the vapours are quenched. The catalyst particles are contacted with an oxygen containing stream in a dense fluidized bed resulting in combustion of residual coke to provide heat to the catalyst and to remove the coke from the catalyst particles.

Accordingly, new uses of C_1-C_3 oxygenate products are being developed and an increasing demand for those products are expected. Such oxygenate products may e.g. be used for producing ethylene glycol and propylene glycol by subjecting the oxygenate product to hydrogenation (see e.g. WO 2016/001169) or for scavenging hydrogen sulphide as described in WO 2017/064267. However, many other uses may be envisaged. To the best of our knowledge, no systems nor processes exist which are in fact suitable for large scale thermolytic conversion of sugars into glycolaldehyde rich mixtures in high yields.

Thus there is still a need for a high yielding and improved process for the preparation of C_1-C_3 oxygenates from sugars suitable for large scale production, as well as for systems for use in such processes.

Summary

In an aspect of the present disclosure, there is provided a process for thermolytic fragmentation of a sugar into C_1-C_3 oxygenates, said process comprising the steps of:

a. providing particles carrying heat and suitable for fluidization;
b. providing a fluidized bed fragmentation reactor comprising a riser and suitable for conducting thermolytic fragmentation and suitable for fluidizing a stream of particles;
c. providing a feedstock solution comprising a sugar;
d. introducing the particles into the reactor at a rate sufficient to maintain a temperature of at least 250°C, such as at least 300 350, 400 or 450 °C, after the thermolytic fragmentation has taken place, and sufficient to obtain a fluidized stream of particles;

e. introducing the feedstock into the fluidized stream of particles to obtain thermolytic fragmentation of the sugar to produce a particle dense fragmentation product; then
f. separating a fraction of the particles from the particle dense fragmentation product to produce a particle lean fragmentation product;
g. quenching the particle lean fragmentation product at least 50 °C such that from introducing the feedstock into the particle containing fluidization stream to the quench is performed, the mean residence time of the gas is maximum 5, such as maximum 3 seconds, such as maximum 2, 1, 0.8 or 0.6 seconds;
h. recovering the crude fragmentation product,
i. transferring the particles separated in step f) to a reheater for heating; and
j. recirculating the heated particles to the fragmentation reactor.

In another aspect of the present disclosure, there is provided a process for the preparation of a C_1-C_3 hydroxy compound from a sugar comprising the steps of:

carrying out a process as disclosed herein;

and then

subjecting the crude fragmentation product to a hydrogenation to obtain the corresponding C_1-C_3 hydroxy compound.

In a further aspect of the present disclosure, there is provided a system for fragmentation of a sugar composition into C_1-C_3 oxygenates comprising a fragmentation reactor, said reactor comprising within the reactor,

- a riser
- a first particle separator
- a fluidization stream inlet

- a particle inlet
- a feedstock inlet
- a particle outlet
- a product outlet,

wherein the riser is arranged within and in the lower part of the fragmentation reactor; and the fluidization stream inlet and the particle inlet is arranged in the lower part of the riser; the feedstock inlet is arranged in the lower part of the riser above the particle inlet; the riser is adapted to fluidize particles in the riser; and the first particle separator is arranged in the upper part of the riser and is adapted to separate at least a part of the particles from a fluidization stream, and

wherein the fragmentation reactor further comprises a cooling section arranged downstream the first particle separator in relation to the gas stream, said cooling section being adapted to cool the fluidization stream exiting the first particle separator and the system further comprises a reheater for reheating particles exiting the fragmentation reactor, the reheater comprises a fuel and combustion air inlet, a burner, a reheater particle inlet, a reheater riser, a reheater particle separator, a reheater gas outlet and a reheater particle outlet.

Detailed description

The present inventors, having a desire to produce C_1-C_3 oxygenates from sustainable sources of high purity and with high yield and efficiency, have found that the processes and systems available for performing thermolytic fragmentation (pyrolysis) of sustainable sources have various drawbacks making them unsuitable for such use in industrial scale.

The inventors have now found a process for producing high purity C_1-C_3 oxygenates in industrial scale. The process involves carrying out thermolytic fragmentation of a sugar solution in a fragmentation reactor, in which a fluidized bed of heat carrying particles receives the sugar solution and transforms into a riser type reactor, a major fraction of the particles are removed from the product stream followed by a quench of the product stream, and the particles removed

CLAIMS

1. A process for thermolytic fragmentation of a sugar into C_1-C_3 oxygenates, said process comprising the steps of:

   a. providing particles carrying heat and suitable for fluidization;
   b. providing a fluidized bed fragmentation reactor comprising a riser and suitable for conducting thermolytic fragmentation and suitable for fluidizing a stream of particles;
   c. providing a feedstock solution comprising a sugar;
   d. introducing the particles into the reactor at a rate sufficient to maintain a temperature of at least 250°C, such as at least 300 350, 400 or 450 °C, after the thermolytic fragmentation has taken place, and sufficient to obtain a fluidized stream of particles;
   e. introducing the feedstock into the fluidized stream of particles to obtain thermolytic fragmentation of the sugar to produce a particle dense fragmentation product; then
   f. separating a fraction of the particles from the particle dense fragmentation product to produce a particle lean fragmentation product;
   g. quenching the particle lean fragmentation product at least 50 °C such that from introducing the feedstock into the particle containing fluidization stream to the quench is performed, the mean residence time of the gas is maximum 5, such as maximum 3 seconds, such as maximum 2, 1, 0.8 or 0.6 seconds;
   h. recovering the crude fragmentation product,
   i. transferring the particles separated in step f) to a reheater for heating; and
   j. recirculating the heated particles to the fragmentation reactor.

2. The process according to claim 1, wherein the feedstock inlet is provided in the lower part of the riser.

3. The process according to any one of claims 1 or 2, wherein the reactor comprises a first particle separator downstream of the riser.

4. The process according to claim 3, wherein the reactor comprises a quench downstream the first particle separator.

5. The process according to any one of claims 1 – 4, wherein the sugar is a mono- and/or di-saccharide.

6. The process according to any one of claims 1 – 5, wherein the feedstock solution comprises an aqueous solution of a sugar selected from the group consisting of sucrose, lactose, xylose, arabinose, ribose, mannose, tagatose, galactose, glucose and fructose; or mixtures thereof.

7. The process according to any one of claims 1 – 6, wherein the concentration of sugar in the feedstock solution is between 10 and 90% by weight.

8. The process according to any one of claims 1 - 7 wherein the temperature of the particles at the particle inlet of the fragmentation reactor is preferably at least 300 °C, such as at least 400, 450, 500, 550, 600 or 650 °C.

9. The process according to any one of claims 1 - 8, wherein the reheater comprises a fuel and combustion air inlet, a burner, a reheater particle inlet, a reheater riser, a reheater particle separator, a reheater gas outlet for flue gas and a reheater particle outlet.

10. The process according to any one of claims 1 - 9, wherein the temperature of the particles exiting the reheater particle outlet is in the range of from 300-800 °C, such as in the range of from 400-800, 400-700 or 500-700 °C.

11. The process according to any one of claims 9 or 10, wherein the burner is arranged within a burner chamber, which is separate from the reheater riser, and combustion gas from the burner chamber is led to the reheater riser.

12. The process according to any one of claims 1 - 11, wherein excess oxygen is stripped from the particles before they are transferred from the reheater to the fragmentation reactor.

13. A process for the preparation of a C_1-C_3 hydroxy compound from a sugar comprising the steps of:

carrying out a process according to any one of claims 1 – 12;

and then

subjecting the crude fragmentation product to a hydrogenation to obtain the corresponding C_1-C_3 hydroxy compound.

14. A system for fragmentation of a sugar composition into C_1-C_3 oxygenates comprising a fragmentation reactor, said reactor comprising within the reactor,

- a riser
- a first particle separator
- a fluidization stream inlet
- a particle inlet
- a feedstock inlet
- a particle outlet
- a product outlet,

wherein the riser is arranged within and in the lower part of the fragmentation reactor; and the fluidization stream inlet and the particle inlet is arranged in the lower part of the riser; the feedstock inlet is arranged in the lower part of the riser above the particle inlet; the riser is adapted to fluidize particles in the riser; and the first particle separator is arranged in the upper part of the riser and is adapted to separate at least a part of the particles from a fluidization stream, and

wherein the fragmentation reactor further comprises a cooling section arranged downstream the first particle separator in relation to the gas stream, said cooling section being adapted to cool the fluidization stream exiting the first particle separator and the system further comprises a reheater for reheating particles exiting the fragmentation reactor, the reheater comprises a fuel and combustion air inlet, a burner, a reheater particle inlet, a reheater riser, a reheater particle separator, a reheater gas outlet and a reheater particle outlet.

15. The system according to claim 14, wherein the cooling section is adapted to quench by injecting a liquid into the fragmentation reactor.

16. The system according to any of claims 14 or 15, wherein the first particle separator is a low volume separator.

17. The system according to any of claims 14 - 16, wherein the first particle separator comprises at least one change of direction separator.

18. The system according to any of claims 14 to 17 , wherein the burner and the reheater fuel and combustion air inlet is arranged upstream the reheater riser, and the reheater particle inlet is arranged in the lower part of the reheater riser downstream the burner, and the reheater particle inlet

is in fluid connection with the fragmentation reactor particle outlet, the reheater riser being adapted to reheat the particles exiting the fragmentation reactor by means of combustion gas from the burner.

19. The system according to any of claims 14 to 18, wherein the reheater particle separator is arranged downstream the reheater riser, and the reheater particle outlet is in fluid connection with the fragmentation reactor particle inlet.

20. The system according to any of claims 14 to 19, wherein the burner is arranged in a separate burner chamber.

21. The system according to claim 20, wherein the burner chamber is separated from the riser by a constriction.

22. The system according to any of claims 14 to 21, wherein a stripping chamber is arranged downstream the reheater particle separator and upstream the fragmentation reactor particle inlet.