

Process for hydrolytically depolymerizing a polyamide

- The present invention relates to a process for hydrolytically depolymerizing polyamide 6 which is contained in a chemical feedstock which, in addition to polyamide 6, contains specific amounts of polyethylene terephthalate and polyamide 6.6. Further, the present invention relates to the use of a mixture comprising polyamide 6 and further contains specific amounts of polyethylene terephthalate and polyamide 6.6 for increasing the yield in ϵ -caprolactam in a hydrolytic polyamide 6 depolymerisation reaction.
- Polyamide, and in particular polyamide 6 being characterized by the formula $(-\text{NH}-(\text{CH}_2)_5-\text{CO}-)_n$, can be found in numerous materials, such as packaging, engineering plastics from automotive and textile filaments. The latter represents about 40 % of the polyamide 6 global market. At present, only a very small part of the textile filaments is recycled while it represents a significant percentage of the global CO_2 emissions. There is thus a need to recycle polyamide 6 from such materials. Processes for alkaline depolymerizing a polyamide exists. Further, the processes in the art are energy-intensive processes. Said materials which are subjected to such recycling processes often contain other polymeric compounds such as polyethylene terephthalate and polyamide 6.6. However, processes for depolymerizing polyamide 6 known in the art may have only a mediocre tolerance to polyethylene terephthalate and, sometimes, also to polyamide 6.6. Therefore, there is the need to provide an improved process for hydrolytically depolymerizing polyamide 6 which is contained in a material which, in addition to polyamide 6, also contains polyethylene terephthalate and polyamide 6.6.

- Surprisingly, it was found that the process of the present invention wherein polyamide 6 is hydrolytically depolymerized and wherein the feedstock which is subjected to said hydrolytic depolymerization process contains the further polymeric compounds polyethylene terephthalate and polyamide 6.6 in specific amounts relative to polyamide 6 allow for increasing the yield in the valuable product, i.e. ϵ -caprolactam, the monomeric compound resulting from depolymerizing polyamide 6. Yet further, the process of the present invention permits to reduce the overall energy consumption compared to known processes which permits to reduce the CO_2 footprint and costs.

- Therefore, the present invention relates to a process for hydrolytically depolymerizing polyamide 6 comprised in a chemical feedstock F, the process comprising
- (i) providing the chemical feedstock F, wherein at least 25 weight-% of the chemical feedstock F consist of the polyamide 6;
 - (ii) providing a liquid aqueous stream S_W ;
 - (iii) preparing a mixture comprising the feedstock F provided according to (i) and the liquid aqueous stream S_W provided according to (ii), and subjecting said mixture to polyamide 6 depolymerisation conditions in a chemical reaction unit U_R , obtaining an aqueous stream S_E leaving U_R , the stream S_E comprising ϵ -caprolactam;

wherein according to (iii), the mixture to be subjected to polyamide 6 depolymerisation conditions comprises the polyamide 6 and further comprises polyethylene terephthalate and polyamide 6.6 at a mass ratio $r_S = (m_{PA6.6} + m_{PET}) / m_{PA6}$ with $0.01 \leq r_S \leq 2.5$.

- 5 Preferably according to the present, as far as the mass ratio r_S is concerned, $0.02 \leq r_S \leq 2$, more preferably $0.03 \leq r_S \leq 1.9$, more preferably $0.04 \leq r_S \leq 1.8$, more preferably $0.05 \leq r_S \leq 1.75$. Also preferably according to the present, as far as the mass ratio r_S is concerned, $0.05 \leq r_S \leq 1$, preferably $0.05 \leq r_S \leq 0.5$, more preferably $0.05 \leq r_S \leq 0.15$. It may be preferred that for the mass ratio r_S , $0.04 \leq r_S \leq 1$, more preferably $0.04 \leq r_S \leq 0.75$, more preferably $0.04 \leq r_S \leq 0.5$.

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Regarding the amounts of polyethylene terephthalate and the polyamide 6.6 which are contained in the feedstock F, it is preferred that for the respective mass ratio $r_T = m_{PET} / m_{PA6.6}$, $0.005 \leq r_T \leq 5$. More preferably, $0.01 \leq r_T \leq 5$, more preferably $0.015 \leq r_T \leq 4$, more preferably $0.02 \leq r_T \leq 3$.

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According to the process of the present invention, it is preferred that the entire amount of polyamide 6 which is comprised in the mixture to be subjected to polyamide 6 depolymerisation conditions according to (iii) is comprised in the chemical feedstock F provided according to (i).

- 20 Further, it is preferred that at least a part of the amount of polyethylene terephthalate which is comprised in the mixture to be subjected to polyamide 6 depolymerisation conditions according to (iii) is comprised in the chemical feedstock F provided according to (i). If only a part of polyethylene terephthalate is comprised in the mixture provided according to (i), it is preferred that after having provided said feedstock, further polyethylene terephthalate is added to said
25 feedstock so that the above-described values and ranges for r_S and preferably also for r_T are achieved for the feedstock which is finally subjected to (iii). Preferably, the entire amount of polyethylene terephthalate which is comprised in the mixture to be subjected to polyamide 6 depolymerisation conditions according to (iii) is already comprised in the chemical feedstock F provided according to (i).

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Yet further, it is preferred that at least a part of the amount of polyamide 6.6 which is comprised in the mixture to be subjected to polyamide 6 depolymerisation conditions according to (iii) is comprised in the chemical feedstock F provided according to (i). If only a part of polyamide 6.6 is comprised in the mixture provided according to (i), it is preferred that after having provided said
35 feedstock, further polyamide 6.6 is added to said feedstock so that the above-described values and ranges for r_S and preferably also for r_T are achieved for the feedstock which is finally subjected to (iii). Preferably, the entire amount of polyamide 6.6 which is comprised in the mixture to be subjected to polyamide 6 depolymerisation conditions according to (iii) is already comprised in the chemical feedstock F provided according to (i).

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Regarding the chemical feedstock provided according to (i) and preferably subjected to (iii), it is preferred that at least 50 weight-% of the chemical feedstock F provided according to (i) consist

- of the polyamide 6, the polyamide 6.6 and the polyethylene terephthalate. More preferably, from 60 to 100 weight-%, more preferably from 70 to 100 weight-%, more preferably from 75 to 100 weight-% of the chemical feedstock F provided according to (i) and preferably subjected to (iii) consist of the polyamide 6, the polyamide 6.6 and the polyethylene terephthalate. Preferably at least 25 weight-% of the chemical feedstock F consist of polyamide 6, wherein it may be preferred that at least 30 weight-% or at least 40 weight-% or at least 50 weight-% or at least 60 weight-% or at least 70 weight-% or at least 80 weight-% or at least 90 weight-% of the chemical feedstock F consist of polyamide 6.
- Regarding the polyamide 6 depolymerisation conditions according to (iii), it is preferred that they comprise a polyamide 6 depolymerisation temperature T_D in the range of from 230 to 330 °C, more preferably in the range of from 250 to 320 °C, more preferably in the range of from 270 to 310, such as in the range of from 270 to 280 °C or in the range of from 280 to 290 °C or in the range of from 290 to 300 °C or in the range of from 300 to 310 °C. The depolymerisation temperature T_D is the temperature of the liquid reaction mixture during (iii). Further regarding the polyamide 6 depolymerisation conditions according to (iii), it is preferred that they comprise a polyamide 6 depolymerisation pressure p_D 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, such as in the range of from 40 to 55 bar or in the range of from 55 to 70 bar or in the range of from 70 to 85 bar or in the range of from 85 to 100 bar or in the range of from 100 to 110 bar.

- As mentioned above, the polyamide 6 depolymerisation according to (iii) is a hydrolytic process. Therefore, as far the amount of water is concerned, it is preferred that the mixture to be subjected to polyamide 6 depolymerisation conditions according to (iii) exhibits a mass ratio
- $$r_W = (m_{PA6} + m_{PA6.6} + m_{PET}) / m_{H_2O} \text{ with } 0.01 \leq r_W \leq 0.4, \text{ more preferably } 0.05 \leq r_W \leq 0.3, \text{ more preferably } 0.1 \leq r_W \leq 0.2.$$

- Generally, the chemical feedstock which is provided according to (i) and preferably subjected to (iii) may further comprise, in addition to polyamide 6, polyethylene terephthalate and polyamide 6.6, one or more other components such as at least one further organic polymeric compound, for example at least one semiaromatic polyamide including one or more of polyamide 6T and polyamide 6I; 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 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. If the feedstock provided according to (i) and preferably subjected to (iii) further comprises such further organic polymeric compound, it is preferred that this further organic polymeric compound comprises at least one polytetrahydrofuran. Further, it may be preferred that the further organic polymeric compound consists of at least one polytetrahydrofuran.

Further, the chemical feedstock which is provided according to (i) and preferably subjected to (iii) may further comprise one or more of at least one pigment material and at least one glass fiber material.

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Preferably according to the present invention, no polyamide 6 depolymerization catalyst such as a mineral acid, such as one or more of hydrochloric acid, nitric acid, sulphuric acid and phosphoric acid, and/or a zinc salt such as zinc chloride, zinc acetate or zinc triflate is added for preparing the mixture to be subjected to hydrolytic polyamide 6 depolymerisation conditions.

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Generally, the chemical feedstock F provided according to (i) may consist of one single material or from several different material, i.e. it consists of w chemical materials M_j with $j=1..w$ and $w \geq 1$. Further according to the present invention, preferably at least one of the chemical materials M_j , more preferably every chemical material M_j comprises, preferably consists of a waste material, said waste material preferably comprising, more preferably consisting of, one or more of at least one textile waste material and at least one engineering plastics waste material, more preferably comprising, more preferably consisting of at least one textile waste material. If $w > 1$, the respective two or more materials may have different chemical compositions which are not subject to any specific restrictions with the proviso that the chemical feedstock exhibits the composition as discussed above.

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Regarding the chemical feedstock F which is provided according to (i), it is preferred that it is provided in solid form, more preferably in the form of particles such as granules, wherein the particle size distribution of said particles is more 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 pairs of values:

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- a D10 value of the particle width in the range of from 0.3 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 0.5 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 0.8 to 30 mm and a D90 value of the particle length in the range of from 0.8 to 30 mm.

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More preferred pairs of values are, for example:

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- a D10 value of the particle width in the range of from 2 to 4 mm and a D10 value of the particle length in the range of from 3.5 to 5.5 mm;
- a D50 value of the particle width in the range of from 2.5 to 4.5 mm and a D50 value of the particle length in the range of from 4 to 7 mm;
- a D90 value of the particle width in the range of from 3 to 5 mm and a D90 value of the particle length in the range of from 4.5 to 8.5 mm.

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The term "particle" as used in this context of the present invention comprises optionally pre-

formed granules, and also comprises shredded pieces.

According to a first alternative of the present invention, the chemical feedstock F is admixed according to (iii) in solid form with the liquid aqueous stream S_W . According to this alternative, it

5 may be preferred that process wherein (i) further comprises

(i) providing the chemical feedstock F in solid form wherein said feedstock has a temperature below the melting point of polyamide 6;

wherein (ii) further comprises

(ii) providing the liquid aqueous stream S_W , wherein from 90 to 100 weight-% of S_W consist of water and wherein S_W has a temperature which is below the melting point of polyamide 6;

10 wherein (iii) further comprises

(iii) feeding the solid chemical feedstock provided according to (i) and the liquid aqueous stream S_W provided according to (ii) into the chemical reaction unit U_R , obtaining a mixture, and subjecting said mixture in U_R to polyamide 6 depolymerization conditions comprising a polyamide 6 temperature T_D wherein T_D is higher than the temperature of the feedstock provided according to (i) and lower than the temperature of the liquid aqueous stream S_W provided according to (ii).

20 According to a second alternative of the present invention, providing the chemical feedstock F according to (i) comprises bringing the chemical feedstock F from the solid form to a liquid form, and wherein according to (iii), the chemical feedstock F is admixed in liquid form with the liquid aqueous stream S_W . Regarding this alternative, the process of the present invention may preferably comprise

(a) providing the feedstock F in a solid form;

25 (b) melting in a melting unit U_M the solid feedstock F, obtaining a liquid stream S_M having a temperature T_{SM} at a pressure p_{SM} ;

(c) providing a liquid aqueous stream S_W having a temperature T_{SW} at a pressure p_{SW} ;

(d) admixing in a pre-reaction unit U_{PR} the stream S_M with the stream S_W , obtaining a liquid reaction feed stream S_F having a temperature T_{SF} at a pressure p_{SF} ;

30 (e) feeding the stream S_F into the chemical reaction unit U_R and subjecting it to polyamide 6 depolymerization conditions in a chemical reaction unit U_R , the polyamide 6 depolymerization conditions comprising a polyamide 6 depolymerization temperature T_D and a polyamide 6 depolymerization pressure p_D , obtaining an aqueous stream S_E leaving U_R , the stream S_E comprising ϵ -caprolactam and one or more decomposition products of

35 one or more of the at least one further organic polymeric compound.

According to this method comprising steps (a) to (e), it is preferred that $0.8 \leq T_{SF}/T_D \leq 1.05$ and $0.9 \leq p_{SF}/p_D \leq 1.05$. It is further preferred that $0.6 \leq T_{SM}/T_{SF} \leq 1.05$ and $0.9 \leq p_{SM}/p_{SF} \leq 1.05$. Yet further, it is preferred that $0.8 \leq T_{SW}/T_{SF} \leq 1.3$ and $0.9 \leq p_{SW}/p_{SF} \leq 1.05$. Further according to this method comprising steps (a) to (e), the pre-reaction unit U_{PR} according to (d) comprises,

40 preferably consists of, a mixing unit, preferably a static mixing unit. The term "static mixing unit" as used herein refers to an arrangement of mixing elements which are installed in a pipe or duct, and which operate essentially without moving parts, preferably entirely without moving parts.

According to the present invention, it may be preferred that said mixing unit is configured as a suitable pipe junction of the pipe for the stream S_M and the pipe for the stream S_W , wherein no specific mixing elements are present. Yet further, it is preferred that the melting unit U_M comprises a kneader or an extruder, more preferably an extruder, wherein more preferably, the melting unit

5 U_M consists of an extruder, wherein more preferably, the extruder is a single-screw extruder or a twin-screw extruder, more preferably a twin-screw extruder. Yet further according to this method comprising steps (a) to (e), it is preferred that downstream of the melting unit U_M and upstream of the reaction unit U_R , a filtration unit U_F is arranged, preferably a filtration unit U_F for separating particles having a particle size in the range of from 100 to 500 micrometer, preferably in the range

10 of from 200 to 400 micrometer, from the liquid stream S_M , wherein the process comprises passing the stream liquid stream S_M through U_F , prior to admixing according to (d).

Regarding step (iii), it is preferred that the feedstock F and the stream S_W are admixed at a mixing ratio $(m_W/\text{kg}) / (m_P/\text{kg})$ in the range of from 1:1 to 20:1, preferably in the range of from 2:1

15 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 the chemical feedstock F .

Regarding the chemical reaction unit U_R , it is preferred that it 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

20 preferably in the range of from 1 to 6, more preferably in the range of from 1 to 5, more preferably in the range of from 1 to 4, more preferably in the range of from 1 to 3. If $z > 1$, at least 2 reactors R_i , preferably z reactors R_i are serially coupled.

The overall residence time of the reaction mixture subjected to polyamide 6 depolymerization conditions in the chemical reaction unit U_R is in the range of from 15 to 800 minutes, preferably in

25 the range of from 30 to 600 minutes, more preferably in the range of from 45 to 360 minutes, more preferably in the range of from 60 to 240 minutes. The term "overall residence time" as used in this context of the present invention refers to the sum of the residence times in all chemical reactors R_i mentioned above.

30 According to the present invention, it may be preferred, in particular as far as the method comprising steps (a) to (e) as described above is concerned, that if $z > 1$, 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 reactor R_i

35 and fed into the reactor R_{i+1} , with $i < z$; and the aqueous liquid stream S_z containing ϵ -caprolactam dissolved in water is removed from the reactor R_z as the stream S_E ; wherein in every reactor R_i , a depolymerization temperature T_{Di} at a depolymerization pressure p_{Di} is maintained, wherein, independently of each other, T_{Di} is in the range of from 230 to 330 °C and p_{Di} is in the range of from 40 to 140 bar, preferably wherein T_{Di} is in the range of from 250 to 320 °C and p_{Di} is

40 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. Preferably for $z > 1$, the z reactors R_i are

vertically arranged, with R_1 being the top-most reactor and R_z being the bottom-most reactor, wherein S_i obtained from R_i is transferred to R_{i+1} by gravity, preferably by gravity only.

More preferably, at least 1, preferably z reactors R_i , are stirred tank reactors, wherein every stirred tank reactor R_i may preferably have, independently from each other, from 2 to 6 compartments, preferably from 2 to 5 compartments, more preferably from 2 to 4 compartments, said compartments preferably being serially, more preferably being serially and vertically arranged, wherein 2 adjacent compartments are separated by a divider which comprises at least one flow-through opening. Said at least one compartment comprised in a reactor R_i may preferably comprise at least one agitator, wherein 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.

Alternatively, regarding the specific design of said stirred tank reactors, it may be particularly preferred according to the present invention that at least one stirred tank reactor R_i , preferably every stirred tank reactor R_i , has, independently from each other, preferably from 2 to 6 compartments, more preferably from 2 to 5 compartments, more preferably from 2 to 4 compartments, said compartments preferably being serially, more preferably being serially and vertically arranged, wherein said reactor R_i comprises at least one agitator and wherein 2 adjacent compartments are formed by, and separated by, one or more suitable components of said agitator such as blades comprised in the 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 the reactor compartment.

The polyamide 6 depolymerization conditions according preferably 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, wherein at least 85 weight-%, preferably at least 90 weight-%, more preferably at least 95 weight-% of the aqueous depolymerization mixture have a t_D in the range of from 30 to 90 min. More preferably, for $z > 1$, the residence time of an aqueous depolymerization mixture in a reactor R_i is t_{Di} and wherein $0.90 \leq (t_{Di} / t_{Di+1}) \leq 1.10$, preferably $0.95 \leq (t_{Di} / t_{Di+1}) \leq 1.05$.

According to the present invention, it may be preferred that the water which is comprised in the stream S_E leaving U_R is suitably recycled as at least a part of S_W . According to this recycling, it is further preferred that the process further comprises

- (iv) generating an aqueous stream S_R comprises subjecting the stream S_E obtained from the chemical reaction unit U_R , optionally after subjecting S_E to filtration, to thermal water separation, obtaining the stream S_R ;
- (v) feeding at least part of the aqueous stream S_R back to the chemical reaction unit U_R as part of the aqueous stream S_W ;

wherein the thermal water separation according to (iv) preferably comprises one or more of distilling and falling film evaporating.

5 Preferably according to (iv), generating the aqueous stream S_R according to (iv) comprises, preferably consists of, distilling the stream S_E obtained from the reaction unit U_R , optionally after
 10 subjecting S_E to filtration, obtaining the stream S_R . Said distilling is preferably carried out in a distillation column at a bottoms temperature preferably in the range of from 70 to 140 °C, more preferably in the range of from 80 to 120 °C, more preferably in the range of from 90 to 110 °C, and a top pressure preferably in the range of from 0.5 to 1.5 bar, more preferably in the range of
 15 from 0.7 to 1.2 bar, more preferably in the range of from 0.8 to 1.1 bar, wherein the stream S_R is obtained at the top of the distillation column. Further, said distilling preferably comprises subjecting the vapor top stream to condensation, obtaining a liquid stream S_R , wherein at least a part of the liquid stream S_R is fed back to the chemical reaction unit U_R as part of the aqueous stream S_W according to (v). Said liquid stream S_R obtained from condensation may preferably be
 20 divided into 2 streams, wherein a first stream obtained from dividing is fed back to the chemical reaction unit U_R as part of the aqueous stream S_W according to (v) and a second stream is fed back to the top of the distillation column, wherein the volume ratio of the first stream relative to the second stream is preferably in the range of from 10:1 to 0.5:1, more preferably in the range of from 7:1 to 1:1, more preferably in the range of from 5:1 to 2:1.

Also preferably according to (iv), the aqueous stream S_R is generated in the course of subjecting the stream S_E to one or more stages downstream of U_R according to which a stream S_{CPL} is prepared comprising purified ϵ -caprolactam which may then be suitably recycled to the material value chain, such as a starting material for preparing polyamide 6. Said one or more downstream
 25 purification stages which may further comprise one or more stages according to which heat contained in the stream S_E is suitably recovered and, for example, used for at least partially meeting the heat demand of one or more of said downstream purification stages, may comprise, for example, the following sequence of stages:

- 30 (A) passing the liquid aqueous stream S_E into an evaporation unit U_E , obtaining from S_E a liquid aqueous stream S_L comprising ϵ -caprolactam dissolved in water at a concentration c_{SL} with $c_{SL} > c_{SR}$, and further obtaining from S_E one or more aqueous vapor streams S_V ;
- (B) passing the aqueous stream S_L into a heat-consuming purification unit U_P , obtaining from S_L a stream S_{CPL} comprising ϵ -caprolactam at a concentration c_{SCPL} with $c_{SCPL} \gg c_{SL}$, and further obtaining from S_L one or more aqueous streams S_{RW} , wherein at
 35 least part of the heat consumed in U_P is provided by at least one of the one or more streams S_V , thereby obtaining from the at least one stream S_V at least one at least partially condensed aqueous stream S_{VW} ;
- (C) recycling, as the stream S_R , at least one stream S_{VW} at least partially and at least one stream S_{RW} at least partially to the reaction unit U_R .

40 The recycling according to (C) may preferably comprise

- (C.1) feeding the at least one stream S_{VW} and the at least one stream S_{RW} into a water treatment unit U_W , obtaining from U_W at least one aqueous recycle stream S_R ;
- (C.2) recycling the at least one aqueous stream S_R at least partially to the reaction unit U_R .
- 5 The water treatment unit U_W according to (C.1) may preferably comprise a water recovery unit U_{WR} and a waste water unit U_{WW} , wherein (x.1) further comprises
- (C.1.1) feeding the at least one stream S_{VW} and the at least one stream S_{RW} into the water recovery unit U_{WR} , obtaining from U_{WR} the at least one aqueous recycle stream S_W and at least one aqueous stream S_{SW} ;
- 10 (C.1.2) feeding the at least one stream S_{SW} to the waste water unit U_{WW} , obtaining from U_{WW} , at least one waste water stream S_{WW} .

The purification unit U_P according to (B) may preferably comprise one or more of a heat-consuming water separation unit U_{WS} , a heat-consuming distillation unit U_D and a heat-consuming crystallization unit U_C , preferably two or more of a heat-consuming water separation unit U_{WS} , a heat-consuming distillation unit U_D and a heat-consuming crystallization unit U_C , more preferably a heat-consuming water separation unit U_{WS} , a heat-consuming distillation unit U_D and a heat-consuming crystallization unit U_C , wherein at least part of the heat consumed in one or more of U_{WS} , U_D and U_C is provided by at least one of the one or more streams S_V .

20 Preferably, the process may comprise one or more of the following; more preferably at least two or more of the following; more preferably all of the following:

- obtaining at least one at least partially condensed aqueous stream S_{VW1} from U_{WS} ;
 - obtaining at least one at least partially condensed aqueous stream S_{VW2} from U_D ;
 - 25 - obtaining at least one at least partially condensed aqueous stream S_{VW3} from U_C ;
- the process further comprising feeding one or more S_{VW1} , S_{VW2} and S_{VW3} ; preferably two or more S_{VW1} , S_{VW2} and S_{VW3} ; more preferably S_{VW1} , S_{VW2} and S_{VW3} into the water treatment unit U_W as defined above.

30 Preferably, at least one of the streams S_{RW} is obtained from U_{WS} .

Preferably, the purification unit U_P may comprise a heat-consuming water separation unit U_{WS} , a heat-consuming distillation unit U_D and a heat-consuming crystallization unit U_C , the process comprising feeding the stream S_L comprising ϵ -caprolactam at a concentration c_{SL} to U_{WS} ,

35 obtaining from U_{WS} a stream U_{WS} comprising ϵ -caprolactam at a concentration c_{UWS} , feeding the stream S_{UWS} to the distillation unit U_D , obtaining from U_D a stream S_{UD} comprising ϵ -caprolactam at a concentration c_{UD} , and feeding the stream S_{UD} into the crystallization unit U_C , and obtaining from U_C a stream S_{CPL} comprising ϵ -caprolactam at a concentration c_{SCPL} , wherein

$$c_{SL} < c_{UWS} < c_{UD} < c_{SCPL}.$$

40 Preferably, the water separation unit U_{WS} may comprise at least two heat-consuming water separation sub-units U_{WS1} and U_{WS2} , preferably two serially coupled heat-consuming water

separation sub-units U_{WS1} and U_{WS2} , wherein the stream S_L is fed into U_{WS1} and wherein at least part of the heat consumed in one or more of U_{WS1} and U_{WS2} is provided by at least one of the one or more streams S_V .

5 Preferably, the process may comprise one or more of the following, more preferably all of the following:

- obtaining at least one at least partially condensed aqueous stream S_{VW11} from U_{WS1} ;
- obtaining at least one at least partially condensed aqueous stream S_{VW12} from U_{WS2} .

10 Preferably, at least one aqueous stream S_{RW1} is obtained from U_{WS1} and at least one aqueous stream S_{RW2} is obtained from U_{WS2} , and wherein at least one of S_{RW1} and S_{RW2} , preferably S_{RW1} and S_{RW2} are fed into U_W .

15 Preferably, the evaporation unit U_E may comprise two or more evaporation sub-units, the process comprising obtaining at least two vapor streams S_{V1} and S_{V2} , passing the vapor stream S_{V1} to at least one heat-consuming unit and passing the vapor stream S_{V2} to at least one heat-consuming unit, wherein the vapor streams S_{V1} and S_{V2} differ from each other in either pressure and/or temperature.

20 Regarding the stream S_{CPL} described above, i.e. the purified ϵ -caprolactam stream, it may be preferred that said stream S_{CPL} is passed to a polyamide 6 production unit U_{PP} where it is employed as starting material. If need be, one or more further streams S_{NCPL} can be additionally passed to U_{PP} , said streams comprising non-recycled ϵ -caprolactam, i.e. ϵ -caprolactam from a conventional source. The respectively prepared polyamide 6 material preferably may then be

25 passed to a unit U_{TP} where it is used as a starting material for preparing a material comprising polyamide 6, preferably a textile material comprising polyamide 6. If need be, one or more further streams S_{NPA6} can be additionally passed to U_{TP} , said streams comprising non-recycled polyamide 6, i.e. polyamide 6 from a conventional source. Depending on the type of material prepared in U_{TP} , also further streams comprising one or more starting materials other than

30 polyamide 6 can be passed to U_{TP} . The material, preferably the textile material M_T obtained from U_{TP} then preferably goes into the market and remains there for a given lifetime T_{MT} . Thereafter, the respective end-of-life material is suitably collected in a collecting unit U_{TC} , preferably a textile material collecting unit, from which it is suitably passed as the feedstock F or part of the feedstock F to the process as described above, optionally after sorting as described herein.

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The process of the present invention as described above may preferably be a continuous process. However, one or more process steps may be carried out in a batch-type mode, and one or more steps may be carried out in a semicontinuous mode.

40 The present invention also relates to the use of a mixture comprising polyamide 6, polyethylene terephthalate and polyamide 6.6 at a mass ratio $r_S = (m_{PA6.6} + m_{PET}) / m_{PA6}$ with $0.01 \leq r_S \leq 2$ for

increasing the yield in ϵ -caprolactam in a hydrolytic polyamide 6 depolymerisation reaction, said reaction comprising

- (i) providing a chemical feedstock F, wherein at least 25 weight-% of the chemical feedstock F consist of the polyamide 6;
 - 5 (ii) providing a liquid aqueous stream S_W ;
 - (iii) preparing a mixture comprising the feedstock F provided according to (i) and the liquid aqueous stream S_W provided according to (ii), and subjecting said mixture to polyamide 6 depolymerisation conditions in a chemical reaction unit U_R , obtaining an aqueous stream S_E leaving U_R , the stream S_E comprising ϵ -caprolactam.
- 10 According to said inventive use referring to the reaction comprising (i), (ii) and (iii), all preferred features and combinations of features regarding (i), (ii) and (iii) discussed hereinabove apply as well.

Further according to said use, the yield in ϵ -caprolactam is in particular increased compared to

- 15 (a) a mixture comprising polyamide 6 and polyethylene terephthalate, wherein said mixture does not contain polyamide 6.6; and
- (b) a mixture comprising polyamide 6 and polyamide 6.6, wherein said mixture does not contain polyethylene terephthalate.

20 Yet further, the present invention also relates to a method of increasing the yield in ϵ -caprolactam in a hydrolytic polyamide 6 depolymerisation reaction, said reaction comprising

- (i) providing a chemical feedstock F, wherein at least 25 weight-% of the chemical feedstock F consist of the polyamide 6;
- (ii) providing a liquid aqueous stream S_W ;
- 25 (iii) preparing a mixture comprising the feedstock F provided according to (i) and the liquid aqueous stream S_W provided according to (ii), and subjecting said mixture to polyamide 6 depolymerisation conditions in a chemical reaction unit U_R , obtaining an aqueous stream S_E leaving U_R , the stream S_E comprising ϵ -caprolactam;

said method comprising preparing the mixture according to (iii) so that it comprises polyamide 6, polyethylene terephthalate and polyamide 6.6 at a mass ratio $r_S = (m_{PA6.6} + m_{PET}) / m_{PA6}$ with
 30 $0.01 \leq r_S \leq 2$. According to said method referring to the reaction comprising (i), (ii) and (iii), all preferred features and combinations of features regarding (i), (ii) and (iii) discussed hereinabove apply as well.

35 Further according to said method, the yield in ϵ -caprolactam is in particular increased compared to

- (a) a mixture comprising polyamide 6 and polyethylene terephthalate, wherein said mixture does not contain polyamide 6.6; and
- (b) a mixture comprising polyamide 6 and polyamide 6.6, wherein said mixture does not
- 40 contain polyethylene terephthalate.

- Providing the chemical feedstock, and the materials M_j , respectively, may comprise an upstream sorting stage. In this regard, it is possible, for example, to spread collected waste material, preferably engineering plastics waste material and/or textile waste material, more preferably textile waste material on a conveyor, which spreading can be carried out either manually and/or mechanically. Thereafter, the respectively spread waste material is subjected to sorting, either by composition and/or by color. Sorting can be carried out either manually and/or optically. If carried out optically, the sorting preferably comprises an infrared sorting, more preferably a near-infrared sorting and/or a mid-infrared sorting. Optionally, prior to sorting, the waste material can be subjected to a suitable metal removing step. If a metal removing step is carried out, ferrous elements are preferably separated, for example by suitable magnetic means, and/or non-ferrous elements are preferably separated, for example by suitable eddy current separating means. After said sorting, the respectively obtained waste material can be subjected to a further treatment, such as cutting and/or milling.
- 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 hydrolytically depolymerizing polyamide 6 comprised in a chemical feedstock F, the process comprising
 - (i) providing the chemical feedstock F, wherein at least 25 weight-% of the chemical feedstock F consist of the polyamide 6;
 - (ii) providing a liquid aqueous stream S_W ;
 - (iii) preparing a mixture comprising the feedstock F provided according to (i) and the liquid aqueous stream S_W provided according to (ii), and subjecting said mixture to polyamide 6 depolymerisation conditions in a chemical reaction unit U_R , obtaining an aqueous stream S_E leaving U_R , the stream S_E comprising ϵ -caprolactam;
 wherein according to (iii), the mixture to be subjected to polyamide 6 depolymerisation conditions comprises the polyamide 6 and further comprises polyethylene terephthalate and polyamide 6.6 at a mass ratio $r_S = (m_{PA6.6} + m_{PET}) / m_{PA6}$ with $0.01 \leq r_S \leq 2.5$.
 2. The process of embodiment 1, wherein $0.02 \leq r_S \leq 2$, preferably $0.03 \leq r_S \leq 1.9$, more preferably $0.05 \leq r_S \leq 1.75$.

3. The process of embodiment 2, wherein $0.05 \leq r_s \leq 1$, preferably $0.05 \leq r_s \leq 0.5$, more preferably $0.05 \leq r_s \leq 0.15$.
- 5 4. The process of any one of embodiments 1 to 3, wherein according to (iii), the mixture to be subjected to polyamide 6 depolymerisation conditions comprises the polyethylene terephthalate and the polyamide 6.6 at a mass ratio $r_T = m_{PET} / m_{PA6.6}$ with $0.005 \leq r_T \leq 5$.
- 10 5. The process of embodiment 4, wherein $0.01 \leq r_T \leq 5$, preferably $0.015 \leq r_T \leq 4$, more preferably $0.02 \leq r_T \leq 3$.
- 15 6. The process of embodiment 5, wherein $0.1 \leq r_T \leq 3$, preferably $0.2 \leq r_T \leq 3$, more preferably $0.5 \leq r_T \leq 3$.
- 20 7. The process of any one of embodiments 1 to 6, wherein
 - the entire amount of polyamide 6 comprised in the mixture to be subjected to polyamide 6 depolymerisation conditions according to (iii) is comprised in the chemical feedstock F provided according to (i);
 - at least part of, preferably the entire amount of polyethylene terephthalate comprised in the mixture to be subjected to polyamide 6 depolymerisation conditions according to (iii) is comprised in the chemical feedstock F provided according to (i);
 - at least part of, preferably the entire amount of polyamide 6.6 comprised in the mixture to be subjected to polyamide 6 depolymerisation conditions according to (iii) is comprised in the chemical feedstock F provided according to (i).
- 25 8. The process of any one of embodiments 1 to 7, wherein at least 50 weight-% of the chemical feedstock F provided according to (i) consist of the polyamide 6, the polyamide 6.6 and the polyethylene terephthalate.
- 30 9. The process of embodiment 8, wherein from 60 to 100 weight-%, more preferably from 70 to 100 weight-%, more preferably from 75 to 100 weight-% of the chemical feedstock F provided according to (i) consist of the polyamide 6, the polyamide 6.6 and the polyethylene terephthalate.
- 35 10. The process of any one of embodiments 1 to 9, wherein the polyamide 6 depolymerisation conditions according to (iii) comprise a polyamide 6 depolymerisation temperature T_D in the range of from 230 to 330 °C, preferably in the range of from 250 to 320 °C, more preferably in the range of from 270 to 310.
- 40 11. The process of any one of embodiments 1 to 10, wherein the polyamide 6 depolymerisation conditions according to (iii) comprise a polyamide 6 depolymerisation pressure p_D 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.

12. The process of any one of embodiments 1 to 11, wherein the mixture to be subjected to polyamide 6 depolymerisation conditions according to (iii) exhibits a mass ratio
 $r_W = (m_{PA6} + m_{PA6.6} + m_{PET}) / m_{H_2O}$ with $0.01 \leq r_W \leq 0.4$, preferably $0.05 \leq r_W \leq 0.3$, more preferably $0.1 \leq r_W \leq 0.2$.
13. The process of any one of embodiments 1 to 12, wherein the chemical feedstock F provided according to (i) further comprises, in addition to the polyamide 6, the polyamide 6.6 and the polyethylene terephthalate, at least one further polymeric compound, said at least one further polymeric compound preferably comprising polytetrahydrofuran.
14. The process of any one of embodiments 1 to 12, wherein the chemical feedstock F provided according to (i) is in solid form, preferably in the form of particles, wherein the particle size distribution of said particles 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 pairs of values:
- a D10 value of the particle width in the range of from 0.3 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 0.5 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 0.8 to 30 mm and a D90 value of the particle length in the range of from 0.8 to 30 mm.
15. The process of embodiment 14, wherein according to (iii), the chemical feedstock F is admixed in solid form with the liquid aqueous stream S_W .
16. The process of embodiment 14, wherein providing the chemical feedstock F according to (i) comprises bringing the chemical feedstock F from the solid form to a liquid form, preferably by subjecting the chemical feedstock F to melt-extrusion, and wherein according to (iii), the chemical feedstock F is admixed in liquid form with the liquid aqueous stream S_W .
17. The process of any one of embodiments 1 to 16, wherein according to (iii), the feedstock F and the stream S_W are admixed 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 F.
18. The process of any one of embodiments 1 to 17, wherein the reaction unit U_R comprises z chemical reactors R_i , $i=1\dots z$, wherein z is in the range of from 1 to 10, preferably in the range of from 1 to 8, more preferably in the range of from 1 to 6, more preferably in the range of from 1 to 5, more preferably in the range of from 1 to 4, more preferably in the range of from 1 to 3.

19. The process of embodiment 18, wherein if $z > 1$, at least 2 reactors R_i , preferably z reactors R_i are serially coupled.
- 5 20. The process of any one of embodiments 1 to 19, wherein the overall residence time in the chemical reaction unit U_R is in the range of from 15 to 800 minutes, preferably in the range of from 30 to 600 minutes, more preferably in the range of from 45 to 360 minutes, more preferably in the range of from 60 to 240 minutes.
- 10 21. The process of any one of embodiments 1 to 20, wherein for preparing the mixture to be subjected to hydrolytic polyamide 6 depolymerisation conditions, no polyamide 6 depolymerization catalyst is added.
- 15 22. The process of any one of embodiments 1 to 21, wherein the chemical feedstock F provided according to (i) consists of w chemical materials M_j with $j=1..w$ and $w \geq 1$.
- 20 23. The process of embodiment 22, wherein at least one of the chemical materials M_i , preferably every chemical material M_i comprises, preferably consists of a waste material, said waste material preferably comprising, more preferably consisting of, one or more of at least one textile waste material and at least one engineering plastics waste material, more preferably comprising, more preferably consisting of at least one textile waste material.
- 25 24. The process of any one of embodiments 1 to 23, being a continuous process, a semicontinuous process, or a batch process.
- 30 25. The process of any one of embodiments 1 to 24, further comprising
 - (iv) generating an aqueous stream S_R comprises subjecting the stream S_E obtained from the chemical reaction unit U_R , optionally after subjecting S_E to filtration, to thermal water separation, obtaining the stream S_R ;
 - (v) feeding at least part of the aqueous stream S_R back to the chemical reaction unit U_R as part of the aqueous stream S_W ;
 wherein the thermal water separation according to (iv) preferably comprises one or more of distilling and falling film evaporating.
- 35 26. The process of embodiment 25, wherein generating the aqueous stream S_R according to (iv) comprises, preferably consists of, distilling the stream S_E obtained from the reaction unit U_R , optionally after subjecting S_E to filtration, obtaining the stream S_R .
- 40 27. The process of embodiment 26, wherein distilling is carried out in a distillation column at a bottoms temperature in the range of from 70 to 140 °C, preferably in the range of from 80 to 120 °C, more preferably in the range of from 90 to 110 °C, and a top pressure in the range of from 0.5 to 1.5 bar(abs), preferably in the range of from 0.7 to 1.2 bar(abs), more

preferably in the range of from 0.8 to 1.1 bar(abs), wherein the stream S_R is obtained at the top of the distillation column.

28. The process of embodiment 27, wherein distilling comprises subjecting the vapor top stream to condensation, obtaining a liquid stream S_R , wherein at least a part of the liquid stream S_R is fed back to the chemical reaction unit U_R as part of the aqueous stream S_W according to (v).
29. The process of embodiment 28, wherein the liquid stream S_R obtained from condensation is divided into 2 streams, wherein a first stream obtained from dividing is fed back to the chemical reaction unit U_R as part of the aqueous stream S_W according to (v) and a second stream is fed back to the top of the distillation column, wherein the volume ratio of the first stream relative to the second stream is preferably in the range of from 10:1 to 0.5:1, more preferably in the range of from 7:1 to 1:1, more preferably in the range of from 5:1 to 2:1.
30. The process of any one of embodiments 1 to 25, wherein generating the aqueous stream S_R according to (iv) comprises
 - (A) passing the liquid aqueous stream S_E into an evaporation unit U_E , obtaining from S_E a liquid aqueous stream S_L comprising ϵ -caprolactam dissolved in water at a concentration c_{SL} with $c_{SL} > c_{SR}$, and further obtaining from S_E one or more aqueous vapor streams S_V ;
 - (B) passing the aqueous stream S_L into a heat-consuming purification unit U_P , obtaining from S_L a stream S_{CPL} comprising ϵ -caprolactam at a concentration c_{SCPL} with $c_{SCPL} \gg c_{SL}$, and further obtaining from S_L one or more aqueous streams S_{RW} , wherein at least part of the heat consumed in U_P is provided by at least one of the one or more streams S_V , thereby obtaining from the at least one stream S_V at least one at least partially condensed aqueous stream S_{VW} ;
 - (C) recycling, as the stream S_R , at least one stream S_{VW} at least partially and at least one stream S_{RW} at least partially to the reaction unit U_R .
31. Use of S_{CPL} , obtainable or obtained by a process according to embodiment 30, 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 embodiment 30 as a starting material.
32. The use or the method of embodiment 31, 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.

34. The use or the method of any one of embodiments 31 to 33, 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:
- 5 - 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, and/or a cushion;
 - 10 - a cloth, an apparel, preferably a shirt, trousers, a pullover, a boot, a shoe, a shoe sole, a tight and/or or jacket;
 - 15 - 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;
 - 20 - 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;
 - 25 - 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.
 - 30
 - 35
35. The use or the method of any one of embodiments 31 to 34, 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 embodiment 30, 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
- 40

- 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.
- 5
36. Use of a mixture comprising polyamide 6, polyethylene terephthalate and polyamide 6.6 at a mass ratio $r_S = (m_{PA6.6} + m_{PET}) / m_{PA6}$ with $0.01 \leq r_S \leq 2$ for increasing the yield in ϵ -caprolactam in a hydrolytic polyamide 6 depolymerisation reaction, said reaction
- 10 comprising
- (i) providing a chemical feedstock F, wherein at least 25 weight-% of the chemical feedstock F consist of the polyamide 6;
 - (ii) providing a liquid aqueous stream S_W ;
 - (iii) preparing a mixture comprising the feedstock F provided according to (i) and the
- 15 liquid aqueous stream S_W provided according to (ii), and subjecting said mixture to polyamide 6 depolymerisation conditions in a chemical reaction unit U_R , obtaining an aqueous stream S_E leaving U_R , the stream S_E comprising ϵ -caprolactam.
37. The use of embodiment 36, wherein the yield in ϵ -caprolactam is increased compared to
- 20 (a) a mixture comprising polyamide 6 and polyethylene terephthalate, wherein said mixture does not contain polyamide 6.6; and
- (b) a mixture comprising polyamide 6 and polyamide 6.6, wherein said mixture does not contain polyethylene terephthalate.
- 25 38. A method of increasing the yield in ϵ -caprolactam in a hydrolytic polyamide 6 depolymerisation reaction, said reaction comprising
- (i) providing a chemical feedstock F, wherein at least 25 weight-% of the chemical feedstock F consist of the polyamide 6;
 - (ii) providing a liquid aqueous stream S_W ;
 - (iii) preparing a mixture comprising the feedstock F provided according to (i) and the
- 30 liquid aqueous stream S_W provided according to (ii), and subjecting said mixture to polyamide 6 depolymerisation conditions in a chemical reaction unit U_R , obtaining an aqueous stream S_E leaving U_R , the stream S_E comprising ϵ -caprolactam;
- said method comprising preparing the mixture according to (iii) so that it comprises
- 35 polyamide 6, polyethylene terephthalate and polyamide 6.6 at a mass ratio $r_S = (m_{PA6.6} + m_{PET}) / m_{PA6}$ with $0.01 \leq r_S \leq 2$.
39. The method of embodiment 38, wherein the yield in ϵ -caprolactam is increased compared to
- 40 (a) a mixture comprising polyamide 6 and polyethylene terephthalate, wherein said mixture does not contain polyamide 6.6; and

- (b) a mixture comprising polyamide 6 and polyamide 6.6, wherein said mixture does not contain polyethylene terephthalate.

5 As far as the embodiment 35 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.

10 As far as the embodiments 31 to 35 are concerned, preparing the polymer, the polymer product, or the polymer and the polymer product may comprise one or more synthesis steps and can be performed by conventional synthesis and techniques well known to the person skilled in the art. Examples of the synthesis steps are described in "Industrial Organic Chemistry", 3rd volume, Wiley-VCH, 1997; ISBN: 978-3-527-28838-0; „Kunststoffhandbuch“, 11 volumes in 17 sub-volumes, Carl Hanser Verlag, especially volume 6, „Polyamide“, 1st edition, 1966; "Injection
15 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.

20 In the context of the present invention, a term "X is one or more of A, B and C", wherein X is a given feature and each of A, B and C stands for specific realization of said feature, is to be understood as disclosing that X is either A, or B, or C, or A and B, or A and C, or B and C, or A and B and C. In this regard, it is noted that the skilled person is capable of transfer to above abstract term to a concrete example, e.g. where X is a chemical element and A, B and C are concrete elements such as Li, Na, and K, or X is a temperature and A, B and C are concrete
25 temperatures such as 10 °C, 20 °C, and 30 °C. In this regard, it is further noted that the skilled person is capable of extending the above term to less specific realizations of said feature, e.g. "X is one or more of A and B" disclosing that X is either A, or B, or A and B, or to more specific realizations of said feature, e.g. "X is one or more of A, B, C and D", disclosing that X is either A, or B, or C, or D, or A and B, or A and C, or A and D, or B and C, or B and D, or C and D, or A and
30 B and C, or A and B and D, or B and C and D, or A and B and C and D.

The term „bar“ as used herein refers to „bar(abs)“, i.e. bar (absolute), sometimes also referred to „bara“.

35 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
40 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.

5 The term “textile waste material” 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.

10 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.

15 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.

20 Preferred aspects of the present invention are further illustrated in the Examples described hereinunder.

Examples

25 **Example 1:** Carrying out the depolymerization reaction

30 According to the weight percentages as shown in Tables 1, 2 and 3 in Example 2, feedstocks F were prepared consisting of polyamide 6 (PA6), polyamide 6.6 (PA6.6), and polyethylene terephthalate (PET). These feedstocks were then subjected to hydrolytic depolymerization in an autoclave wherein the depolymerization mixture consisted of the respective feedstock and water, wherein the mass ratio of feedstock relative to water, $m_F : m_{H_2O}$, was 1:10. After the mixture was fed into the autoclave, the autoclave was sealed and heated to the respective temperature T_D as indicated in Tables 1, 2 and 3 below, which temperature T_D was then maintained for Δt_D as indicated in said Tables.

35 Heating to said temperature was carried out at a heating ramp of 30 to 70 K/h. After Δt_D , the obtained reaction mixture was cooled in the autoclave at a cooling ramp of 10 to 100 K/h. The respectively obtained reaction mixtures were then removed from the autoclave, and probes were sampled and subjected to GC analysis which lead to the results (yields) shown in Tables 1, 2, 40 and 3.

The yields given in said Tables were calculated as the mass of ϵ -caprolactam monomer

contained in the reaction mixture obtained from depolymerization divided by the mass of polyamide 6 contained in the feedstock to be subjected to depolymerization.

Example 2: Inventive and comparative examples

5

The experiments shown in the Tables 1, 2 and 3 below were carried out as described above in Example 1.

Table 1

10 Variation of the chemical composition of the feedstock F

No.	Composition feedstock F			T _D / °C	Δt _D / min	Yield CPL ^{*)} / %
	PA6 / wt%	PA6.6 / wt%	PET / wt.-%			
#1	90	10	0	300	60	78
#2	90	5	5	300	60	93
#3	90	0	10	300	60	89

^{*)} CPL = ε-caprolactam monomer

As shown in Table 1 above, it was surprisingly found that at a constant content of PA6, the yield in the valuable product ε-caprolactam monomer has a maximum if both PA6.6 and PET are contained in the feedstock F (#2), compared to feedstocks containing either only PA6.6 (#1) or only PET (#2) in addition to PA6.

15

Table 2

Variation of the chemical composition of the feedstock F

No.	Composition feedstock F			T _D / °C	Δt _D / min	Yield CPL ^{*)} / %
	PA6 / wt%	PA6.6 / wt%	PET / wt.-%			
#4	95	5	0	300	60	79
#2	90	5	5	300	60	93
#5	95	0	5	300	60	86

20

^{*)} CPL = ε-caprolactam monomer

As shown in Table 2 above, it was surprisingly found that although the PA6 content of #4 was increased compared to #1 of Table 1 above, and although the PA6 content of #5 was increased compared to #3 of Table 1 above, the yield in the valuable product ε-caprolactam monomer still

has a maximum if both PA6.6 and PET are contained in the feedstock F (#2) at a lower PA6 content.

Table 3

5 Variation of T_D

No.	Composition feedstock F			T _D / °C	Δt _D / min	Yield CPL ^{*)} / %
	PA6 / wt%	PA6.6 / wt%	PET / wt.-%			
#6	90	5	5	270	60	79
#7	90	5	5	285	60	96
#2	90	5	5	300	60	93
#8	90	5	5	320	60	92
#9	90	5	5	340	60	85

^{*)} CPL = ε-caprolactam monomer

According to Table 3 above, the parameter T_D was varied based on the advantageous feedstock F according to #2. Surprisingly, it was found that in terms of the yield in the valuable product ε-caprolactam monomer, a temperature range exists for which said yield shows superior values.

GC analysis measurements according to present invention were carried out as follows:

For GC analysis on purity of ε-caprolactam, samples were prepared in deionized water at concentration of approx. 200 mg/mL. Analysis was performed on a standard GC instrument equipped with a split/splitless injector and an FID. The injection volume was 1 μL (microL) at a split ratio of 15:1. The injector temperature was 250 °C. The instrument was operated in constant pressure mode at 14.5 psi (~ 1 bar), and nitrogen was used as carrier gas. Separation was performed on a Wax 52 CB column, 50 m x 0.32 mm, 1.2 μm from Agilent Technologies. The temperature program started with a ramp from 80 °C to 185 °C at a heating rate of 7 °C/min, and a hold time at 185 °C for 30 min. A second ramp was from 185 °C to 200 °C at a heating rate of 7 °C/min, and a hold time at 200 °C for 5 min. The detector (Flame Ionization Detector, FID) temperature was 250 °C. Evaluation of purity values Ω_{GC} was based on area-% distribution, corrected by the content of water determined by Carl Fisher Method.

Claims

1. A process for hydrolytically depolymerizing polyamide 6 comprised in a chemical feedstock F, the process comprising
 - (i) providing the chemical feedstock F, wherein at least 25 weight-% of the chemical feedstock F consist of the polyamide 6;
 - (ii) providing a liquid aqueous stream S_W ;
 - (iii) preparing a mixture comprising the feedstock F provided according to (i) and the liquid aqueous stream S_W provided according to (ii), and subjecting said mixture to polyamide 6 depolymerisation conditions in a chemical reaction unit U_R , obtaining an aqueous stream S_E leaving U_R , the stream S_E comprising ϵ -caprolactam; wherein according to (iii), the mixture to be subjected to polyamide 6 depolymerisation conditions comprises the polyamide 6 and further comprises polyethylene terephthalate and polyamide 6.6 at a mass ratio $r_S = (m_{PA6.6} + m_{PET}) / m_{PA6}$ with $0.01 \leq r_S \leq 2.5$.
2. The process of claim 1, wherein $0.02 \leq r_S \leq 2$, preferably $0.03 \leq r_S \leq 1.9$, more preferably $0.05 \leq r_S \leq 1.75$.
3. The process of claim 1 or 2, wherein according to (iii), the mixture to be subjected to polyamide 6 depolymerisation conditions comprises the polyethylene terephthalate and the polyamide 6.6 at a mass ratio $r_T = m_{PET} / m_{PA6.6}$ with $0.005 \leq r_T \leq 5$; preferably $0.01 \leq r_T \leq 5$, more preferably $0.015 \leq r_T \leq 4$, more preferably $0.02 \leq r_T \leq 3$.
4. The process of any one of claims 1 to 3, wherein at least 50 weight-%, preferably from 60 to 100 weight-%, more preferably from 70 to 100 weight-%, more preferably from 75 to 100 weight-% of the chemical feedstock F provided according to (i) consist of the polyamide 6, the polyamide 6.6 and the polyethylene terephthalate.
5. The process of any one of claims 1 to 4, wherein the polyamide 6 depolymerisation conditions according to (iii) comprise a polyamide 6 depolymerisation temperature T_D in the range of from 230 to 330 °C, preferably in the range of from 250 to 320 °C, more preferably in the range of from 270 to 310, and further comprise a polyamide 6 depolymerisation pressure p_D 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.
6. The process of any one of claims 1 to 5, wherein the mixture to be subjected to polyamide 6 depolymerisation conditions according to (iii) exhibits a mass ratio $r_W = (m_{PA6} + m_{PA6.6} + m_{PET}) / m_{H_2O}$ with $0.01 \leq r_W \leq 0.4$, preferably $0.05 \leq r_W \leq 0.3$, more preferably $0.1 \leq r_W \leq 0.2$; wherein according to (iii), the chemical feedstock F is admixed in solid form with the liquid aqueous stream S_W , or wherein (i) comprises bringing the chemical feedstock F from the solid form to a liquid form, preferably by subjecting the chemical feedstock F to melt-

- extrusion, and wherein according to (iii), the chemical feedstock F is admixed in liquid form with the liquid aqueous stream S_W ;
 wherein according to (iii), the feedstock F and the stream S_W are admixed preferably at a mixing ratio $(m_W/\text{kg}) / (m_P/\text{kg})$ 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 F.
7. The process of any one of claims 1 to 6, wherein the overall residence time in the chemical reaction unit U_R is in the range of from 15 to 800 minutes, preferably in the range of from 30 to 600 minutes, more preferably in the range of from 45 to 360 minutes, more preferably in the range of from 60 to 240 minutes.
8. The process of any one of claims 1 to 7, wherein the chemical feedstock F provided according to (i) consists of w chemical materials M_j with $j=1..w$ and $w \geq 1$, wherein at least one of the chemical materials M_j , preferably every chemical material M_j comprises, preferably consists of a waste material, said waste material preferably comprising, more preferably consisting of, one or more of at least one textile waste material and at least one engineering plastics waste material, more preferably comprising, more preferably consisting of at least one textile waste material.
9. The process of any one of claims 1 to 8, further comprising
 (iv) generating an aqueous stream S_R comprises subjecting the stream S_E obtained from the chemical reaction unit U_R , optionally after subjecting S_E to filtration, to thermal water separation, obtaining the stream S_R ;
 (v) feeding at least part of the aqueous stream S_R back to the chemical reaction unit U_R as part of the aqueous stream S_W ;
 wherein the thermal water separation according to (iv) preferably comprises one or more of distilling and falling film evaporating.
10. The process of claim 9, wherein generating the aqueous stream S_R according to (iv) comprises, preferably consists of, distilling the stream S_E obtained from the reaction unit U_R , optionally after subjecting S_E to filtration, obtaining the stream S_R .
11. The process of claim 10, wherein distilling is carried out in a distillation column at a bottoms temperature in the range of from 70 to 140 °C, preferably in the range of from 80 to 120 °C, more preferably in the range of from 90 to 110 °C, and a top pressure in the range of from 0.5 to 1.5 bar(abs), preferably in the range of from 0.7 to 1.2 bar(abs), more preferably in the range of from 0.8 to 1.1 bar(abs), wherein the stream S_R is obtained at the top of the distillation column, wherein distilling preferably comprises subjecting the vapor top stream to condensation, obtaining a liquid stream S_R , wherein at least a part of the liquid stream S_R is fed back to the chemical reaction unit U_R as part of the aqueous stream S_W according to (v).

12. The process of any one of claims 1 to 9, wherein generating the aqueous stream S_R according to (iv) comprises
- 5 (A) passing the liquid aqueous stream S_E into an evaporation unit U_E , obtaining from S_E a liquid aqueous stream S_L comprising ϵ -caprolactam dissolved in water at a concentration c_{SL} with $c_{SL} > c_{SR}$, and further obtaining from S_E one or more aqueous vapor streams S_V ;
- 10 (B) passing the aqueous stream S_L into a heat-consuming purification unit U_P , obtaining from S_L a stream S_{CPL} comprising ϵ -caprolactam at a concentration c_{SCPL} with $c_{SCPL} \gg c_{SL}$, and further obtaining from S_L one or more aqueous streams S_{RW} , wherein at least part of the heat consumed in U_P is provided by at least one of the one or more streams S_V , thereby obtaining from the at least one stream S_V at least one at least partially condensed aqueous stream S_{VW} ;
- 15 (C) recycling, as the stream S_R , at least one stream S_{VW} at least partially and at least one stream S_{RW} at least partially to the reaction unit U_R .
13. Use of S_{CPL} , obtainable or obtained by a process according to claim 12, 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
- 20 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 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
- 25 obtainable or obtained by a process according to claim 12, wherein the at least one further polymeric compound preferably comprises one or more of 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
- 30 as wool and cotton; at least one cellulose material; at least one natural elastomer; at least one synthetic elastomer; at least one copolymer 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.
- 35 14. The use of claim 13, 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:
- 40 - 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

- 5 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, and/or a cushion;
- 10 - a cloth, an apparel, preferably a shirt, trousers, a pullover, a boot, a shoe, a shoe sole, a tight and/or or jacket;
- 15 - 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;
- 20 - 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;
- 25 - 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.
- 30 15. Use of a mixture comprising polyamide 6, polyethylene terephthalate and polyamide 6.6 at a mass ratio $r_S = (m_{PA6.6} + m_{PET}) / m_{PA6}$ with $0.01 \leq r_S \leq 2$ for increasing the yield in ϵ -caprolactam in a hydrolytic polyamide 6 depolymerisation reaction, said reaction comprising
- 35 (i) providing a chemical feedstock F, wherein at least 25 weight-% of the chemical feedstock F consist of the polyamide 6;
- (ii) providing a liquid aqueous stream S_W ;
- (iii) preparing a mixture comprising the feedstock F provided according to (i) and the liquid aqueous stream S_W provided according to (ii), and subjecting said mixture to polyamide 6 depolymerisation conditions in a chemical reaction unit U_R , obtaining an aqueous stream S_E leaving U_R , the stream S_E comprising ϵ -caprolactam.