 100 weight-%, of the solid material M consist of the polyamide 6, wherein the solid material M provided according to (i.1) preferably comprises, more preferably consists of, a waste material, preferably one or more of a textile waste material and an engineering plastics waste material, more preferably of a textile waste material.

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3. The process of claim 1 or 2, wherein the evaporation unit U_E according to (ii) comprises two evaporation sub-units U_{E1} and U_{E2} , wherein U_{E1} and U_{E2} are preferably serially coupled, and wherein preferably at least one evaporation sub-unit, more preferably the two evaporation sub-units U_{E1} and U_{E2} comprise, preferably consist of a flash drum.

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4. The process of claim 3, wherein (ii) comprises
 (ii.1) subjecting the liquid aqueous stream S_R obtained according to (i.4) to depressurization in the evaporation sub-unit U_{E1} , obtaining from U_{E1} an aqueous vapor stream S_{EV1A} having the pressure p_{EV1} , and further obtaining an at least partially aqueous liquid stream S_{LU1} ;
 (ii.2) dividing the stream S_{EV1A} , obtaining the stream S_{EV1} and a stream S_{EV1B} having the pressure p_{EV1} ;
 (ii.3) subjecting the stream S_{EV1B} to depressurization in a unit U_{V1} , U_{V1} preferably comprising a valve, more preferably a pressure relief valve, obtaining the stream S_{EV2} ;
 (ii.4) subjecting the stream S_{LU1} obtained according to (ii.1) to depressurization in U_{E2} , obtaining from U_{E2} an aqueous vapor stream S_{EV3A} and the liquid stream S_L ;
 wherein the aqueous vapor stream S_{EV3A} is the aqueous vapor stream S_{EV3} .

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5. The process of claim 4, wherein obtaining the stream S_{EV3} further comprises one or more of (ii.5.1) and (ii.5.2):

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- (ii.5.1) separating a stream S_{EV1C} from the stream S_{EV1A} , obtained according to (ii.1), the stream S_{EV1C} having the pressure p_{EV1} ; subjecting the stream S_{EV1C} to depressurization in a unit U_{V2} , U_{V2} preferably comprising a valve, more preferably a pressure relief valve, obtaining a stream S_{EV3B} having the pressure p_{EV3} ;

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- (ii.5.2) separating a stream S_{EV2A} from the stream S_{EV2} obtained according to (ii.3), the stream S_{EV2A} having the pressure p_{EV2} ; subjecting the stream S_{EV2A} to depressurization in a unit U_{V3} , U_{V3} preferably comprising a valve, more preferably a pressure relief valve, obtaining a stream S_{EV3C} having the pressure p_{EV3} ;
 and further comprises

- (ii.6) admixing one or more of the streams S_{EV3B} obtained according to (ii.5.1) and the stream S_{EV3C} obtained according to (ii.5.2) to the stream S_{EV3A} obtained according to (ii.4), obtaining the stream S_{EV3} .

- 5 6. The process of any one of claims 1 to 5, wherein
- p_D is in the range of from 40 to 140 bar, preferably in the range of from 40 to 125 bar, more preferably in the range of from 40 to 110 bar; and
 T_D is in the range of from 230 to 335 °C, preferably in the range of from 250 to 320 °C, more preferably in the range of from 270 to 310 °C;
 - 10 - p_{EV1} is in the range of from 13 to 19 bar, preferably in the range of from 14 to 18 bar, more preferably in the range of from 15 to 17 bar; and
 T_{EV1} is in the range of from 170 to 230 °C, preferably in the range of from 180 to 220 °C, more preferably in the range of from 190 to 210 °C;
 - 15 - p_{EV2} is in the range of from 5 to 11 bar, preferably in the range of from 6 to 10 bar, more preferably in the range of from 7 to 9 bar; and
 T_{EV2} is in the range of from 150 to 210 °C, preferably in the range of from 160 to 200 °C, more preferably in the range of from 170 to 190 °C;
 - 20 - p_{EV3} is in the range of from 0.95 to 1.5 bar, preferably in the range of from 1.0 to 1.4 bar, more preferably in the range of from 1.1 to 1.3 bar; and
 T_{EV3} is in the range of from 90 to 140 °C, preferably in the range of from 100 to 130 °C, more preferably in the range of from 110 to 120 °C.
7. The process of any one of claims 1 to 6, wherein
- $0.95 p_{EV1} \leq p_{EL1} \leq p_{EV1}$; and
 $\Delta T_{VL1} = T_{EV1} - T_{EL1}$ is in the range of from 2 to 10 °C, preferably in the range of from 3 to 8 °C, more preferably in the range of from 4 to 6 °C;
 - 25 - $0.95 p_{EV2} \leq p_{EL2} \leq p_{EV2}$; and
 $\Delta T_{VL2} = T_{EV2} - T_{EL2}$ is in the range of from 15 to 40 °C, preferably in the range of from 18 to 32 °C, more preferably in the range of from 20 to 30 °C;
 - 30 - $0.95 p_{EV3} \leq p_{EL3} \leq p_{EV3}$; and
 $\Delta T_{VL3} = T_{EV3} - T_{EL3}$ is in the range of from 10 to 30 °C, preferably in the range of from 12.5 to 27.5 °C, more preferably in the range of from 15 to 25 °C.
8. The process of any one of claims 1 to 7, wherein (v) and (vi) comprise
- 35 (v) combining at least part of the stream S_{EL2} and at least part of the stream S_{EL3} in a unit U_C , obtaining a combined aqueous liquid stream S_C , and subjecting at least part of the aqueous liquid stream S_C to heat exchange in a heat exchange unit U_H , wherein at least part of the heat transferred in U_H is provided by the aqueous vapor stream S_{EV1} or a part stream thereof, thereby obtaining from S_C an aqueous liquid stream S_{RW}
 - 40 having a temperature $T_{RW} > T_C$, and obtaining from S_{EV1} or the part stream thereof an at least partially condensed aqueous stream S_{EL1} having a temperature T_{EL1} with $T_{EL1} < T_{EV1}$, the process further comprising combining at least part of the stream S_{EL1} in U_C with S_{EL2} or the part stream thereof and the stream S_{EL3} or the part stream thereof;

- (vi) recycling at least part of the stream S_{RW} into the reaction unit U_R .
9. The process of any one of claims 1 to 8, comprising
- 5 (iii) passing the aqueous liquid stream S_L obtained according to (ii) through a heat-consuming purification unit U_P at least comprising m heat-consuming purification sub-units $U_{P1}(j)$, $j=1..m$, $m \geq 2$, and n heat-consuming purification sub-units $U_{P2}(k)$, $k=1..n$, $n \geq 2$ obtaining from U_P a stream S_{CPL} comprising ϵ -caprolactam at an ϵ -caprolactam concentration C_{SCPL} with $C_{SCPL} \gg C_{SL}$;
- 10 (iv) dividing the stream S_{EV3} in at least m part streams $S_{EV3}(j)$ having a temperature $T_{EV3}(j) = T_{EV3}$ and a pressure $p_{EV3}(j) = p_{EV3}$, and dividing the stream S_{EV2} in at least n part streams $S_{EV2}(k)$ having a temperature $T_{EV2}(j) = T_{EV2}$ and a pressure $p_{EV2}(j) = p_{EV2}$; and providing at least part of the heat consumed in $U_{P1}(j)$ by $S_{EV3}(j)$, thereby obtaining from $S_{EV3}(j)$ an at least partially condensed aqueous stream $S_{EL3}(j)$ having a pressure $p_{EL3}(j)$ and a temperature $T_{EL3}(j)$ with $T_{EL3}(j) < T_{EV3}(j)$; and providing at least part of the
- 15 heat consumed in $U_{P2}(k)$ by $S_{EV2}(k)$, thereby obtaining from $S_{EV2}(k)$ an at least partially condensed aqueous stream $S_{EL2}(k)$ having a pressure $p_{EL2}(k)$ and a temperature $T_{EL2}(k)$ with $T_{EL2}(k) < T_{EV2}(k)$;
- 20 (v) subjecting at least parts of the aqueous streams $S_{EL3}(j)$ and $S_{EL2}(k)$ to heat exchange in a heat exchange unit U_H , wherein at least part of the heat transferred in U_H is provided by the aqueous vapor stream S_{EV1} or a part stream thereof, thereby obtaining from the streams $S_{EL3}(j)$ and the streams $S_{EL2}(k)$ an aqueous liquid stream S_{RW} having a temperature T_{RW} with $T_{RW} > T_{EL3}(j)$ and $T_{RW} > T_{EL2}(k)$, and obtaining from S_{EV1} or the part stream thereof an at least partially condensed aqueous stream S_{EL1} having a temperature T_{EL1} with $T_{EL1} < T_{EV1}$;
- 25 (vi) recycling at least part of the stream S_{RW} and at least part of the stream S_{EL1} into the reaction unit U_R ;
- wherein according to (iii), the m heat-consuming purification sub-units $U_{P1}(j)$ preferably comprise one or more of a water separation unit U_{WS} and a crystallization unit U_{CR} ;
- wherein the water separation unit U_{WS} preferably comprises one or more of an evaporator
- 30 arranged upstream of a flash tank and a film evaporator, more preferably one or more of an evaporator arranged upstream of a flash tank and a falling film evaporator;
- wherein the crystallization unit U_{CR} preferably comprises at least one heat exchanger preferably for providing a heating medium used for crystallization purposes.
- 35 10. The process of claim 9, wherein
- a stream $S_{EV3}(j)$ is used for providing at least part of the heat consumed by the evaporator arranged upstream of the flash tank comprised in the water separation unit U_{WS} , thereby obtaining a stream $S_{EL3}(j)$;
- 40 - a stream $S_{EV3}(j)$ is used for providing at least part of the heat consumed in the water separation unit U_{WS} , thereby obtaining a stream $S_{EL3}(j)$;
- a stream $S_{EV3}(j)$ is used for providing at least part of the heat consumed by the at least one heat exchanger of the crystallization unit U_{CR} , thereby obtaining a stream $S_{EL3}(j)$.

11. The process of claim 9 or 10, wherein according to (iii), the n heat-consuming purification sub-units $U_{P2}(k)$ comprise a distillation unit U_{DI} , wherein U_{DI} preferably comprises at least one distillation column, preferably at least two distillation columns, more preferably at least three distillation columns, more preferably at least three serially arranged distillation columns, wherein preferably in at least one of the distillation columns, more preferably in each distillation column, a first stream $S_{EV2}(k_1)$ is passed as a direct heating medium through a heating jacket of said distillation column, thereby obtaining a first stream $S_{EL2}(k_1)$, and second stream $S_{EV2}(k_2)$ is passed as an indirect heating medium through a heat exchanger, preferably a heat exchanger used for sump evaporation of said distillation column, thereby obtaining a second stream $S_{EL2}(k_2)$;
 wherein the distillation preferably in at least one distillation column is carried out as a vacuum distillation, wherein the process more preferably further comprises operating at least one vacuum generating means, preferably at least one vacuum ejector, with at least one stream $S_{EV2}(k)$;
 the n heat-consuming purification sub-units $U_{P2}(k)$ preferably further comprising one or more of a high-boiler separation unit U_{HS} and a chemical treatment unit U_{CT} , more preferably a high-boiler separation unit U_{HS} and a chemical treatment unit U_{CT} .
12. The process of any one of claims 9 to 11, wherein (v) and (vi) comprise
 (v) combining at least one of the streams $S_{EL2}(k)$ or a part stream thereof, preferably all streams $S_{EL2}(k)$ or part streams thereof, and at least one of the streams $S_{EL3}(j)$ or a part stream thereof, preferably all streams $S_{EL3}(j)$ or part streams thereof, in a unit U_C , obtaining a combined aqueous liquid stream S_C , and subjecting at least a part of the aqueous liquid stream S_C to heat exchange in a heat exchange unit U_H , wherein at least part of the heat transferred in U_H is provided by the aqueous vapor stream S_{EV1} or a part stream thereof, thereby obtaining from S_C an aqueous liquid stream S_{RW} having a temperature $T_{RW} > T_C$, and obtaining from S_{EV1} or the part stream thereof an at least partially condensed aqueous stream S_{EL1} having a temperature T_{EL1} with $T_{EL1} < T_{EV1}$, the process further comprising combining at least a part of the stream S_{EL1} in U_C with S_{EL2} and S_{EL3} ;
 (vi) recycling at least part of the stream S_{RW} into the reaction unit U_R .
13. The process of any one of claims 1 to 12, exhibiting a heat efficiency ΔH_{EFF} of at least 80 %, preferably in the range of from 80 to 100 %, more preferably in the range of from 90 to 100 %, with $\eta_{EFF} = (\Delta H_{UP1} + \Delta H_{UP2} + \Delta H_{UH}) / \Delta H_{SR}$
 wherein
 ΔH_{UP1} is the total heat demand of the purification sub-unit U_{P1} according to (iii);
 ΔH_{UP2} is the total heat demand of the purification sub-unit U_{P2} according to (iii);
 ΔH_{UH} is the total heat transferred in the heat exchange unit U_H according to (v);
 ΔH_{SR} is the amount of usable energy contained in the stream S_R obtained according to (i.4).

14. The process of claim 13, wherein at least one of, more preferably at least two of, more preferably the three following relative quantities are realized:
- $\Delta H_{UP1}(\text{rel}) = \Delta H_{UP1} / (\Delta H_{UP1} + \Delta H_{UP2} + \Delta H_{UH})$ is preferably in the range of from 30 to 50 %, more preferably in the range of from 35 to 45 %;
 - 5 - $\Delta H_{UP2}(\text{rel}) = \Delta H_{UP2} / (\Delta H_{UP1} + \Delta H_{UP2} + \Delta H_{UH})$ is preferably in the range of from 15 to 30 %, more preferably in the range of from 20 to 25 %;
 - $\Delta H_{UH}(\text{rel}) = \Delta H_{UH} / (\Delta H_{UP1} + \Delta H_{UP2} + \Delta H_{UH})$ is preferably in the range of from 30 to 45 %, more preferably in the range of from 35 to 40 %;
- with the proviso that $\Delta H_{UP1}(\text{rel}) + \Delta H_{UP2}(\text{rel}) + \Delta H_{UH}(\text{rel}) = 1$.
- 10 15. The process of any one of claims 1 to 14, being a continuous process, a semicontinuous process or a batch process.
- 15 16. Use of S_{CPL} , obtainable or obtained by a process according to any one of claims 1 to 15, for preparing one or more of a polymer and a polymer product, 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; and wherein the polymer, or the polymer product, or the polymer and the
- 20 polymer product comprises or comprise polyamide 6 and optionally at least one further polymeric compound, said polyamide 6 being at least partially obtainable or obtained from S_{CPL} , said S_{CPL} being obtainable or obtained by a process according to any one of claims 1 to 15, 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
- 25 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.
- 30 17. The use of claim 16, wherein the polymer, or the polymer product, or the polymer and the polymer product is or are one of the following or a part of one of the following:
- a part of a car, preferably a cylinder head cover, an engine cover, a housing for a charge air cooler, a charge air cooler flap, an intake pipe, an intake manifold, a connector, a gear wheel, a fan wheel, a cooling water box, a housing or a housing part for a heat exchanger, a coolant cooler, a charge air cooler, a thermostat, a water pump, a radiator,
 - 35 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
 - 40 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.