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(54) **Title:** PROCESS FOR HYDROLYTICALLY DEPOLYMERIZING A POLYAMIDE

(57) **Abstract:** A process for hydrolytically depolymerizing a polyamide 6 comprised in a solid material M, the process comprising providing the solid material M; melting in a melting unit U_M the solid material M, obtaining a liquid stream S_M having a temperature T_{SM} at a pressure p_{SM}; providing a liquid aqueous stream S_W having a temperature T_{SW} at a pressure p_{SW}; 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}; feeding the stream S_F into a chemical reaction unit U_R; subjecting the stream S_F in the reaction unit U_R to polyamide 6 depolymerization conditions comprising a polyamide 6 depolymerization temperature T_D at a polyamide 6 depolymerization pressure p_D, obtaining in U_R an aqueous depolymerization mixture comprising ε-caprolactam dissolved in water; removing an aqueous liquid reactor exit stream S_R from U_R, the stream S_R comprising ε-caprolactam dissolved in water; wherein $0.8 \leq T_{SF}/T_D \leq 1.05$ and $0.9 \leq p_{SF}/p_D \leq 1.05$.

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Process for hydrolytically depolymerizing a polyamide

The present invention relates to a process for hydrolytically depolymerizing a polyamide prepared from ε-caprolactam and an apparatus for carrying out a process for hydrolytically depolymerizing a polyamide prepared from ε-caprolactam, preferably for carrying out the aforementioned process.

Polyamide, and in particular polyamide 6 being characterized by the formula $(-NH-(CH_2)_5-CO-)_n$, 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. Thus, there is a need to provide an improved process for depolymerizing a polyamide able to overcome these issues.

According to the present invention, it was found that an efficient depolymerization reaction wherein polyamide 6 is hydrolytically hydrolyzed can be realized when upstream of the chemical reaction unit in which the depolymerization reaction actually takes place, a specific sequence of a melting unit and a pre-reaction unit is realized. Further, it was found that the process can be rendered even more efficient if a specific design of the chemical reaction unit is realized. Based thereon, and in combination with specific sequences of stages upstream and in particular downstream of said chemical reaction unit allowing for the recycling of water and a very effective use of process-internal heat, an advantageous overall process for recycling materials containing polyamide 6 can be provided by the present invention.

Therefore, the present invention relates to a process for hydrolytically depolymerizing a polyamide 6 comprised in a solid material M, the process comprising

(i) providing the solid material M;
(ii) melting in a melting unit U_M the solid material M provided according to (i), obtaining a liquid stream S_M having a temperature T_{SM} at a pressure p_{SM};
(iii) providing a liquid aqueous stream S_W having a temperature T_{SW} at a pressure p_{SW};
(iv) admixing in a pre-reaction unit U_{PR} the stream S_M obtained according to (ii) with the stream S_W provided according to (iii), obtaining a liquid reaction feed stream S_F having a temperature T_{SF} at a pressure p_{SF};
(v) feeding the stream S_F obtained according to (iv) into a chemical reaction unit U_R;
(vi) subjecting the stream S_F in the reaction unit U_R to polyamide 6 depolymerization conditions comprising a polyamide 6 depolymerization temperature T_D at a polyamide 6 depolymerization pressure p_D, obtaining in U_R an aqueous depolymerization mixture comprising ε-caprolactam dissolved in water;
(vii) removing an aqueous liquid reactor exit stream S_R from U_R, the stream S_R comprising ε-caprolactam dissolved in water;

wherein $0.8 \leq T_{SF}/T_D \leq 1.05$ and $0.9 \leq p_{SF}/p_D \leq 1.05$.

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 stream S_F to be subjected to hydrolytic polyamide 6 depolymerisation conditions according to (vi).

Preferably, $0.6 \leq T_{SM}/T_{SF} \leq 1.05$ and $0.9 \leq p_{SM}/p_{SF} \leq 1.05$. According to the present invention, one or more of the following ranges may be preferred: $0.6 \leq T_{SM}/T_{SF} \leq 0.7$; $0.7 \leq T_{SM}/T_{SF} \leq 0.8$; $0.8 \leq T_{SM}/T_{SF} \leq 0.9$; $0.9 \leq T_{SM}/T_{SF} \leq 1.0$; $1.0 \leq T_{SM}/T_{SF} \leq 1.05$.

Further preferably, $0.8 \leq T_{SW}/T_{SF} \leq 1.3$ and $0.9 \leq p_{SW}/p_{SF} \leq 1.05$. Further according to the present invention, one or more of the following ranges may be preferred: $0.8 \leq T_{SW}/T_{SF} \leq 0.9$; $0.9 \leq T_{SW}/T_{SF} \leq 1.0$; $1.0 \leq T_{SW}/T_{SF} \leq 1.1$; $1.1 \leq T_{SW}/T_{SF} \leq 1.2$; $1.2 \leq T_{SW}/T_{SF} \leq 1.3$.

Regarding the pre-reaction unit U_{PR} according to (iv), no specific limitations exist, provided that a liquid reaction feed stream S_F having the temperature T_{SF} at the pressure p_{SF} can be obtained. Preferably, the pre-reaction unit U_{PR} according to (iv) comprises, more preferably consists of a mixing unit, wherein more preferably, said mixing unit is 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.

According to the present invention, it is preferred that according to (iv), 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. Preferred ranges are, for example, from 5:1 to 6:1 or from 6:1 to 7:1 or from 7:1 to 8:1 from 8:1 to 9:1 or from 9:1 to 10:1.

Regarding the melting unit U_M according to (ii), no specific limitations exist, provided that a liquid stream S_M having the temperature T_{SM} at the pressure p_{SM} can be obtained. Preferably, the melting unit U_M according to (ii) comprises a kneader or an extruder, more preferably an extruder, wherein more preferably, the melting unit U_M according to (ii) 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. More preferably, the solid material M which is provided according to (i) and which has a temperature which is lower than T_{SM} is fed into the extruder and melted therein while being conveyed through the extruder. Preferably, the temperature of solid material which is fed into the extruder has a temperature in the range of from 10 to 50 °C, more preferably in the range of from 15 to 40 °C, more preferably in the range of from 20 to 30 °C. Further preferably, the solid material is fed into the extruder at a pressure in the range of from 0.75 to 5 bar, more preferably in the range of from 0.85 to 3 bar, more preferably in the range of from 0.95 to 1.5 bar. For melting the material M, the extruder is preferably equipped with suitable heating means so as to respectively heat up the material M, wherein when leaving the extruder, the liquid stream S_M has the temperature T_{SM}. Said suitable heating means can be arranged in a manner so that the extruder exhibits one heating zone or more than one heating zones. It is conceivable that for feeding the solid material M, the extruder has more than one feeding zone. Further according to the present invention, the extruder can be operated either starve-fed or flood-fed.

Preferably, the melting unit U_M, preferably the extruder, is equipped with a degassing system which serves for removing one or more gases during the melting process in the extruder. While it is generally conceivable that the extruder has more than one degassing zone, it is preferred that it has one degassing zone. Preferably, the degassing zone located directly before the pressure build-up in the extruder discharge zone. If the melting unit U_M, preferably the extruder, is equipped with a degassing system, the process preferably comprises removing a gas stream S_{GM} from U_M during melting according to (ii). Preferably, said gas stream S_{GM} has a temperature T_{GM} at a pressure p_{GM}, wherein $0.95 \leq T_{GM}/T_{SM} \leq 1.05$, preferably $0.95 \leq T_{GM}/T_{SM} \leq 1.0$. Preferably according to the present invention, the stream S_{GM} obtained from the melting unit 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. Prior to being subjected to scrubbing, the stream S_{GM} obtained from the melting unit U_M is preferably subjected to cooling, preferably in a vacuum system via which the stream S_{GM} is preferably removed from the melting unit U_M.

According to the present invention, the stream S_M has a pressure p_{SM} wherein said pressure p_{SM} is preferably in the range $0.9 \leq p_{SM}/p_{SF} \leq 1.05$ and wherein p_{SF} is in the range $0.9 \leq p_{SF}/p_D \leq 1.05$. As discussed below, the polyamide 6 depolymerization pressure p_D is preferably in the range of from 40 to 140 bar. Therefore, it is preferred according to the present invention that the pressure p_{SM} is higher, more preferably significantly higher than the pressure at which the solid material M is fed into the melting unit U_M, preferably into the extruder. According to the present invention, it may be conceivable that this increase in pressure is achieved in the extruder itself. However, it is particularly preferred that for achieving said increase in pressure is achieved by a suitable compression device which is comprised in the melting unit U_M, for example a compression device which is arranged downstream of the extruder. According to this preferred arrangement, it may be preferred that the liquid stream leaving the extruder is at essentially the same pressure as the solid material which is fed into the extruder, wherein said liquid stream is then suitably compressed in said compression device to result in the stream S_M having the temperature T_{SM} at the pressure p_{SM}. Preferably according to the present invention, said compression device comprises, more preferably consists of, at least one suitably gear pump, wherein is more than one gear pump is installed, it is preferred that at least two gear pumps are serially arranged.

Further according to the present invention, it may be preferred to pass the liquid stream S_M leaving the melting unit U_M through a filter unit U_F before it is admixed with the liquid aqueous stream S_W according to (iv). Preferably, 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 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 (iv). Yet further, if the melting unit U_M comprises a compression device as described above, it may be preferred to pass the liquid stream, preferably obtained from the extruder, through said filter device U_F before the stream is passed through the compression device.

Further according to the present invention, it is possible that the melting unit U_M comprises more than one melting apparatus, preferably more than one extruder, wherein, for example, two or more extruders can be arranged in parallel.

Regarding the polyamide 6 depolymerization conditions according to (vi), it is preferred that T_D is in the range of from 230 to 330 °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 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.

Therefore, preferred ranges for T_D are, for example, from 270 to 280 °C or 280 to 290 °C or 290 to 300 °C or 300 to 310 °C, and preferred ranges for p_D are, for example, from 40 to 55 bar or from 55 to 70 bar or from 70 to 85 bar or from 85 to 100 bar or from 100 to 110 bar.

According to the present invention, the reaction unit U_R according to (v) comprises at least one reactor in which the liquid stream S_F is subjected to depolymerization conditions according to (vi). Preferably, the reaction unit U_R according to (v) comprises z chemical reactors R_i, i=1…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 preferably, the reaction unit U_R according to (v) comprises 3 reactors R_1, R_2 and R_3.

If the reaction unit U_R according to (v) comprises more than one reactor R_i, i.e. if z > 1, it is preferred that at least 2 reactors R_i, preferably all z reactors R_i are serially coupled, wherein

- according to (v), the stream S_F is fed into R_i, with i = 1;
- an aqueous liquid stream S_i containing ε-caprolactam dissolved in water is removed from reactor R_i and fed into the reactor R_{i+1}, with i < z;
- according to (vii), the aqueous liquid stream S_z containing ε-caprolactam dissolved in water is removed from the reactor R_z as the stream S_R;

wherein in every reactor R_i, a depolymerization temperature T_{Di} at a depolymerization pressure p_{Di} is maintained, wherein, independently of each other, T_{Di} is in the range of from 230 to 330 °C and p_{Di} is in the range of from 40 to 140 bar, preferably wherein T_{Di} is in the range of from 250 to

320 °C and p_{Di} is in the range of from 40 to 125 bar, more preferably wherein T_{Di} is in the range of from 270 to 310 °C and p_{Di} is in the range of from 40 to 110 bar. Regarding the preferred arrangement of three reactors R_1, R_2 and R_3, it is preferred that these three reactors are serially coupled, wherein

- according to (v), the stream S_F is fed into R_1;
- an aqueous liquid stream S_1 containing ε-caprolactam dissolved in water is removed from reactor R_1 and fed into the reactor R_2;
- an aqueous liquid stream S_2 containing ε-caprolactam dissolved in water is removed from reactor R_2 and fed into the reactor R_3;
- according to (vii), the aqueous liquid stream S_3 containing ε-caprolactam dissolved in water is removed from the reactor R_3 as the stream S_R;

wherein in the reactor R_1, a depolymerization temperature T_{D1} at a depolymerization pressure p_{D1} is maintained, wherein T_{D1} is in the range of from 230 to 330 °C and p_{D1} is in the range of from 40 to 140 bar, preferably wherein T_{D1} is in the range of from 250 to 320 °C and p_{D1} is in the range of from 40 to 125 bar, more preferably wherein T_{D1} is in the range of from 270 to 310 °C and p_{D1} is in the range of from 40 to 110 bar; wherein preferred ranges for T_{D1} are, for example, from 270 to 280 °C or 280 to 290 °C or 290 to 300 °C or 300 to 310 °C, and preferred ranges for p_{D1} are, for example, from 40 to 55 bar or from 55 to 70 bar or from 70 to 85 bar or from 85 to 100 bar or from 100 to 110 bar;
wherein in the reactor R_2, a depolymerization temperature T_{D2} at a depolymerization pressure p_{D2} is maintained, wherein T_{D2} is in the range of from 230 to 330 °C and p_{D2} is in the range of from 40 to 140 bar, preferably wherein T_{D2} is in the range of from 250 to 320 °C and p_{D2} is in the range of from 40 to 125 bar, more preferably wherein T_{D2} is in the range of from 270 to 310 °C and p_{D2} is in the range of from 40 to 110 bar; wherein preferred ranges for T_{D2} are, for example, from 270 to 280 °C or 280 to 290 °C or 290 to 300 °C or 300 to 310 °C, and preferred ranges for p_{D2} are, for example, from 40 to 55 bar or from 55 to 70 bar or from 70 to 85 bar or from 85 to 100 bar or from 100 to 110 bar;
wherein in the reactor R_3, a depolymerization temperature T_{D3} at a depolymerization pressure p_{D3} is maintained, wherein T_{D3} is in the range of from 230 to 330 °C and p_{D3} is in the range of from 40 to 140 bar, preferably wherein T_{D3} is in the range of from 250 to 320 °C and p_{D3} is in the range of from 40 to 125 bar, more preferably wherein T_{D3} is in the range of from 270 to 310 °C and p_{D3} is in the range of from 40 to 110 bar; wherein preferred ranges for T_{D3} are, for example, from 270 to 280 °C or 280 to 290 °C or 290 to 300 °C or 300 to 310 °C, and preferred ranges for p_{D3} are, for example, from 40 to 55 bar or from 55 to 70 bar or from 70 to 85 bar or from 85 to 100 bar or from 100 to 110 bar.

According to the present invention, it is preferred that 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. Regarding the preferred arrangement of three reactors R_1, R_2 and R_3, it is preferred that the reactors R_1, R_2 and R_3 are vertically arranged, with R_1 being the top-most reactor and R_3 being the bottom-most reactor, wherein S_1 obtained from R_1 is transferred to R_2 by gravity, preferably by gravity only, and wherein S_2 obtained from R_2 is transferred to R_3 by gravity, preferably by gravity only.

Regarding the specific design of the one or more reactors R_i, it is preferred that at least one reactor R_i is an stirred tank reactor, and more preferably all z reactors are stirred tank reactors. Regarding the preferred arrangement of three reactors R_1, R_2 and R_3, it is preferred that the reactors R_1, R_2 and R_3 are stirred tank reactors.

While there are no general restrictions regarding the specific design of said stirred tank reactors, it is 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 2 adjacent compartments are separated by a divider which comprises at least one flow-through opening. Preferably at least one compartment comprised in a reactor R_i comprises at least one agitator, wherein more preferably, every compartment of every reactor R_i comprises at least one agitator, wherein more preferably, every compartment of every reactor R_i comprises one agitator, 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. Regarding the preferred arrangement of three reactors R_1, R_2 and R_3, it is more preferred that the stirred tank reactor R_1 has 3 vertically and serially arranged compartments wherein every compartment comprises an agitator, the stirred tank reactor R_2 has 3 vertically and serially arranged compartments wherein every compartment comprises an agitator, and the stirred tank reactor R_3 has 3 vertically and serially arranged compartments wherein every compartment comprises an agitator. Particular reference is made to Figure 5 of the present invention and its respective description.

Alternatively, regarding the specific design of said stirred tank reactors, it is 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. In this regard, and further regarding the preferred arrangement of three reactors R_1, R_2 and R_3, it is more preferred that the stirred tank reactor R_1 has 2 vertically and serially arranged compartments formed by, and separated by, said suitable components of the agitator comprised in R_1, the stirred tank reactor R_2 has 2 vertically and serially arranged compartments formed by, and separated by, said suitable components of the agitator comprised in R_2, and the stirred tank reactor R_3 has 2 vertically and serially arranged compartments formed by, and separated by, said suitable components of the agitator comprised in R_3.

Preferably according to the present invention, the polyamide 6 depolymerization conditions according to (vi) 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. The term “total 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. In particular for z > 1, it is preferred that 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 $0.95 \leq (t_{Di} / t_{Di+1}) \leq 1.05$. Therefore, according to the present invention, it is preferred that a narrow residence time distribution is realized. Regarding the preferred arrangement of three reactors R_1, R_2 and R_3, it is more preferred that the residence time of the aqueous depolymerization mixture in the reactor R_1 is t_{D1}, the residence time of the aqueous depolymerization mixture in the reactor R_2 is t_{D2} and the residence time of the aqueous depolymerization mixture in the reactor R_3 is $t_{D3,}$ and wherein $0.90 \leq (t_{D1} / t_{D2}) \leq 1.10$, preferably $0.95 \leq (t_{D1} / t_{D2}) \leq 1.05$, and wherein $0.90 \leq (t_{D2} / t_{D3}) \leq 1.10$, preferably $0.95 \leq (t_{D2} / t_{D3}) \leq 1.05$.

Preferably according to the present, at least one of the reactors R_i, preferably all reactors R_i have one or more outlet means for removing a gas stream from the respective reactor R_i, i.e. outlet means for degassing the respective reactor R_i. Therefore, the process of the present invention preferably comprises removing from at least one reactor R_i, preferably from all z reactors R_i, a respective gas stream S_{Gi}, a given gas stream S_{Gi} having a temperature T_{Gi} at a pressure p_{Gi}, wherein $0.95 \leq T_{Gi}/T_{Di} \leq 1.05$. Regarding the preferred arrangement of three reactors R_1, R_2 and R_3, the process more preferably comprises removing from R_1 a gas stream S_{G1}, S_{G1} having a temperature T_{G1} at a pressure p_{G1}, wherein $0.95 \leq T_{G1}/T_{D1} \leq 1.05$, removing from R_2 a gas stream S_{G2}, S_{G2} having a temperature T_{G2} at a pressure p_{G2}, wherein $0.95 \leq T_{G2}/T_{D2} \leq 1.05$, and removing from R_3 a gas stream S_{G3}, S_{G3} having a temperature T_{G3} at a pressure p_{G3}, wherein $0.95 \leq T_{G3}/T_{D3} \leq 1.05$. According to the present invention, it may be preferred that the process further comprises combining at least one of the gas streams S_{Gi}, more preferably all streams S_{Gi}, more preferably the gas streams S_{G1}, S_{G2} and S_{G3} with the gas stream S_{GM} as described hereinabove, preferably prior to subjecting the gas stream S_{GM} to scrubbing as described hereinabove.

Generally, there are no specific restrictions how the solid material M is provided according to (i). Preferably, providing the solid material M according to (i) comprises

(i.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.2) passing the solid material M provided according to (i.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.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.2) comprises at least one unit U_{MRD}, 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 comprises at least particle separation unit U_{FMPS}, more preferably at least one filter, more preferably at least one mesh filter.

Further 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 least one gas stream is preferably pre-treated by at least one of filtrating, compressing and cooling, more preferably by filtrating, compressing and cooling.

Further preferably, the second connecting line according to (i.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.

Preferably according to (i), the solid material M is provided, preferably provided to U_M, 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, 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 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 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 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.

More preferred pairs of values are, for example:

- a D10 value of the particle width in the range of from 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 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 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.

The term “particle” as used in this context of the present invention comprises optionally pre-formed granules, and also comprises shredded pieces.

Preferably from 10 to 100 weight-%, more preferably from 30 to 100 weight-%, more preferably from 50 to 100 weight-%, more preferably from 60 to 100 weight-%, more preferably from 70 to 100 weight-%, more preferably from 80 to 100 weight-%, of the solid material M provided according to (i) consist of the polyamide 6. If the polyamide 6 content of the solid material M is less than 100 weight-%, it may be preferred that the solid material M additionally comprises one or more elastanes. Generally, the solid material M may comprise, in addition to polyamide 6, at least one further polymeric compound, 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 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. Further, in addition to polyamide 6, the solid material M may further comprise one or more of at least one pigment material and at least one glass fiber material.

Preferably, the solid material M provided according to (i) comprises, more preferably consists of, a waste material, more preferably one or more of a textile waste material and an engineering plastics waste material, more preferably a textile waste material. Generally, the solid material M provided according to (i) may consist of one single material or from several different materials, i.e. it consists of w chemical materials M_j with j=1..w and w≥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 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 solid material M exhibits the composition as discussed above.

According to the present invention, it is preferred that from 90 to 100 weight-%, more preferably from 91 to 100 weight-%, more preferably from 92 to 100 weight-%, more preferably from 93 to 100 weight-%, more preferably from 94 to 100 weight-%, more preferably from 95 to 100 weight-% of the liquid aqueous stream S_W provided according to (iii) consist of water. More preferred ranges may be from 96 to 100 weight-% or from 97 to 100 weight-% or from 99 to 100 weight-% or from 99 to 100 weight-%.

Preferably according to the present invention, providing the liquid aqueous stream S_W according to (iii) comprises generating an aqueous stream comprising at least part of the water comprised in the stream S_R, and feeding at least part of said generated aqueous stream back to the chemical reaction unit U_R as the aqueous stream S_W or as part thereof.

Regarding said recycling of water, it is possible, for example, that the process comprises subjecting the stream S_R obtained from the chemical reaction unit U_R, optionally after subjecting S_R to filtration, to thermal water separation, obtaining an aqueous stream S_X; and feeding at least part of the aqueous stream S_X back to the chemical reaction unit U_R as part of the aqueous stream S_W, wherein said thermal water separation preferably comprises one or more of distilling and falling film evaporating. Preferably, generating the aqueous stream S_X may comprise distilling the stream S_R obtained from the reaction unit U_R, optionally after subjecting S_R to filtration, obtaining the stream S_X. Said distilling preferably may be 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 from 0.7 to 1.2 bar, more preferably in the range of from 0.8 to 1.1 bar, wherein the stream S_X is obtained at the top of the distillation column. Further, said distilling preferably may comprise subjecting the vapor top stream to condensation, obtaining a liquid stream S_X, wherein at least a part of the liquid stream S_X is fed back to the chemical reaction unit U_R as part of the aqueous stream S_W. Said liquid stream S_X obtained from condensation may preferably be 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 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.

Regarding said recycling of water, it is preferred according to the process of the present invention wherein according to (vii), the stream S_R comprising ε-caprolactam dissolved in water at a concentration c_{SR}, the stream S_R further comprising one or more impurities, that the process further comprises

(viii) passing the liquid aqueous stream S_R into an evaporation unit U_E, obtaining from S_R a liquid aqueous stream S_L comprising ε-caprolactam dissolved in water at a concentration c_{SL} with $c_{SL} > c_{SR}$, and further obtaining from S_R one or more aqueous vapor streams S_V;

(ix) 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 $c_{SCPL} >> c_{SL}$, 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};

(x) recycling at least one stream S_{VW} at least partially to the reaction unit U_R and at least one stream S_{RW} at least partially to the reaction unit U_R.

The recycling according to (x) preferably comprises

(x.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_W;

(x.2) recycling the at least one aqueous stream S_W at least partially to the reaction unit U_R.

The water treatment unit U_W preferably comprises a water recovery unit U_{WR} and a waste water unit U_{WW}, wherein (x.1) preferably further comprises

(x.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};

(x.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 preferably comprises 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, more 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.

For such purification unit U_P, the process preferably comprises one or more of (a-1), (a-2) and (a-3); more preferably at least two or more of (a-1), (a-2) and (a-3); more preferably (a-1), (a-2) and (a-3):

(a-1) obtaining at least one at least partially condensed aqueous stream S_{VW1} from U_{WS};

(a-2) obtaining at least one at least partially condensed aqueous stream S_{VW2} from U_D;

(a-3) obtaining at least one at least partially condensed aqueous stream S_{VW3} from U_C;

wherein the process further comprises 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 in embodiment 29.

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

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

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

Preferably, the water separation unit U_{WS} comprises at least two heat-consuming water separation sub-units U_{WS1} and U_{WS2}, more preferably two serially coupled heat-consuming water separation sub-units U_{WS1} and U_{WS2}, wherein the stream S_L is preferably fed into U_{WS1} and wherein at least part of the heat consumed in one or more of U_{WS1} and U_{WS2} is preferably provided by at least one of the one or more streams S_V.

For such water separation unit U_{WS}, the process preferably comprises one or more of (b-1) and (b-2) preferably (b-1) and (b-2):

(b-1) obtaining at least one at least partially condensed aqueous stream S_{VW11} from U_{WS1};

(b-2) obtaining at least one at least partially condensed aqueous stream S_{VW12} from U_{WS2}.

Further for such water separation unit U_{WS}, it is preferred that 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.

Yet further for such water separation unit U_{WS}, it is preferred that downstream of U_{WS1} and upstream of U_{WS2}, a separation unit U_I is located, wherein the process preferably comprises obtaining from U_{WS1} an aqueous stream S_{UWS1}, feeding the stream S_{UWS1} into the separation unit U_I, obtaining from U_I an aqueous stream S_{UI}, and feeding the stream S_{UI} into the unit U_{WS2}, wherein in U_I, one or more of impurities are separated from S_{UWS1}, thereby obtaining from U_I an impurity stream S_I, said impurities preferably comprising at least one impurity comprised in S_R according to (vii).

Preferably, the evaporation unit U_E comprises two or more evaporation sub-units, wherein the process preferably comprises 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.

Preferably, downstream of U_R, at least one solid-liquid separation unit is arranged, wherein it is preferred that at least one of the streams S_L and S_R is passed through at least one solid-liquid separation unit prior to being passed to the next downstream unit.

According to the present invention, it is preferred that the solid material M provided according to (i) 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.

Regarding the stream S_{CPL} described above, i.e. the purified ε-caprolactam stream, is 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 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 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 solid material M or as part of the solid material M to the process as described above, optionally after sorting as described herein.

Therefore, according to the present invention, the process may preferably further comprise providing the stream S_{CPL} 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 via U_M.

Therefore, the present invention also relates to the use of S_{CPL}, obtainable or obtained by a process as described hereinabove, for preparing polyamide 6, said use preferably further comprising employing said polyamide 6 as a feedstock for preparing a textile material.

Further, 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 hereinabove, as a starting material, wherein said method preferably further comprises employing said polyamide 6 as a feedstock for preparing a textile material.

Further according to the present invention, the process may preferably further comprise providing the stream S_{CPL} 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.

Therefore, the present invention also relates to the use of S_{CPL}, obtainable or obtained by a process as described hereinabove, for preparing polyamide 6, said use preferably further comprising employing said polyamide 6 as a feedstock for preparing an engineering plastics material.

Further, 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 hereinabove, as a starting material, wherein said method preferably further comprises employing said polyamide 6 as a feedstock for preparing an engineering plastics material.

According to a further aspect, the present invention relates to an integrated process for preparing polyamide 6, comprising

(α) preparing a stream S_{CPL} according to a process as described herein, said stream S_{CPL} comprising purified ε-caprolactam;

(β) passing the stream S_{CPL} to a polyamide 6 production unit U_{PA};

(γ) subjecting the stream S_{CPL} in U_{PA} to ε-caprolactam polymerization conditions, obtaining from U_{PA} a polyamide 6 material M_P and a stream comprising water and one or more ε-caprolactam oligomers;

(δ) optionally subjecting to stream comprising water and one or more ε-caprolactam oligomers to concentration with respect to the one or more ε-caprolactam oligomers in at least one concentration stage, obtaining a concentrated stream comprising water and one or more ε-caprolactam oligomers;

(ε) passing the optionally concentrated stream comprising water and one or more ε-caprolactam oligomers into at least one of the melting unit U_M and the water separation sub-unit U_{WS2} described herein.

Preferably, the optionally concentrated stream comprising water and one or more ε-caprolactam oligomers according to (ε) further comprises ε-caprolactam, i.e. monomeric ε-caprolactam. Further preferably, said integrated process comprises

(γ) subjecting the stream S_{CPL} in U_{PA} to ε-caprolactam polymerization conditions, obtaining from U_{PA} a polyamide 6 material M_P and a stream S_{EW} comprising water at a concentration $c_{EW}(W)$, ε-caprolactam at a concentration $c_{EW}(C)$, and one or more ε-caprolactam oligomers at a total concentration $c_{EW}(O)$;

(δ) subjecting the stream S_{EW} to concentration, comprising

(δ.1) subjecting the stream S_{EW} to concentration in a first concentration unit U_{C1}, obtaining from U_{C1} a concentrated stream S_{C1} comprising water at a concentration $c_{C1}(W)$, ε-caprolactam at a concentration $c_{C1}(C)$, and one or more ε-caprolactam oligomers at a total concentration $c_{C1}(O)$, with $c_{C1}(W) < c_{EW}(W)$, $c_{C1}(C) > c_{EW}(C)$ and $c_{C1}(O) > c_{EW}(O)$, and further obtaining from U_{C1} an aqueous stream S_{W1} comprising water at a concentration $c_{W1}(W) > c_{EW}(W)$;

(δ.2) subjecting the stream S_{C1} to concentration in a second concentration unit U_{C2}, obtaining from U_{C2} a concentrated stream S_{C2} comprising one or more ε-caprolactam oligomers at a total concentration $c_{C2}(O)$, with $c_{C2}(O) > c_{C1}(O)$, and further obtaining from U_{C2} an aqueous stream S_{W2} comprising water at a concentration $c_{W2}(W)$ and ε-caprolactam at a concentration $c_{W2}(C)$, with $c_{W2}(W) > c_{W1}(W)$ and $c_{W2}(C) > c_{W1}(C)$;

(ε) passing the stream S_{C2} to the sub-unit U_M and the stream S_{W2} to the sub-unit U_{WS2}.

As described above, the stream S_{EW} which is obtained from the polyamide 6 polymerization unit U_{PA} comprises water, monomeric ε-caprolactam and one or more ε-caprolactam oligomers. Usually, this aqueous stream S_{EW} furher comprises one or more further organic compounds other than monomeric ε-caprolactam and one or more ε-caprolactam oligomers. Therefore, it is preferred that the stream S_{EW} further comprises one or more organic compounds X other than ε-caprolactam and oligomers thereof at a total concentration $c_{EW}(X)$, the process according to (δ) comprising

(δ.1) subjecting the stream S_{EW} to concentration in a first concentration unit U_{C1}, obtaining from U_{C1} a concentrated stream S_{C1} comprising water at a concentration $c_{C1}(W)$, ε-caprolactam at a concentration $c_{C1}(C)$, one or more ε-caprolactam oligomers at a total concentration $c_{C1}(O)$ and one or more organic compounds X at a total concentration $c_{C1}(X)$, with $c_{C1}(W) < c_{EW}(W)$, $c_{C1}(C) > c_{EW}(C)$, $c_{C1}(O) > c_{EW}(O)$ and $c_{C1}(X) > c_{EW}(X)$, and further obtaining from U_{C1} an aqueous stream S_{W1} comprising water at a concentration $c_{W1}(W) > c_{EW}(W)$;

(δ.2) subjecting the stream S_{C1} to concentration in a second concentration unit U_{C2}, obtaining from U_{C2} a concentrated stream S_{C2} comprising one or more ε-caprolactam oligomers at a total concentration $c_{C2}(O)$ and one or more organic compounds X at a total concentration $c_{C2}(X)$, with $c_{C2}(O) > c_{C1}(O)$ and $c_{C2}(X) > c_{C1}(X)$, and further obtaining from U_{C2} an aqueous stream S_{W2} comprising water at a concentration $c_{W2}(W)$ and ε-caprolactam at a concentration $c_{W2}(C)$, with $c_{W2}(W) > c_{W1}(W)$ and $c_{W2}(C) > c_{W1}(C)$.

More preferably according to the present invention, (γ) comprises

(γ.1) passing the stream S_{CPL} and preferably an aqueous stream S_{AQ0} to a polymerization stage ST_0, obtaining from ST_0 a polyamide 6 crude product stream S_{PA1} and an aqueous stream S_{WA1};

(γ.2) passing the stream S_{PA1} and preferably an aqueous stream S_{AQ1} to a granulation stage ST_1, obtaining from ST_1 a crude granulated polyamide 6 material M_{PA2} and an aqueous stream S_{WA2};

(γ.3) passing the material M_{PA2} and preferably an aqueous stream S_{AQ2} to an extraction stage ST_2, obtaining from ST_2 a purified granulated polyamide 6 material M_{PA3} and an aqueous stream S_{WA3};

(γ.4) passing the material M_{PA3} to a drying stage ST_3, obtaining from ST_3 the polyamide 6 material M_P and an aqueous stream S_{WA4}.

Assuming that some of the polyamide 6 material obtained from the production unit U_{PA} does not meet the specifications, the process may preferably further comprise passing at least some of said material M_{PR} to the unit U_M.

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.

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 a polyamide 6 comprised in a solid material M, the process comprising
   (i) providing the solid material M;
   (ii) melting in a melting unit U_M the solid material M provided according to (i), obtaining a liquid stream S_M having a temperature T_{SM} at a pressure p_{SM};
   (iii) providing a liquid aqueous stream S_W having a temperature T_{SW} at a pressure p_{SW};
   (iv) admixing in a pre-reaction unit U_{PR} the stream S_M obtained according to (ii) with the stream S_W provided according to (iii), obtaining a liquid reaction feed stream S_F having a temperature T_{SF} at a pressure p_{SF};
   (v) feeding the stream S_F obtained according to (iv) into a chemical reaction unit U_R;
   (vi) subjecting the stream S_F in the reaction unit U_R to polyamide 6 depolymerization conditions comprising a polyamide 6 depolymerization temperature T_D at a polyamide 6 depolymerization pressure p_D, obtaining in U_R an aqueous depolymerization mixture comprising ε-caprolactam dissolved in water;
   (vii) removing an aqueous liquid reactor exit stream S_R from U_R, the stream S_R comprising ε-caprolactam dissolved in water;

   wherein $0.8 \leq T_{SF}/T_D \leq 1.05$ and $0.9 \leq p_{SF}/p_D \leq 1.05$.

2. The process of embodiment 1, wherein $0.6 \leq T_{SM}/T_{SF} \leq 1.05$ and $0.9 \leq p_{SM}/p_{SF} \leq 1.05$.

3. The process of embodiment 1, wherein $0.8 \leq T_{SW}/T_{SF} \leq 1.3$ and $0.9 \leq p_{SW}/p_{SF} \leq 1.05$.

4. The process of any one of embodiments 1 to 3, wherein the pre-reaction unit U_{PR} according to (iv) comprises, preferably consists of, a mixing unit, preferably a static mixing unit.

5. The process of any one of embodiments 1 to 4, wherein according to (iv), 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.

6. The process of any one of embodiments 1 to 5, wherein the melting unit U_M comprises, preferably consists of an extruder, preferably a single-screw extruder or a twin-screw extruder.

7. The process of any one of embodiments 1 to 6, preferably of embodiment 6, wherein the melting unit U_M is equipped with a degassing system, wherein the process comprises removing a gas stream S_{GM} from U_M during melting according to (ii), said gas stream S_{GM} having a temperature T_{GM} at a pressure p_{GM}, wherein $0.95 \leq T_{GM}/T_{SM} \leq 1.05$.

8. The process of embodiment 7, wherein 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.

9. The process of any one of embodiments 1 to 8, wherein 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 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 (iv).

10. The process of any one of embodiments 1 to 9, wherein according to (vi), T_D is in the range of from 230 to 330 °C and p_D is in the range of from 40 to 140 bar, preferably wherein 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 preferably wherein 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.

11. The process of any one of embodiments 1 to 10, wherein the reaction unit U_R according to (v) comprises z chemical reactors R_i, i=1…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.

12. The process of embodiment 11, wherein if $z > 1$, at least 2 reactors R_i, preferably z reactors R_i are serially coupled, wherein
- according to (v), the stream S_F is fed into R_i, with $i = 1$;
- an aqueous liquid stream S_i containing ε-caprolactam dissolved in water is removed from reactor R_i and fed into the reactor R_{i+1}, with $i < z$;
- according to (vii), the aqueous liquid stream S_z containing ε-caprolactam dissolved in water is removed from the reactor R_z as the stream S_R;

wherein in every reactor R_i, a depolymerization temperature T_{Di} at a depolymerization pressure p_{Di} is maintained, wherein, independently of each other, T_{Di} is in the range of from 230 to 330 °C and p_{Di} is in the range of from 40 to 140 bar, preferably wherein T_{Di} is in the range of from 250 to 320 °C and p_{Di} is in the range of from 40 to 125 bar, more preferably wherein T_{Di} is in the range of from 270 to 310 °C and p_{Di} is in the range of from 40 to 110 bar.

13. The process of embodiment 12, wherein 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.

14. The process of any one of embodiments 11 to 13, wherein at least 1, preferably z reactors R_i, are stirred tank reactors.

15. The process of embodiment 14, wherein 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, 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.

16. The process of embodiment 15, wherein at least one compartment comprised in a reactor R_i comprises 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.

17. The process of any one of embodiments 1 to 16, preferably of any one of embodiments 11 to 16, more preferably of embodiment 15 or 16, wherein the polyamide 6 depolymerization conditions according to (vi) 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.

18. The process of embodiment 17 as far as embodiment 17 is dependent on any one of embodiments 11 to 16 with z > 1, preferably on embodiment 15 or 16 with z > 1, wherein 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 $0.95 \leq (t_{Di} / t_{Di+1}) \leq 1.05$.

19. The process of any one of embodiments 11 to 18, comprising removing from at least one reactor R_i, preferably from all z reactors R_i, a respective gas stream S_{Gi}, a given gas stream S_{Gi} having a temperature T_{Gi} at a pressure p_{Gi}, wherein $0.95 \leq T_{Gi}/T_{Di} \leq 1.05$.

20. The process of embodiment 19, further comprising combining at least one of the gas streams S_{Gi}, preferably all streams S_{Gi}, with the gas stream S_{GM} as defined in embodiment 7, prior to subjecting the gas stream S_{GM} to scrubbing as defined in embodiment 8.

21. The process of any one of embodiments 1 to 20, wherein providing the solid material M according to (i) comprises
    (i.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.2) passing the solid material M provided according to (i.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.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.

22. The process of embodiment 21, wherein the first connecting line according to (i.2) comprises at least one unit U_{MRD}, 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 comprises at least particle separation unit U_{FMPS}, more preferably at least one filter, more preferably at least one mesh filter.

23. The process of embodiment 21 or 22, wherein 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 least one gas stream is preferably pre-treated by at least one of filtrating, compressing and cooling, more preferably by filtrating, compressing and cooling.

24. The process of any one of embodiments 21 to 23, wherein the second connecting line according to (i.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.

25. The process of any one of embodiments 1 to 24, wherein according to (i), 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:
- a D10 value of the particle width in the range of from 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 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 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.

26. The process of any one of embodiments 1 to 25, wherein from 10 to 100 weight-%, more preferably from 30 to 100 weight-%, more preferably from 50 to 100 weight-%, more preferably from 60 to 100 weight-%, more preferably from 70 to 100 weight-%, more preferably from 80 to 100 weight-%, of the solid material M consist of the polyamide 6.

27. The process of any one of embodiments 1 to 26, wherein providing the liquid aqueous stream S_W according to (iii) comprises generating an aqueous stream comprising at least part of the water comprised in the stream S_R, and feeding at least part of said generated aqueous stream back to the chemical reaction unit U_R as the aqueous stream S_W or as part thereof.

28. The process of any one of embodiments 1 to 27, wherein according to (vii), the stream S_R comprising ε-caprolactam dissolved in water at a concentration c_{SR}, the stream S_R further comprising one or more impurities, the process further comprising
(viii) passing the liquid aqueous stream S_R into an evaporation unit U_E, obtaining from S_R a liquid aqueous stream S_L comprising ε-caprolactam dissolved in water at a concentration c_{SL} with $c_{SL} > c_{SR}$, and further obtaining from S_R one or more aqueous vapor streams S_V;
(ix) 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

$c_{SCPL} >> c_{SL}$, 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};

(x) recycling at least one stream S_{VW} at least partially to the reaction unit U_R and at least one stream S_{RW} at least partially to the reaction unit U_R.

29. The process of embodiment 28, wherein the recycling according to (x) comprises
(x.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_W;
(x.2) recycling the at least one aqueous stream S_W at least partially to the reaction unit U_R.

30. The process of embodiment 29, wherein the water treatment unit U_W comprises a water recovery unit U_{WR} and a waste water unit U_{WW}, wherein (x.1) further comprises
(x.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};
(x.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}.

31. The process of any one of embodiments 28 to 30, wherein the purification unit U_P comprises 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.

32. The process of embodiment 31, comprising one or more of (i-1), (i-2) and (i-3); preferably at least two or more of (i-1), (i-2) and (i-3); more preferably (i-1), (i-2) and (i-3):
(i-1) obtaining at least one at least partially condensed aqueous stream S_{VW1} from U_{WS};
(i-2) obtaining at least one at least partially condensed aqueous stream S_{VW2} from U_D;
(i-3) 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 in embodiment 29.

33. The process of embodiment 31 or 32, wherein at least one of the streams S_{RW} is obtained from U_{WS}.

34. The process of any one of embodiments 28 to 33, wherein the purification unit U_P comprises 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}, 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 $c_{SL} < c_{UWS} < c_{UD} < c_{SCPL}$.

35. The process of any one of embodiments 28 to 34, wherein the water separation unit U_{WS} comprises 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.

36. The process of embodiment 35, comprising one or more of (ii-1) and (ii-2) preferably (ii-1) and (ii-2):
(ii-1) obtaining at least one at least partially condensed aqueous stream S_{VW11} from U_{WS1};
(ii-2) obtaining at least one at least partially condensed aqueous stream S_{VW12} from U_{WS2}.

37. The process of embodiment 36, wherein 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.

38. The process of any one of embodiments 35 to 37, wherein downstream of U_{WS1} and upstream of U_{WS2}, a separation unit U_I is located, the process comprising obtaining from U_{WS1} an aqueous stream S_{UWS1}, feeding the stream S_{UWS1} into the separation unit U_I, obtaining from U_I an aqueous stream S_{UI}, and feeding the stream S_{UI} into the unit U_{WS2}, wherein in U_I, one or more of impurities are separated from S_{UWS1}, thereby obtaining from U_I an impurity stream S_I, said impurities preferably comprising at least one impurity comprised in S_R according to (vii).

39. The process of any one of embodiments 28 to 38, wherein the evaporation unit U_E comprises 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.

40. The process of any one of embodiments 28 to 39, wherein downstream of U_R, at least one solid-liquid separation unit is arranged, wherein preferably at least one of the streams S_L

and S_R is passed through at least one solid-liquid separation unit prior to being passed to the next downstream unit.

41. The process of any one of embodiments 28 to 40, further comprising providing the stream S_{CPL} 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 via U_M.

42. The process of any one of embodiments 1 to 41, wherein from 90 to 100 weight-%, preferably from 91 to 100 weight-%, more preferably from 92 to 100 weight-%, more preferably from 93 to 100 weight-%, more preferably from 94 to 100 weight-%, more preferably from 95 to 100 weight-% of the liquid aqueous stream S_W provided according to (iii) consist of water.

43. The process of any one of embodiments 1 to 42, being a continuous process, a semicontinuous process or a batch process.

44. The process of any one of embodiments 1 to 43, wherein the solid material M provided according to (i) 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.

45. Use of S_{CPL}, obtainable or obtained by a process according to any one of embodiments 28 to 44, 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.

46. A method for preparing polyamide 6, said method comprising employing S_{CPL}, obtainable or obtained by a process according to any one of embodiments 28 to 44, 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.

47. Use of S_{CPL}, obtainable or obtained by a process according to any one of embodiments 28 to 44, 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 28 to 44, as a starting material.

48. The use or the method of embodiment 47, 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.

49. The use or the method of embodiment 47 or 48, 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, 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 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.

50. The use or the method of any one of embodiments 47 to 49, 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, and/or a cushion;
- a cloth, an apparel, preferably a shirt, trousers, a pullover, a boot, a shoe, a shoe sole, a tight 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.

51. The use or the method of any one of embodiments 47 to 50, wherein the polymer, or the polymer product, or the polymer and the polymer product contains or contain polyamide 6 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 51 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 47 to 51 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 herein refers to „bar(abs)”, i.e. bar (absolute), sometimes also referred to “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.

The term “elastane” as used herein is also referred to as “spandex”, and common brand names for spandex include Lycra, Elaspan, Acepora, Creora, Inviya, Roica, Dorlastan, Linel or ESPA.

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 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 B and C, or A and B and D, or B and C and D, or A and B and C and D.

Preferred aspects of the present invention are further illustrated in the Figures 1 to 14 as described hereinunder.

Description of the figures

Fig. 1 illustrates a process according to the present invention. A suitably provided solid material M comprising polyamide 6 is fed into a melting unit U_M from which a liquid stream S_M is obtained and further passed to a pre-reaction unit U_{PR} where it is admixed with a liquid aqueous stream S_W. A liquid stream S_F which is obtained from the unit U_{PR} is then passed to a reaction unit U_R where it is subjected to polyamide 6 depolymerization conditions to obtain an aqueous depolymerization mixture which comprises ε-caprolactam dissolved in water. From the unit U_R, an aqueous liquid reactor exit stream S_R comprising ε-caprolactam dissolved in water then removed.

Fig. 2 illustrates a process according to the present invention. In addition to the process design shown in Fig. 1, the melting unit U_M according to Fig. 2 is equipped with a degassing system. Via this degassing system, a gas stream S_{GM} is removed which is obtained when the solid material M is melted in U_M. The stream S_{GM} is then passed to a scrubbing unit U_S.

Fig. 3 illustrates a process according to the present invention. In addition to the process design shown in Fig. 2, a filtration unit U_F is arranged downstream of the melting unit U_M and upstream of the reaction unit U_R. The stream S_M which is obtained from the unit U_M is passed through this filtration unit and, downstream of U_F, is passed as suitably filtrated stream S_M to the pre-reaction unit U_{PR}.

Fig. 4 illustrates a process according to the present invention. Compared to the process design shown in Fig. 3, a preferred design of the reaction unit U_R is shown. According to this preferred design, the unit U_R consists of three reactors R_1, R_2 and R_3 which are arranged in series and which are preferably vertically arranged. The stream S_{SF} which is obtained from the pre-reaction unit U_{PR} is fed into the reactor R_1 where it is subjected to polyamide 6 depolymerization conditions, and from which a liquid aqueous stream S_1 is obtained which comprises ε-caprolactam dissolved in water and further comprises non-depolymerized polyamide 6. The stream S_1 is then passed, preferably by gravity only, to the reactor R_2 where it is subjected to polyamide 6 depolymerization conditions, and from which a liquid aqueous stream S_2 is obtained which comprises ε-caprolactam dissolved in water und further comprises non-depolymerized polyamide 6. The stream S_2 is then passed, preferably by gravity only, to the reactor R_3 where it is subjected to polyamide 6 depolymerization conditions, and from which a liquid aqueous stream S_3 is obtained which comprises ε-caprolactam dissolved in water. This stream S_3 is then removed as the stream S_R from the reaction unit U_R.

Fig. 5 shows a preferred design of a reactor R_i used according to the present invention. If more than one reactor R_i is used, as, for example, described hereinabove in the context of Fig. 4, it is preferred that every reactor R_i exhibits this preferred design. Fig. 5 shows a reactor R_i which is an stirred tank reactor. In Fig. 5, the following reference numbers are used:

(1)	vertically arranged three-compartment reactor R_i
(2)	outlet means for degassing the reactor
(3)	outlet means for removing a liquid reaction mixture from R_i
(4)	inlet means for feeding a liquid stream into R_i, such as the stream S_F into R_1
(5)	heating jacket
(6.1)	top compartment
(6.2)	middle compartment
(6.3)	bottom compartment
(7.1)	agitator of top compartment
(7.2)	agitator of middle compartment
(7.3)	agitator of middle compartment
(8)	drive unit for agitators according to (7.1)-(7.3)
(9.1)	divider between top and middle compartment with flow-through opening
(9.2)	divider between middle and bottom compartment with flow-through opening
(10.1)	inlet means for passing heating medium into the heating jacket (5)
(10.2)	outlet means for removing heating medium from the heating jacket (5)

Fig. 6 illustrates a process according to the present invention. Compared to the process design shown in Fig. 4, a preferred design is shown how the solid material M is provided. According to Fig. 6, the solid material is provided in a delivering unit M_{MD} which, for example, may comprise one or more big bag stations and/or one or more bulk container stations. From the unit U_{MD}, the material is then passed to a suitably material collecting unit M_{MC} which preferably comprises, more preferably consists of a drum. From the unit M_{MC}, the material is then suitably passed to the melting unit U_M.

Fig. 7 illustrates a process according to the present invention. Compared to the process design shown in Fig. 6, a preferred process is shown how the solid material is passed from the delivering unit U_{MD} to the collecting unit U_{MC} via a first connecting line. The unit U_{MD} according to Fig. 7 comprises, for example, one bulk container station from which material M is passed to a particle separation unit U_{FMPS}(1), and two big bag stations, wherein from the first big bag station, material M is passed to a particle separation unit U_{FMPS}(2.1) and wherein from the second big bag station, material M is passed to a particle separation unit U_{FMPS}(2.2). From U_{FMPS}(1), material M is then passed through a feeding unit U_{FMF}(1), such as a rotary feeder, and via U_{FMF}(1), it is passed and optionally distributed to the receiving and discharge means U_{MRD}(3), preferably a hopper, and U_{MRD}(4), preferably a hopper. Further, from U_{FMPS}(2.1), material M is then passed to a receiving and discharge means U_{MRD}(2.1), preferably a hopper, and from U_{MRD}(2.1) through a feeding unit U_{FMF}(2.1), such as a rotary feeder, and via U_{FMF}(2.1), it is passed and optionally distributed to the receiving and discharge means U_{MRD}(3) and U_{MRD}(4). Likewise, from U_{FMPS}(2.2), material M is then passed to a receiving and discharge means U_{MRD}(2.2), preferably a hopper, and from U_{MRD}(2.2) through a feeding unit U_{FMF}(2.2), such as a rotary feeder, and via U_{FMF}(2.2), it is passed and optionally distributed to the receiving and discharge means $U_{MRD}(3)$ and $U_{MRD}(4)$. From either $U_{MRD}(3)$ and/or $U_{MRD}(4)$, material M is then passed to the collecting unit UMC via either the unit $U_{FMF}(3)$, preferably a rotary feeder, and/or the unit $U_{FMF}(4)$, preferably a rotary feeder. Further in Fig. 7, gas streams $S_G(1)$, $S_G(2)$ and $S_G(3)$ are shown which are passed into the respective sections of the first connecting line to (pneumatically) transport material M to the respective downstream units as shown. At least one of said gas streams, preferably all gas streams are preferably subject to gas filtration, followed by compression and subsequent cooling, prior to being passed into the respective sections of the first connecting line (not shown).

Fig. 8 illustrates a process according to the present invention. Compared to the process design shown in Fig. 6, a preferred process is shown how the solid material is passed from the collecting unit U_{MC}, preferably comprising a collecting drum, to the melting unit U_M via a second connecting line. According to Fig. 8, the solid material M is passed from the unit U_{MC} through a first feeding unit $U_{SMF}(1)$, such as a rotary feeder, to a particle separation unit U_{SMPS} such as a vibrating screen. From U_{SMPS}, material M is then passed to a second feeding unit $U_{SMF}(2)$, preferably a loss-in weight feeding means such as a loss-in-weight screw from which the material M is then suitably passed to the melting unit U_M. Preferably, the preferred process upstream of the unit U_M as shown in Fig. 8 is to be seen in connection with the preferred process as shown in Fig. 6.

Fig. 9 illustrates a process according to the present invention. Compared to the process design shown in Fig. 4, it is further shown that a gas stream S_{Gi} is obtained in and removed from each reactor R_i comprised in the unit U_R. These gas streams, specifically S_{G1}, S_{G2} and S_{G3} are then suitably combined and passed to a scrubber unit U_S. It is noted that the streams S_{Gi} may also be passed to the unit U_S separately (alternative not shown). It is further conceivable that one or more of the streams S_{Gi} are combined, prior to being fed into U_S, with the gas stream S_{GM} obtained from the melting unit U_M (alternative not shown).

Fig. 10 illustrates a process according to the present invention. In Fig. 10, a preferred sequence of stages downstream of the reaction unit U_R are shown, as well as a preferred recycling of water via the stream S_W. According to the process of Fig. 10, a liquid aqueous stream S_3 is obtained and removed as the stream S_R from the last reactor R_3 of the unit UR which comprises ε-caprolactam and one or more impurities. This stream S_R is then passed to an evaporation unit U_E from which a liquid aqueous stream S_L and one or more aqueous vapor streams S_V are obtained and removed; in Fig. 10, only one vapor stream S_V is shown. The stream S_L has a higher ε-caprolactam concentration than the stream S_R. The stream S_L is then passed to a heat-consuming purification unit U_P where a further purification with regard to ε-caprolactam occurs. From the stream S_L which is fed into U_P, a product stream S_{CPL} is finally obtained which comprises ε-caprolactam at a concentration which is significantly higher than the ε-caprolactam concentration of the stream S_L. According to the process of the present invention, at least a part of the heat consumed in the purification unit U_P is at least partially provided by at least one of the one or more vapor streams S_V and based on S_V, one or more at last partially condensed aqueous streams S_{VW} are obtained and removed from U_P; only one stream S_{VW} is shown in Fig. 10. Yet further from the purification unit U_P, one or more aqueous streams S_{RW} are obtained from S_L. At least one stream S_{VW} is then at least partially recycled to the reaction unit U_R, and also at least one stream S_{RW} is at least partially recycled to the reaction unit U_R wherein, for said recycling purposes, the streams S_{VW} and S_{RW} are passed into a water treatment unit U_W from which a stream S_W is obtained which is then (at least partially) recycled as aqueous stream S_W (or part thereof) to the reaction unit U_R. Further from U_W, one or more waste water streams S_{WW} are obtained which are not recycled to the process. Preferably, the water treatment unit U_W comprises a water recovery unit U_{WR} and optionally a waste water unit U_{WW}. Preferably, the streams S_{VW} and S_{RW} are passed into the water treatment unit U_W where they are suitably purified and/or suitably collected in order to obtain the one or more aqueous recycle streams. Streams which are obtained from such purification may then be passed to the waste water treatment unit U_{WW} from which a waste water stream S_{WW} is obtained.

Fig. 11 illustrates a process according to the present invention. The process according to Fig. 11 shows the further use of the stream S_{CPL}, i.e. the purified ε-caprolactam. According to the present invention, stream S_{CPL} is preferably 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 is then 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 polyamide 6 can be passed to U_{TP}. The material, preferably the textile material M_T obtained from U_{TP} then 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 stream the S_M or as part of the stream S_M to the reaction unit U_R preferably via a unit U_M for providing the stream S_M to U_R. Such unit U_M usually comprises any apparatus by which the preferably solid material M can be suitably passed to the reaction unit U_R. Preferably, U_M comprises apparatuses such as one or more silos, one or more hoppers, one or more truck unloading stations, one or more big bag unloading station, and the like. Further in Fig. 11, it is shown that in the production unit U_{TP}, remaining material M_R is obtained from the production process, i.e. material which is not comprised in M_T. By way of example, M_R may be in the form of textile cuttings. This material can be fed, either via U_{TC} and/or directly via U_M, to U_R as the stream S_M or as part of stream S_M, preferably according to processes illustrated in Figs. 6, 7 and 8 hereinabove.

Fig. 12 illustrates a process according to the present invention. Compared to Fig. 11, a preferred design of the unit U_P is shown, i.e. the process as shown in Fig. 12 shows a preferred way of purifying the stream S_L with respect to ε-caprolactam. According to this process, the stream S_L is first passed to a water separation unit U_{WS} from which the one or more streams S_{RW} are obtained which are then preferably passed to the water treatment unit U_W as already shown in Fig. 11. Further, at least one of the streams S_V is passed to U_{WS} for at least partially meeting the heat demand of U_{WS}; based on this at least one stream S_V passed to U_{WS}, one or more at least partially condensed streams S_{VW1} are obtained and preferably further passed to the water treatment unit U_W, specifically U_{WR}. The stream S_{UWS} comprising ε-caprolactam is then preferably passed to a distillation unit U_D for further purification with respect to ε-caprolactam. Further, at least one of the streams S_V is passed to U_D for at least partially meeting the heat demand of U_D; based on this at least one stream S_V passed to U_D, one or more at least partially condensed streams S_{VW2} are obtained and preferably further passed to the water treatment unit U_W, specifically U_{WR}. The stream S_{UD} comprising ε-caprolactam is then preferably passed to a crystallization unit U_C for further purification with respect to ε-caprolactam. Further, at least one of the streams S_V is passed to U_C for at least partially meeting the heat demand of U_C; based on this at least one stream S_V passed to U_C, one or more at least partially condensed streams S_{VW3} are obtained and preferably further passed to the water treatment unit U_W, specifically U_{WR}.

Fig. 13 illustrates a process according to the present invention. Compared to Fig. 13, a preferred design of the unit U_{WS} is shown, i.e. the process as shown in Fig. 13 shows a preferred way of separating water from the stream S_L. According to this process, the stream S_L is first passed to a first stage of water separation, carried out in the unit U_{WS1}. From U_{WS1}, a stream S_{UWS1} comprising ε-caprolactam is then passed to an intermediate treatment stage U_I where impurities may be removed. The thus purified stream S_{UI} obtained from U_I is then further passed to a second stage of water separation, carried out in the unit U_{WS2}. From said unit U_{WS2}, a stream S_{UWS2} comprising ε-caprolactam is obtained which corresponds to the stream S_{UWS} as shown in Fig. 12 and which is then preferably passed to the distillation unit U_D. From the intermediate unit U_I, a stream S_I comprising the respectively separated impurities is removed which, depending on the amount and/or the chemical nature of the impurities, may be put to further use. According to this process, one or more aqueous streams S_{RW1} are obtained which are then preferably passed to the water treatment unit U_W, specifically U_{WR}. Further according to this process, one or more aqueous streams S_{RW2} are obtained which are then preferably passed to the water treatment unit U_W, specifically U_{WR}. Preferably, at least one of the streams S_V is passed to U_{WS1} for at least partially meeting the heat demand of U_{WS1}; based on this at least one stream S_V passed to U_{WS1}, one or more at least partially condensed streams S_{VW11} are obtained and preferably further passed to the water treatment U_W, specifically U_{WR}. Preferably, at least one of the streams S_V is passed to U_{WS2} for at least partially meeting the heat demand of U_{WS2}; based on this at least one stream S_V passed to U_{WS2}, one or more at least partially condensed streams S_{VW12} are obtained and preferably further passed to the water treatment U_W, specifically U_{WR}.

Fig. 14 illustrates a process according to the present invention. Compared to Fig. 13, the preferred recycling loop as already shown in Fig. 11 hereinabove is additionally shown, as well as the treatment of the gas streams S_{Gi} obtained in and removed from the reactors R_1, R_2 and R_3, as already shown in Fig. 9 hereinabove.

Claims

1. A process for hydrolytically depolymerizing a polyamide 6 comprised in a solid material M, the process comprising
   (i) providing the solid material M;
   (ii) melting in a melting unit U_M the solid material M provided according to (i), obtaining a liquid stream S_M having a temperature T_{SM} at a pressure p_{SM};
   (iii) providing a liquid aqueous stream S_W having a temperature T_{SW} at a pressure p_{SW};
   (iv) admixing in a pre-reaction unit U_{PR} the stream S_M obtained according to (ii) with the stream S_W provided according to (iii), obtaining a liquid reaction feed stream S_F having a temperature T_{SF} at a pressure p_{SF};
   (v) feeding the stream S_F obtained according to (iv) into a chemical reaction unit U_R;
   (vi) subjecting the stream S_F in the reaction unit U_R to polyamide 6 depolymerization conditions comprising a polyamide 6 depolymerization temperature T_D at a polyamide 6 depolymerization pressure p_D, obtaining in U_R an aqueous depolymerization mixture comprising ε-caprolactam dissolved in water;
   (vii) removing an aqueous liquid reactor exit stream S_R from U_R, the stream S_R comprising ε-caprolactam dissolved in water;

   wherein $0.8 \leq T_{SF}/T_D \leq 1.05$ and $0.9 \leq p_{SF}/p_D \leq 1.05$.

2. The process of claim 1, wherein $0.6 \leq T_{SM}/T_{SF} \leq 1.05$ and $0.9 \leq p_{SM}/p_{SF} \leq 1.05$ and wherein $0.8 \leq T_{SW}/T_{SF} \leq 1.3$ and $0.9 \leq p_{SW}/p_{SF} \leq 1.05$.

3. The process of claim 1 or 2, wherein the pre-reaction unit U_{PR} according to (iv) comprises, preferably consists of, a mixing unit, preferably a static mixing unit, wherein according to (iv), S_W and S_M are admixed in U_{PR} at a mixing ratio $(m_W/kg) / (m_P/kg)$ preferably 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;
   wherein the melting unit U_M comprises, preferably consists of an extruder, preferably a single-screw extruder or a twin-screw extruder, wherein the melting unit U_M is preferably equipped with a degassing system, the process preferably comprising removing a gas stream S_{GM} from U_M during melting according to (ii), said gas stream S_{GM} having a temperature T_{GM} at a pressure p_{GM}, wherein preferably $0.95 \leq T_{GM}/T_{SM} \leq 1.05$, wherein the gas stream S_{GM} removed from U_M is preferably subjected to scrubbing in a scrubbing unit U_S.

4. The process of any one of claims 1 to 3, wherein 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 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 (iv).

5. The process of any one of claims 1 to 4, wherein according to (vi), T_D is in the range of from 230 to 330 °C and p_D is in the range of from 40 to 140 bar, preferably wherein 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 preferably wherein 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.

6. The process of any one of claims 1 to 5, wherein the reaction unit U_R according to (v) comprises z chemical reactors R_i, i=1…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, wherein if z > 1, at least 2 reactors R_i, preferably z reactors R_i are serially coupled, wherein
- according to (v), the stream S_{SF} is fed into R_i, with i = 1;
- an aqueous liquid stream S_i containing ε-caprolactam dissolved in water is removed from reactor R_i and fed into the reactor R_{i+1}, with i < z;
- according to (vii), the aqueous liquid stream S_z containing ε-caprolactam dissolved in water is removed from the reactor R_z as the stream S_R;

wherein in every reactor R_i, a depolymerization temperature T_{Di} at a depolymerization pressure p_{Di} is maintained, wherein, independently of each other, T_{Di} is in the range of from 230 to 330 °C and p_{Di} is in the range of from 40 to 140 bar, preferably wherein T_{Di} is in the range of from 250 to 320 °C and p_{Di} is in the range of from 40 to 125 bar, more preferably wherein T_{Di} is in the range of from 270 to 310 °C and p_{Di} is in the range of from 40 to 110 bar, wherein for z > 1, the z reactors R_i are preferably 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} preferably by gravity, more preferably by gravity only.

7. The process of claim 6, wherein at least 1, preferably z reactors R_i, are stirred tank reactors, wherein 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 2 adjacent compartments are separated by a divider which comprises at least one flow-through opening, wherein preferably at least one compartment comprised in a reactor R_i comprises at least one agitator, wherein more preferably every compartment of every reactor R_i comprises at least one agitator, wherein more preferably, every compartment of every reactor R_i comprises one agitator, 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;

wherein the polyamide 6 depolymerization conditions according to (vi) preferably further comprise a total residence time t_D of the aqueous depolymerization mixture in the unit U_R, more 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; wherein for z > 1, the residence time of an aqueous depolymerization mixture in a reactor R_i is t_{Di} and wherein preferably $0.90 \leq (t_{Di} / t_{Di+1}) \leq 1.10$, more preferably $0.95 \leq (t_{Di} / t_{Di+1}) \leq 1.05$.

8. The process of claim 6 or 7, comprising removing from at least one reactor R_i, preferably from all z reactors R_i, a respective gas stream S_{Gi}, a given gas stream S_{Gi} having a temperature T_{Gi} at a pressure p_{Gi}, wherein $0.95 \leq T_{Gi}/T_{Di} \leq 1.05$, the process preferably further comprising combining at least one of the gas streams S_{Gi}, preferably all streams S_{Gi}, with the gas stream S_{GM} as defined in claim 3, prior to subjecting the gas stream S_{GM} to scrubbing as defined in claim 3.

9. The process of any one of claims 1 to 8, wherein providing the solid material M according to (i) comprises
(i.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.2) passing the solid material M provided according to (i.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.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;

wherein the first connecting line according to (i.2) preferably comprises at least one unit U_{MRD}, preferably at least one hopper, more preferably at least one one-zone hopper, and preferably further comprises at least one unit U_{FMF}, preferably at least one rotary feeder, and preferably further comprises at least particle separation unit U_{FMPS}, more preferably at least one filter, more preferably at least one mesh filter;
wherein 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 preferably 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 least one gas stream is preferably pre-treated by at least one of filtrating, compressing and cooling, more preferably by filtrating, compressing and cooling;

wherein the second connecting line according to (i.3) preferably 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.

10. The process of any one of claims 1 to 9, wherein according to (i), 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:
    - a D10 value of the particle width in the range of from 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 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 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;

    wherein preferably from 10 to 100 weight-%, more preferably from 30 to 100 weight-%, more preferably from 50 to 100 weight-%, more preferably from 60 to 100 weight-%, more preferably from 70 to 100 weight-%, more preferably from 80 to 100 weight-%, of the solid material M consist of the polyamide 6.

11. The process of any one of claims 1 to 10, wherein from 90 to 100 weight-%, preferably from 91 to 100 weight-%, more preferably from 92 to 100 weight-%, more preferably from 93 to 100 weight-%, more preferably from 94 to 100 weight-%, more preferably from 95 to 100 weight-% of the liquid aqueous stream S_W provided according to (iii) consist of water.

12. The process of any one of claims 1 to 11, wherein the solid material M provided according to (i) 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.

13. The process of any one of claims 1 to 12, wherein according to (vii), the stream S_R comprising ε-caprolactam dissolved in water at a concentration c_{SR}, the stream S_R further comprising one or more impurities, the process further comprising
    (viii) passing the liquid aqueous stream S_R into an evaporation unit U_E, obtaining from S_R a liquid aqueous stream S_L comprising ε-caprolactam dissolved in water at a concentration c_{SL} with $c_{SL} > c_{SR}$, and further obtaining from S_R one or more aqueous vapor streams S_V;
    (ix) 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 $c_{SCPL} >> c_{SL}$, 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};

(x) recycling at least one stream S_{VW} at least partially to the reaction unit U_R and at least one stream S_{RW} at least partially to the reaction unit U_R.

14. The process of claim 13, further comprising providing the stream S_{CPL} obtained according to (ix) 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 via U_M.

15. Use of S_{CPL}, obtainable or obtained by a process according to claim 16 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 polymer product comprises or comprise polyamide 6 and optionally at least one further polymeric compound, 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 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;

wherein the polymer, or the polymer product, or the polymer and the polymer product is or are preferably 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, and/or a cushion;

- a cloth, an apparel, preferably a shirt, trousers, a pullover, a boot, a shoe, a shoe sole, a tight 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.

Figure 1

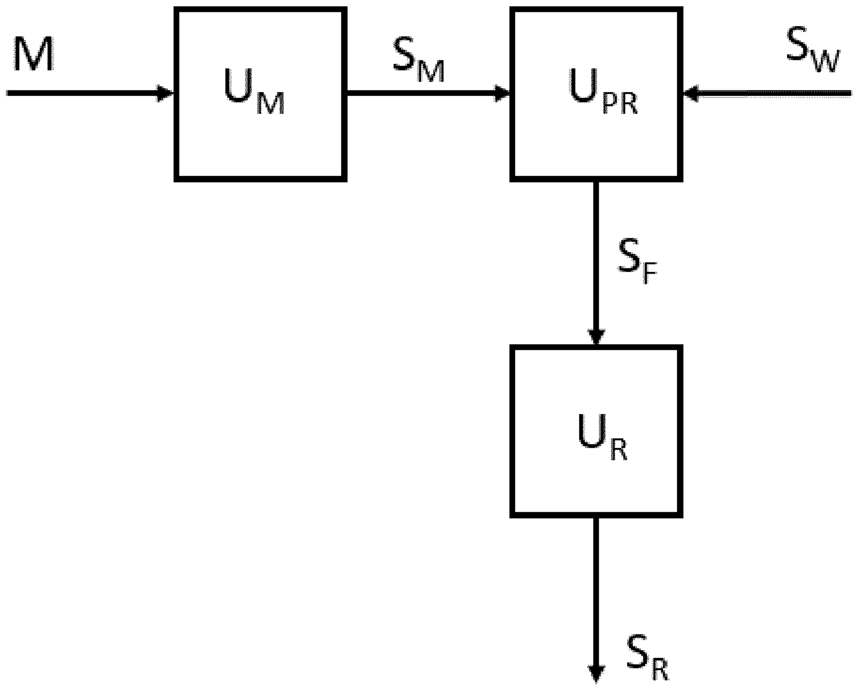


Figure 2

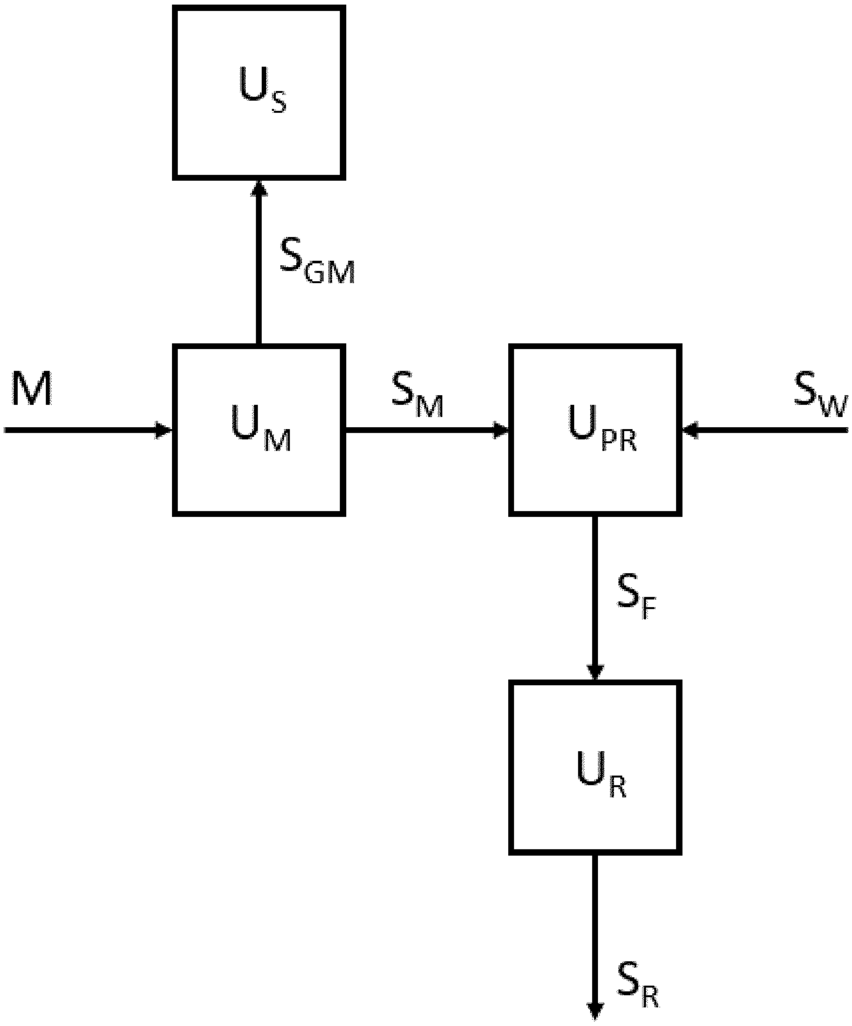


Figure 3

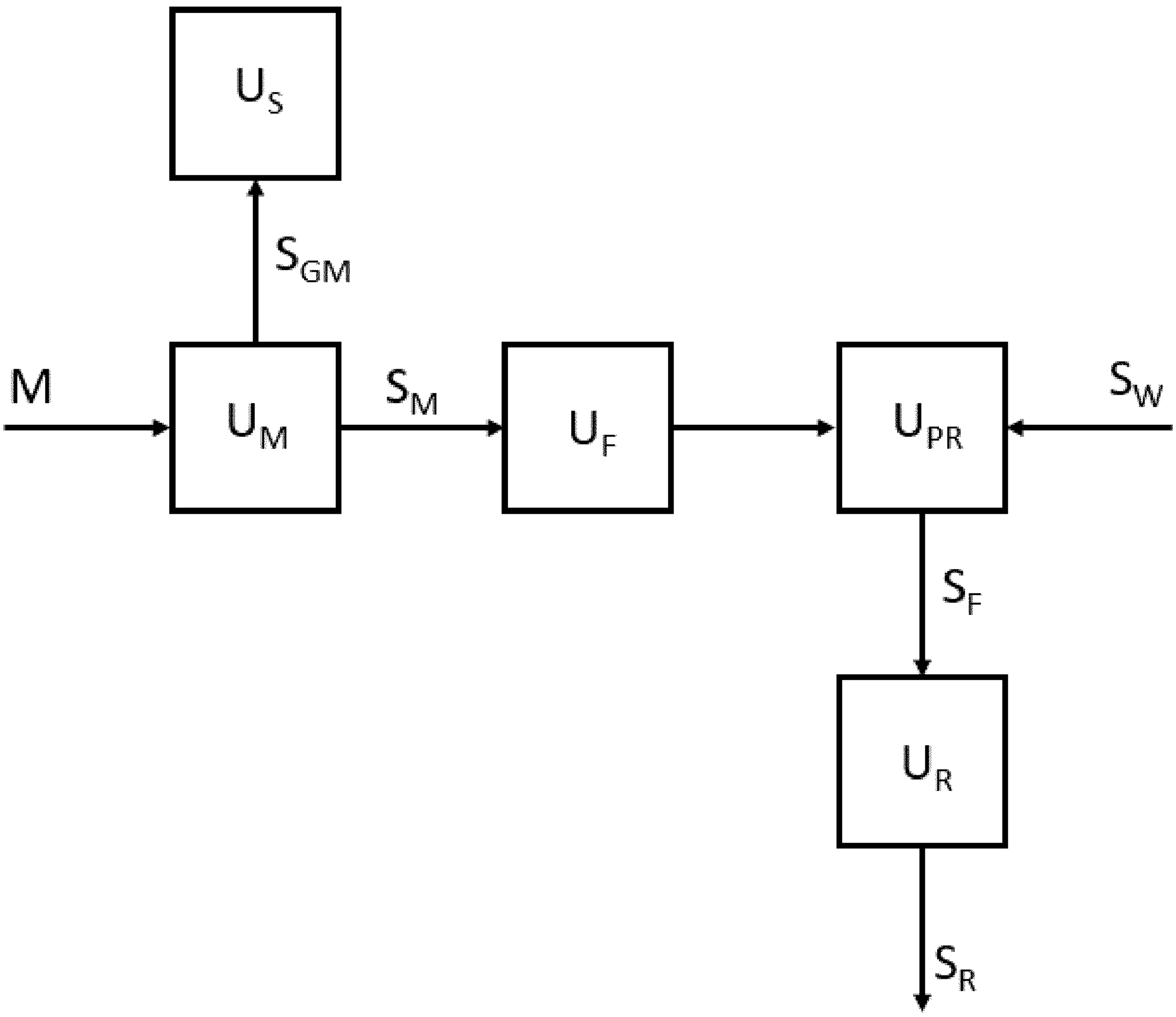
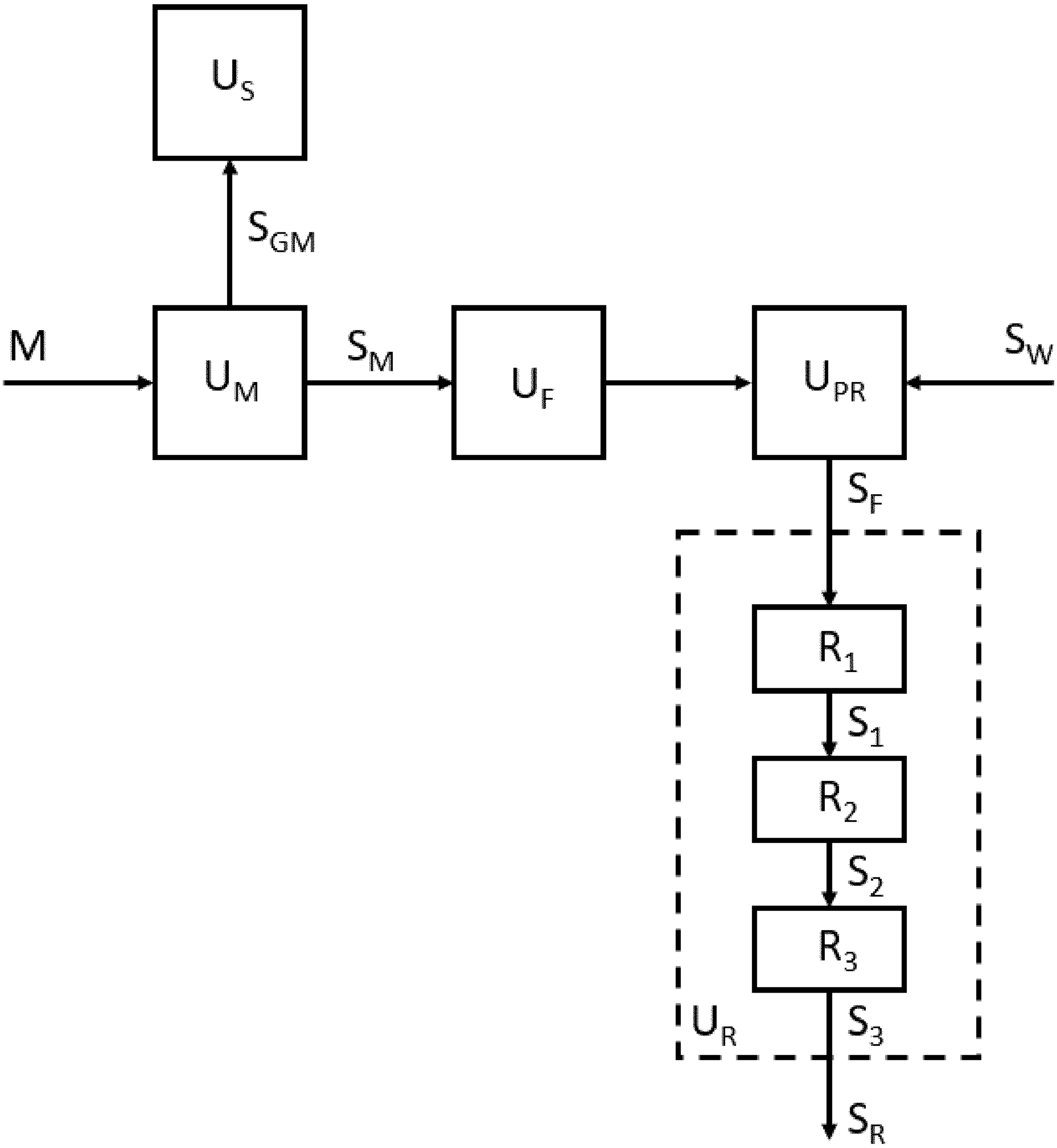


Figure 4



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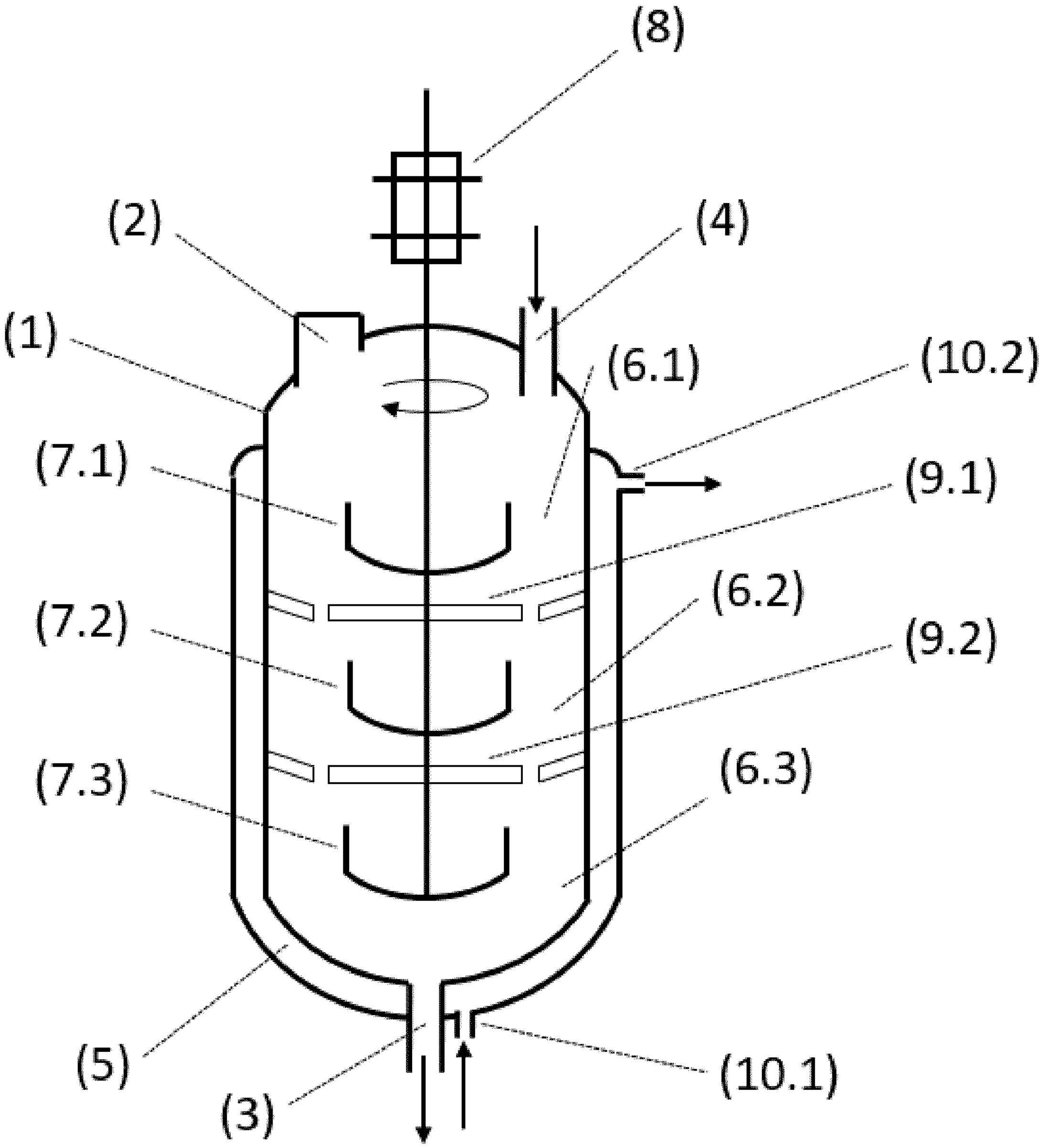

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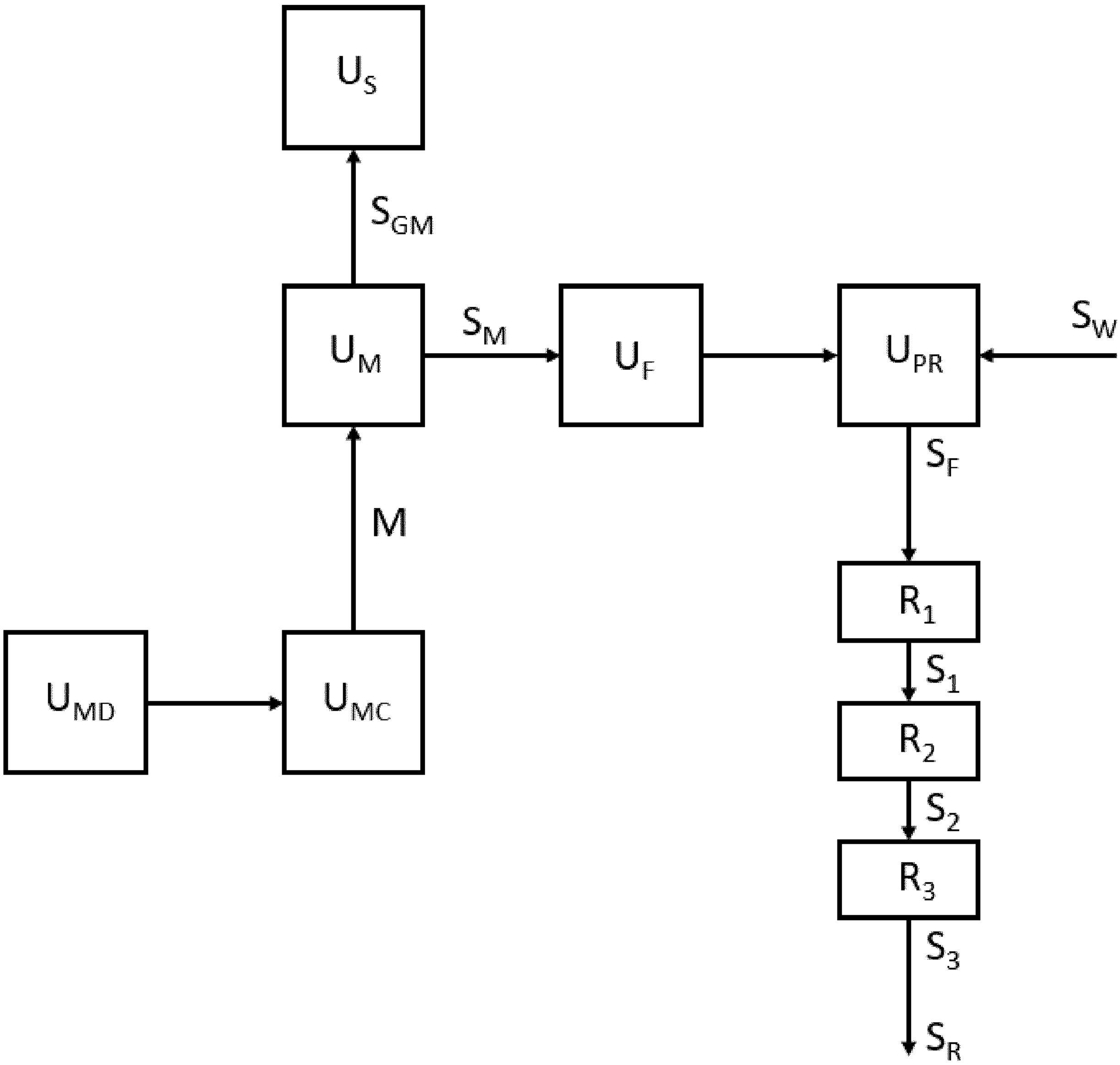

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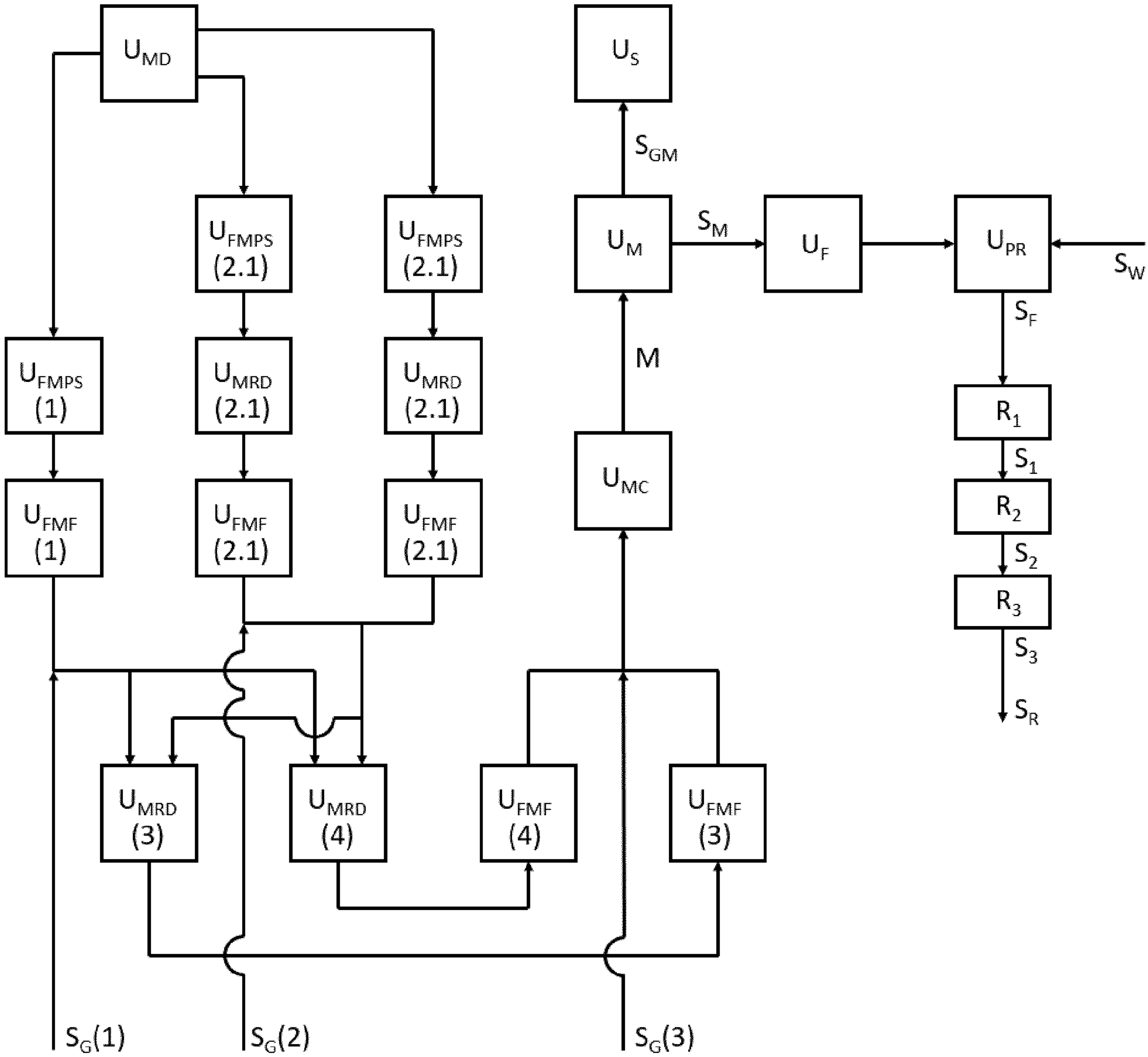
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U_FMPS (2.1)
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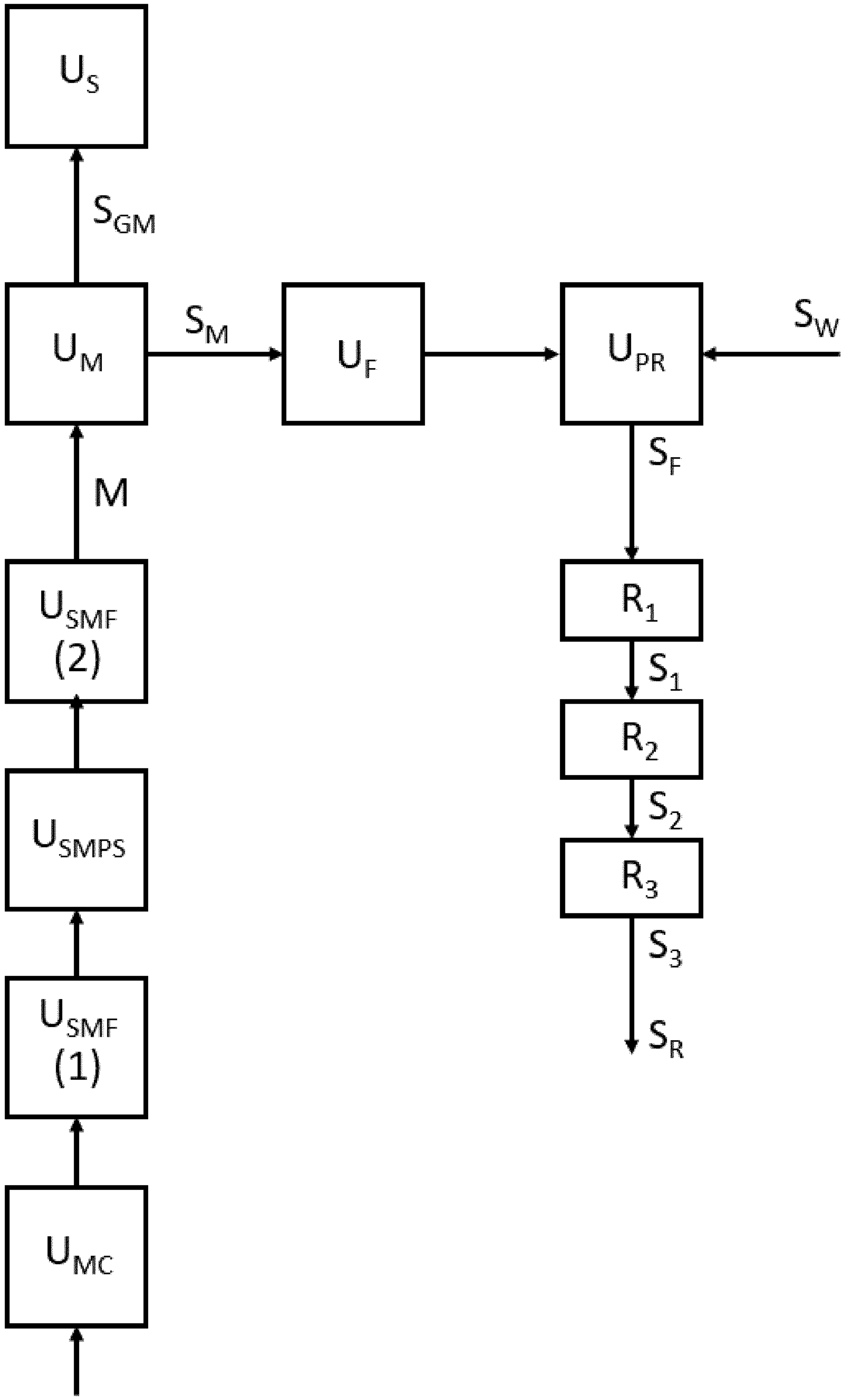
U_MRD (2.1)
U_MRD (2.1)
U_FMF (1)
U_FMF (2.1)
U_FMF (2.1)
U_MRD (3)
U_MRD (4)
U_FMF (4)
U_FMF (3)
S_G(1)
S_G(2)
S_G(3)
U_S
S_GM
U_M
S_M
U_F
U_PR
S_W
M
U_MC
S_F
R_1
S_1
R_2
S_2
R_3
S_3
S_R

Figure 8



U_S
S_GM
U_M
S_M
U_F
U_PR
S_W
M
S_F
U_SMF (2)
R_1
S_1
R_2
S_2
U_SMPS
R_3
S_3
S_R
U_SMF (1)
U_MC

Figure 9

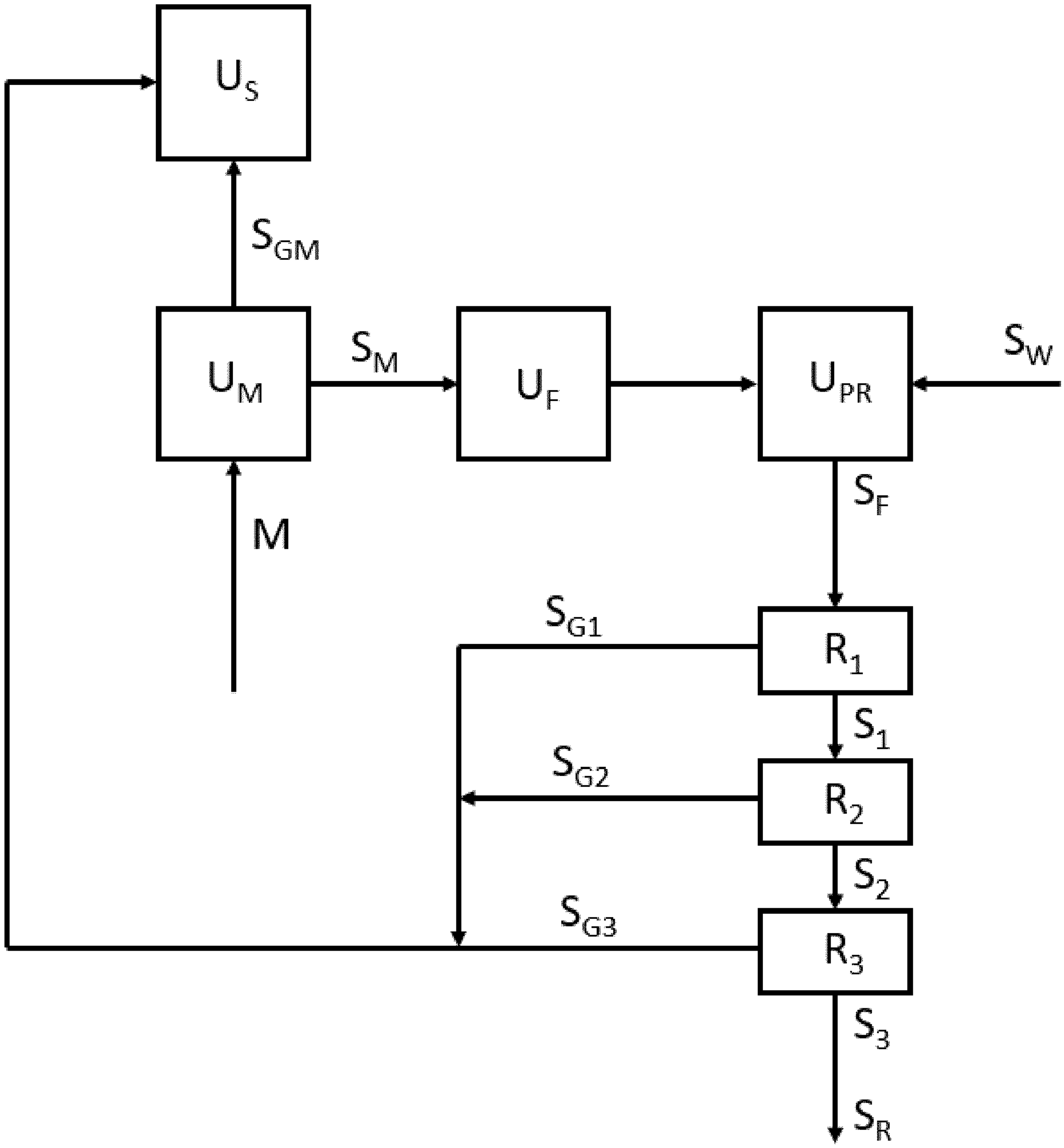
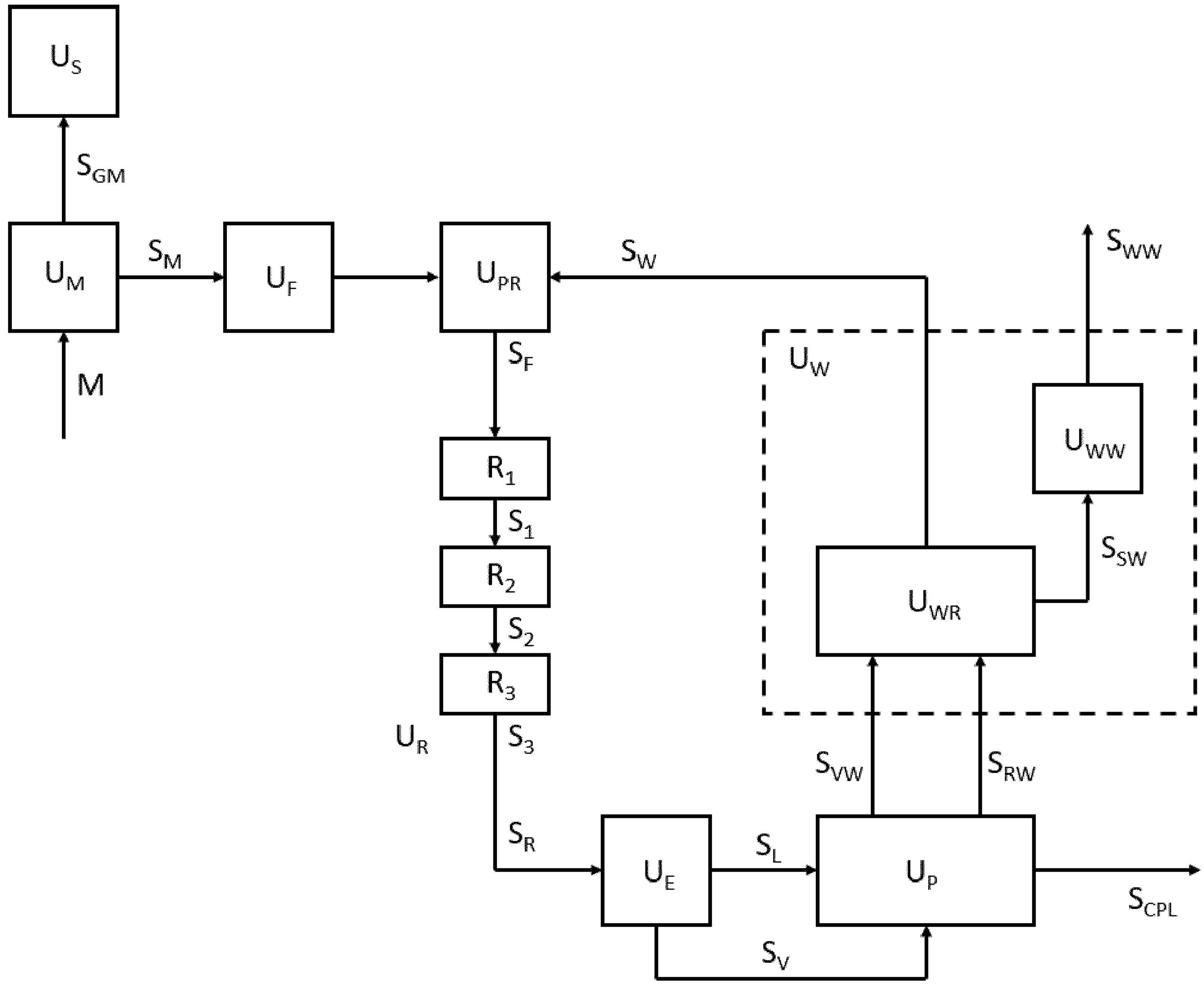


Figure 10



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U_M
S_M
U_F
U_{PR}
S_W
S_{WW}
M
S_F
U_W
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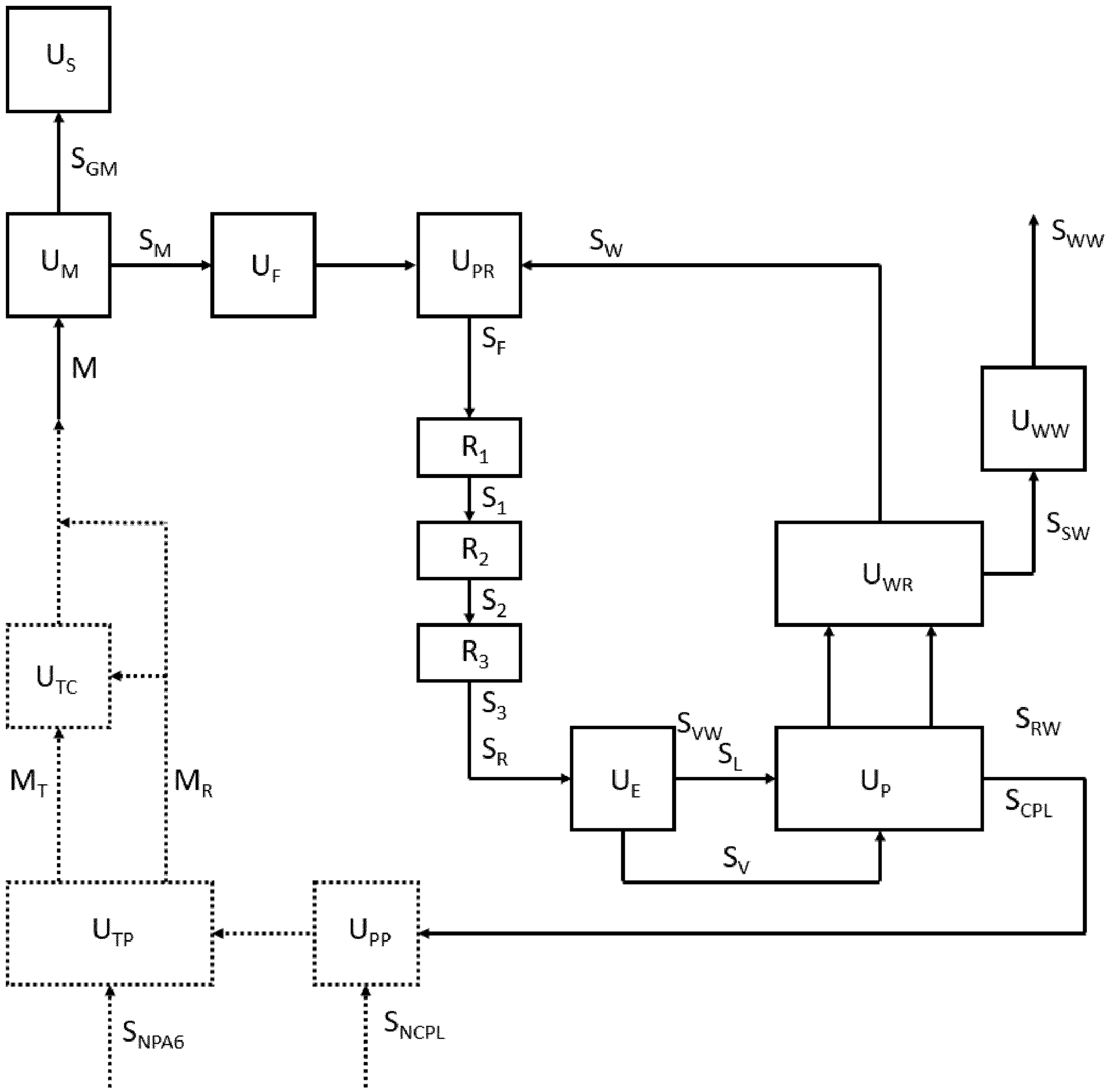
S_1
S_{SW}
R_2
U_{WR}
S_2
R_3
U_R
S_3
S_{VW}
S_{RW}
S_R
U_E
S_L
U_P
S_{CPL}
S_V

Figure 11



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U_{PR}
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S_F
M
R_1
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S_3
S_R
U_{WW}
S_{SW}
U_{WR}
U_{TC}
S_{VW}
S_L
S_{RW}
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U_P
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M_R
S_V
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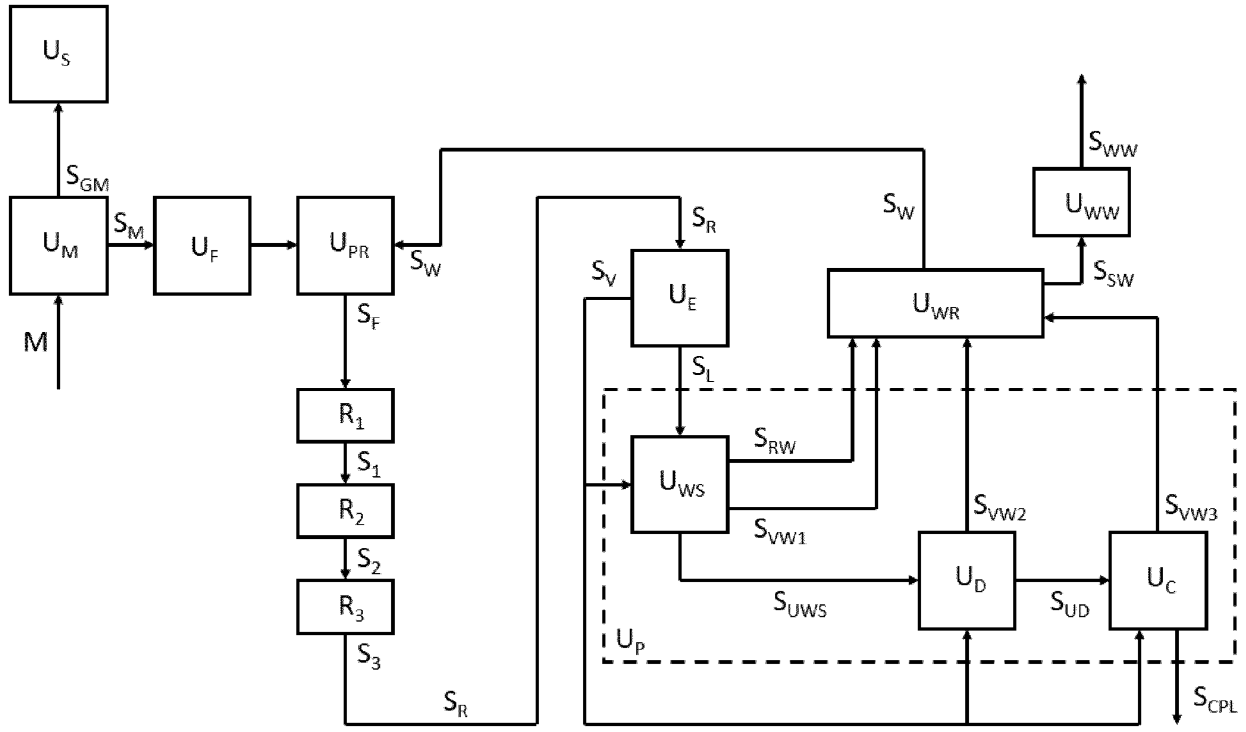
U_{PP}
S_{NPA6}
S_{NCPL}

Figure 12



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R_2
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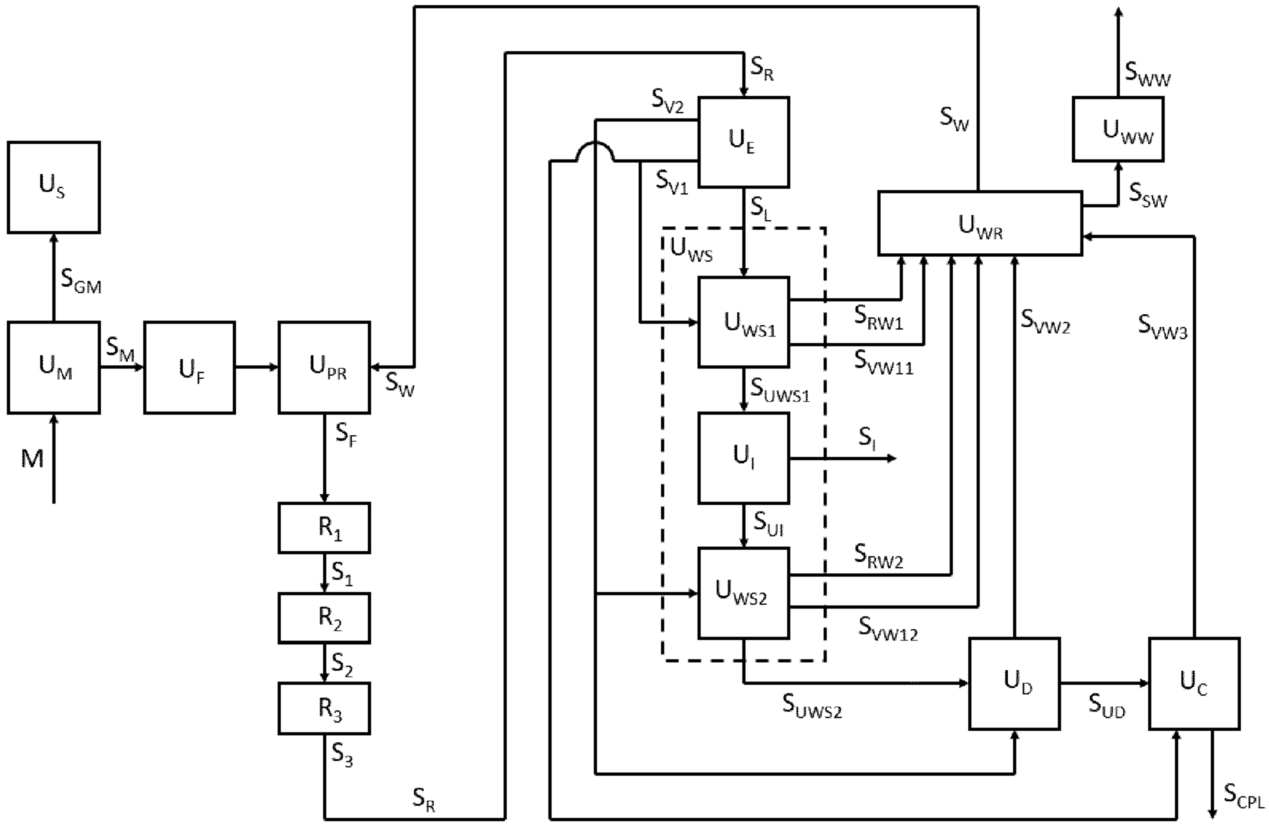
S_SW
U_WW
S_WW

Figure 13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R_3
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S_V2
U_E
S_V1
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U_I
S_I
S_UI
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S_RW1
S_VW11
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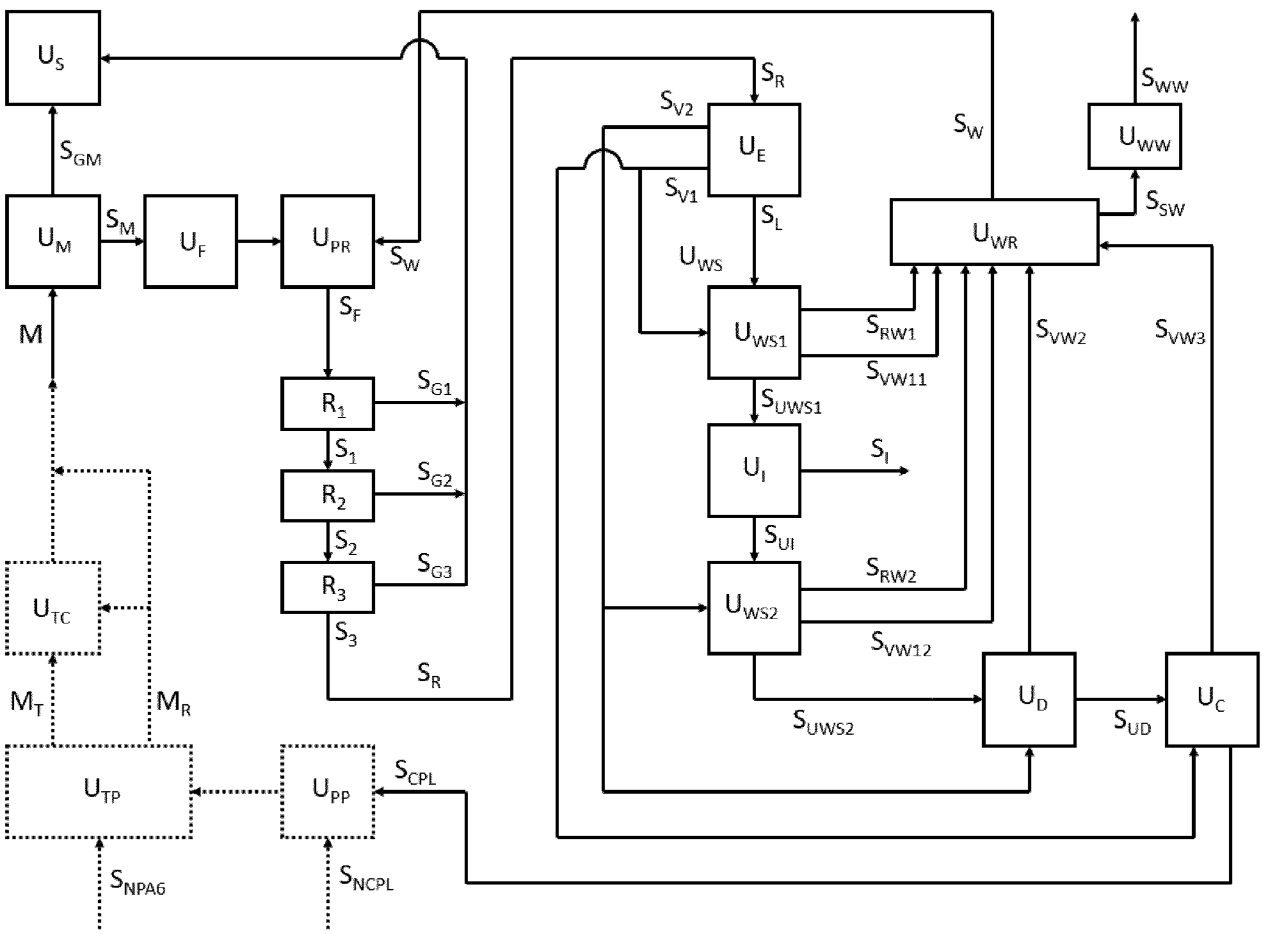
U_D
S_UD
U_C
S_CPL

Figure 14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M_R
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U_PP
S_CPL
S_NCPL
S_R
S_V2
U_E
S_V1
S_L
U_WS
U_WS1
S_RW1
S_VW11
S_UWS1
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U_D
S_UD
U_C
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S_VW2
S_VW3
U_WW
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S_SW

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2024/065380

A. CLASSIFICATION OF SUBJECT MATTER
INV. C07D201/12 C08J11/14
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
C07D C08J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 96/18613 A1 (BASF AG [DE]) 20 June 1996 (1996-06-20) claim 2; examples 1-11 -----	1-15
X	WO 99/11616 A1 (ALLIED SIGNAL INC [US]) 11 March 1999 (1999-03-11) Page 17: Crude Caprolactam preparation -----	1-15
X	WO 2023/074437 A1 (TORAY INDUSTRIES [JP]) 4 May 2023 (2023-05-04) the whole document -----	1-15
X	WO 97/06137 A1 (ALLIED SIGNAL INC [US]) 20 February 1997 (1997-02-20) claim 1 -----	1-15

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[x] Further documents are listed in the continuation of Box C.

[x] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
3 September 2024	16/09/2024

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Baston, Eckhard

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C(Continuation). **DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	IWAYA T ET AL: "Kinetic analysis for hydrothermal depolymerization of nylon 6", POLYMER DEGRADATION AND STABILITY, BARKING, GB, vol. 91, no. 9, 1 September 2006 (2006-09-01), pages 1989-1995, XP027949588, ISSN: 0141-3910 [retrieved on 2006-09-01] Page 1990, Experimental -----	1-15
A,P	MINOR ANN-JOELLE ET AL: "Chemical Recycling Processes of Nylon 6 to Caprolactam: Review and Techno-Economic Assessment", CHEMICAL ENGENEERING JOURNAL, ELSEVIER, AMSTERDAM, NL, vol. 474, 9 August 2023 (2023-08-09), XP087412771, ISSN: 1385-8947, DOI: 10.1016/J.CEJ.2023.145333 [retrieved on 2023-08-09] figure 2 -----	1-15

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2024/065380

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			WO	9911616	A1	11-03-1999
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			TW	380145	B	21-01-2000
			US	5656757	A	12-08-1997
			WO	9706137	A1	20-02-1997