of esters of 2-hydroxy-3-butenoic acid provide a higher combined yield of esters of lactic acid and 2-hydroxy-3-butenoic acid, together with providing a higher conversion of the sugar. These advantages also apply to the preparation of the α-hydroxy methionine analogues.

Summary

In one aspect of the present disclosure, there is provided a continuous flow process for the preparation of one or more esters of lactic acid and 2-hydroxy-3-butenoic acid from a sugar in the presence of a solid Lewis acid catalyst and a solvent comprising an organic solvent and water, wherein the water is present in an amount of up to or equal to 10 vol. % of the organic solvent.

Disclosure of the invention

It has now been discovered that the presence of water in the organic solvent of a continuous flow reaction facilitates Lewis acid catalyst stability for continuous flow reactions. Deposition of carbonaceous species on the catalyst leading to deactivation or poisoning of the catalyst Lewis acid active sites is not observed to any industrially significant extent. Retention in activity, i.e. stability of the catalyst, results in the continued high yields of the desired product for sustained reaction durations of continuous flow reactions.

Claims:

1. A continuous flow process for the preparation of one or more esters of lactic acid and 2-hydroxy-3-butenoic acid from a sugar in the presence of a solid Lewis acid catalyst and a solvent comprising an organic solvent and water, wherein the water is present in an amount of up to or equal to 10 vol. % of the organic solvent.

2. A process according to claim 1, wherein the yield of the one or more lactic acid esters decreases by up to 0.25 % per hour on stream on average.

3. A process according to claim 1 or 2, wherein the yield of the one or more lactic acid esters decreases by up to 0.10 % per hour on average.

4. A process according to any one of claims 1, 2 and 3, wherein the yield of the one or more lactic acid esters decreases by up to 5 % after 50 hours on stream.

5. A process according to any one of claims 1 to 4, wherein the yield of the one or more lactic acid esters is greater than 40% after 50 hours on stream.

6. A process according to claims 1 to 5, wherein the solid Lewis acid catalyst is calcined after 450 hours of continuous flow process.

7. A process according to any one of claims 1 to 6, wherein the solid Lewis acid catalyst has a framework structure, which is selected from the group consisting of BEA, MFI, FAU, MOR, FER, MWW, MCM-41 and SBA-15.

8. A process according to any one of claims 1 to 7, wherein the solid Lewis acid catalyst comprises an active metal selected from one or more of the group consisting of Sn, Ti, Pb, Zr, Ge and Hf.

9. A process according to any one of claims 1 to 8, wherein the solid Lewis acid catalyst is selected from the group consisting of Sn-BEA, Sn-MFI, Sn-FAU, Sn-MOR, Sn-MWW, Sn-MCM-41 and Sn-SBA-15.

10. A process according to any one of claims 1 to 9, wherein the solid Lewis acid catalyst comprises Sn and the loss of Sn from the solid Lewis acid catalyst is less than or equal to 0.11% of the initial amount of Sn per hour on stream.

11. A process according to any one of claims 1 to 10, wherein the solid Lewis acid catalyst comprises Sn and the loss of Sn from the solid Lewis acid catalyst is less than 8% of the initial amount of Sn after 50 hours on stream.

12. A process according to any one of claims 1 to 11, wherein the yield of 2-hydroxy-3-butenoic acid ester is greater than 12 % after 50 hours on stream.

13. A process according to any one of claims 1 to 12, wherein the sugar is selected from one or more of the group consisting of glucose, fructose, mannose, sucrose, xylose, erythrose, erythrulose, threose and glycolaldehyde.

14. A process according to any one of claims 1 to 13, wherein an alkaline earth metal or alkali metal ion is present in the process.

15. A process according to any one of claims 1 to 14, wherein the solvent is selected from one or more of the group consisting of methanol, ethanol, 1-propanol, 1-butanol and isopropanol.

16. A process according to any one of claims 1 to 15, wherein the temperature of the process is from 140 °C to 200 °C.

17. A process according to any one of claims 1 to 16, wherein at least a fraction of the water is introduced to the solvent by mixing the organic solvent with an aqueous sugar solution.

18. A process according to any one of claims 1 to 17, wherein the aqueous sugar solution is a sugar syrup with a sugar dry matter content of 30% or higher.