out at low concentration of one or more of the substrates. In particular there is a need for a device and a method which permits to perform reactions which are to be carried out in high dilution in reactors with a reduced volume, using reduced quantities of solvent, while providing a sufficiently high reaction yield and good selectivity to the desired reaction product. The present invention provides an answer to these needs.

SUMMARY

This problem is solved according to the present disclosure with a process as defined herein.

In one aspect, there is provided a process for carrying out a chemical reaction of a substrate in a highly diluted reaction mixture comprising a solvent, the reaction being selected from a cyclisation reaction, ~~a polymerization reaction~~the synthesis of cyclic polymers, an enzymatic reaction showing substrate inhibition, an enzymatic reaction showing product inhibition, a reaction showing precipitation of the substrate or of the reactant, and combinations thereof, the process comprising the steps of

a) supplying a highly diluted substrate-solvent mixture to the inlet of a reactor,

b) causing the reaction medium in the reactor to react,

c) discharging, from an outlet of the reactor, reaction mixture comprising reaction product, solvent, and substrate that has not reacted,

d) conducting the reaction mixture to a first filtration membrane, with a retentate side and a permeate side, whereby the first filtration membrane is permeable to the solvent and having a substrate rejection of 80%-100%, and

e) returning retentate comprising substrate that has not reacted, from the retentate side of the first filtration membrane to the reactor,

characterized in that in step (a) said highly diluted substrate-solvent mixture is supplied continuously or intermittently in portions to said inlet of said reactor from a diluting substrate feed system, said diluting substrate fee system diluting a substrate from a substrate feed tank and wherein said diluting substrate feed system for supplying substrate to the

reactor optionally comprises a second filtration membrane which is permeable to the solvent, wherein the permeability of the second filtration membrane for the substrate is selected such that the permeate of the second membrane has a desired concentration of the substrate in the solvent, wherein permeate with the desired concentration of the substrate in the solvent is supplied from the permeate side of the second filtration membrane to the reactor; and wherein said substrate feed tank comprises a feed solution having a substrate concentration in solvent higher than the substrate concentration in the highly diluted substrate-solvent mixture;

characterized in that the first filtration membrane is directly coupled to the reactor outlet; and

characterised in that the process further comprises the step of continuously returning solvent which permeated the first filtration membrane from the permeate side of the first membrane to said diluting substrate feed system to dilute the substrate in the diluting substrate feed system thereby forming said highly diluted substrate-solvent mixture; and wherein the supply rate of the diluted solvent/substrate mixture from the diluted substrate feed system to the reactor is controlled through operational parameters of the membrane filtration by said first and/or second filtration membrane.

In an embodiment, the present disclosure provides a process for carrying out a chemical reaction of a substrate (X) in a diluted reaction mixture comprising a solvent (S), the reaction being selected from a cyclisation reaction, a polymerization reaction, an enzymatic reaction showing substrate inhibition, an enzymatic reaction showing product inhibition, a reaction showing precipitation of the substrate or of the reactant, and combinations thereof, the process comprising the steps of

a) diluting the substrate with solvent in a diluting substrate feed system to form a diluted substrate-solvent mixture, and supplying the diluted substrate-solvent mixture to the inlet of a reactor,

b) causing the reaction medium in the reactor to react,

c) discharging from an outlet of the reactor the reaction mixture comprising reaction product, solvent, and substrate that has not reacted,

d) conducting the reaction mixture to a first membrane with a retentate side and a permeate side, whereby the first membrane is permeable to the solvent (S) and provided to be impermeable to the substrate (X) and to at least one of the group consisting of the catalyst, the reactants which are caused to react with the substrate and combinations thereof,

e) returning solvent (S) which permeated the first membrane from the permeate side of the first membrane to the diluting substrate feed system to dilute the substrate in the diluting substrate feed system, and

CLAIMS

1. A process for carrying out a chemical reaction of a substrate in a highly diluted reaction mixture comprising a solvent, the reaction being selected from a cyclisation reaction, ~~a polymerization reaction~~the synthesis of cyclic polymers, an enzymatic reaction showing substrate inhibition, an enzymatic reaction showing product inhibition, a reaction showing precipitation of the substrate or of the reactant, and combinations thereof, the process comprising the steps of

a) supplying a highly diluted substrate-solvent mixture to the inlet of a reactor,

b) causing the reaction medium in the reactor to react,

c) discharging, from an outlet of the reactor, reaction mixture comprising reaction product, solvent, and substrate that has not reacted,

d) conducting the reaction mixture to a first filtration membrane, with a retentate side and a permeate side, whereby the first filtration membrane is permeable to the solvent and having a substrate rejection of 80%-100%, and

e) returning retentate comprising substrate that has not reacted, from the retentate side of the first filtration membrane to the reactor,

characterized in that in step (a) said highly diluted substrate-solvent mixture is supplied continuously or intermittently in portions to said inlet of said reactor from a diluting substrate feed system, said diluting substrate feed system diluting a substrate from a substrate feed tank and wherein said diluting substrate feed system for supplying substrate to the reactor optionally comprises a second filtration membrane which is permeable to the solvent, wherein the permeability of the second filtration membrane for the substrate is selected such that the permeate of the second membrane has a desired concentration of the substrate in the solvent, wherein permeate with the desired concentration of the substrate in the solvent is supplied from the permeate side of the second filtration membrane to the reactor; and wherein said substrate feed tank comprises a feed solution having a substrate concentration in solvent higher than the substrate concentration in the highly diluted substrate-solvent mixture;

characterized in that the first filtration membrane is directly coupled to the reactor outlet; and

characterised in that the process further comprises the step of continuously returning solvent which permeated the first filtration membrane from the permeate side of the first membrane to said diluting substrate feed system to dilute the substrate in the diluting substrate feed system thereby forming said highly diluted substrate-solvent mixture; and wherein the supply rate of the diluted solvent/substrate mixture from the diluted substrate feed system to the reactor is controlled through operational parameters of the membrane filtration by said first and/or second filtration membrane.

2. The process according to claim 1, wherein the first filtration membrane has a rejection of at least one compound selected from the reaction product, catalyst and one or more of the reactants which are caused to react with the substrate of 60-95%, and wherein the at least one compound is returned from the retentate side of the first filtration membrane to the reactor.

3. The process according claim 1 or 2, wherein the first membrane has a substrate rejection of at least 95%.

~~4. The process according to any one of the preceding claims wherein the diluting substrate feed system for supplying substrate to the reactor comprises a second filtration membrane which is permeable to the solvent, wherein the permeability of the second filtration membrane for the substrate is selected such that the permeate of the second membrane has a desired concentration of the substrate in the solvent, wherein permeate with the desired concentration of the substrate in the solvent is supplied from the permeate side of the second filtration membrane to the reactor.~~

~~5~~4. The process according to ~~claim 4~~any one of the preceding claims, wherein the second filtration membrane comprises a retentate side, and substrate which is rejected by the second filtration membrane is supplied to a substrate feed tank and is further mixed with solvent, and wherein a mixture containing solvent and substrate is supplied from the substrate feed tank to the second filtration membrane.

~~6~~5. The process according to claim ~~4 or 5~~, comprising the returning of solvent from the permeate side of the first filtration membrane to the substrate feed tank with the purpose of replacing solvent which has been supplied to the second membrane.

~~7~~6. The process according to ~~any one of claims 4 to 6~~claim 4 or 5, wherein the second filtration membrane has a substrate rejection of 50% - 99.5%, preferably 60% - 95%.

~~8~~7. The process according to any one of claims 4 to ~~7~~6 wherein the first and second filtration membranes are different.

~~9~~8. The process according to any one of claims 4 to ~~7~~6 wherein the first and second filtration membrane have the same performance characteristics, preferably the first and second filtration membrane comprising the same membrane material.

~~10~~9. The process according to any one of claims 4 to ~~9~~8, wherein the first and second filtration membrane are

independently selected from the group consisting of a nano-filtration membrane, a microfiltration membrane, an ultrafiltration membrane, a reverse osmosis filtration membrane, and combinations thereof.

~~11~~10. The process according to claim ~~10~~9, wherein at least one of the first and second filtration membrane are nanofiltration membranes, preferably solvent resistant nanofiltration membranes, preferably both membranes being nanofiltration membranes.

~~12~~11. The process according to any of claims 1 to 3, wherein a concentrated substrate solution is supplied from a substrate feed tank to a mixing tank in the diluting substrate feed system and mixing the substrate in the mixing tank with an appropriate amount of solvent to obtain an envisaged dilution of the substrate in the solvent.

~~13~~12. The process according to claim ~~12~~11 wherein the mixing tank comprises a solvent/substrate mixture with a substrate dilution of 50 – 1000 litre of solvent per mole of substrate.

~~14~~13. The process according to claim ~~12~~11 or ~~13~~12, further comprising conducting solvent containing permeate from the permeate side of the first filtration membrane to the mixing tank and mixing the permeate with substrate supplied from the substrate feed tank to the mixing tank, and supplying the substrate – solvent mixture from the mixing tank to the reactor.

~~15~~14. The process according to any one of claims 4 to ~~14~~13, wherein the substrate in the substrate feed tank of the diluting substrate feed system has a substrate dilution of 0.5 – 25 litre of solvent per mole of substrate.

~~16~~15. The process according to any one of the preceding claims, wherein the substrate dilution at the reactor inlet is 50 – 1000 l/mol.

~~17~~16. The process according to any one of the preceding claims, wherein at least one of the group consisting of the first membrane, the second membrane, and both the first and the second membrane, is operated in cross-flow.

~~18~~17. The process according to any one of the preceding claims, wherein the substrate is a compound which is capable of undergoing at least one chemical reaction selected from an intramolecular

reaction and a homo- or hetero-intermolecular reaction, and preferably of both an intramolecular reaction and a homo- or hetero-intermolecular reaction.

~~19~~18. The process according to any one of the preceding claims, wherein the substrate is an organic compound.

~~20. The process according to any one of the preceding claims, wherein the substrate feed is supplied continuously or intermittently in portions.~~

~~21~~19. The process according to any one of the preceding claims, wherein the reactor contains at least 100 litre of reaction medium per mole of substrate.