from the circumstances discussed in the introduction of this specification. Dependent claims 2 to 1718 protect advantageous embodiments of the claimed MMA production process.

Accordingly, in an aspect, there is provided a process for producing MMA, comprising the following steps:

A) producing methacrolein from propanal and formaldehyde and

B) reacting the methacrolein obtained in step A) with methanol in an oxidative esterification reaction to give MMA,

which is characterized in that the two steps A) and B) are carried out in a continuous process and take place in a liquid phase at a pressure of from 2 to 100 bar, and step B) is carried out in the presence of a heterogeneous noble-metal-containing catalyst comprising metals and/or comprising metal oxides.

By virtue of the claimed process it is possible, in a manner that was not foreseeable, to provide an MMA production process which does not have the disadvantages of conventional processes. Surprisingly, it has been found here that, contrary to the general teaching of the prior art, steps A) and B) can also be combined without any complicated intervening purification or dewatering of the methacrolein, and lead to high methyl methacrylate yields.

In particular, MMA can be produced with relatively low energy usage. The process can moreover be carried out in a manner that provides a high level of protection of the environment, giving relatively small quantities of wastes and substantially increasing atom efficiency.

In particular, neither of the reaction steps A) and B) in the claimed process requires that additional water be introduced into the reaction mixture and then in turn removed, and overall reaction volumes and volume flow rates can therefore be kept low.

The process can moreover be carried out with relatively few steps, and these are simple and reproducible and proceed with relatively high space-time yields.

Catalyst requirement, in particular organic base requirement per metric ton of MMA produced, is moreover very small.

The process can moreover be carried out with relatively simple and inexpensive plant. Capital expenditure for the plant is low. Maintenance of this plant is simple and inexpensive.

In this context it should be stated that, in comparison with the processes according to the prior art, the number of return streams and the magnitude of these have been reduced.

The by-products produced can moreover be removed very simply from the reaction mixtures, and the overall process can therefore be carried out with high yield, without any need for complicated purification steps.

Patent claims

1. Process for producing methyl methacrylate, comprising the following steps:

   A) producing methacrolein from propanal and formaldehyde and

   B) reacting the methacrolein obtained in step A) with methanol in an oxidative esterification reaction to give methyl methacrylate,

   characterized in that the two steps A) and B) are carried out in a continuous process and take place in a liquid phase at a pressure of from 2 to 100 bar, and step B) is carried out in the presence of a heterogeneous noble-metal-containing catalyst comprising metals and/or comprising metal oxides.

2. Process according to claim 1, characterized in that step A) is carried out in the presence of from 0.1 to 20 mol% of organic base and from 0.1 to 20 mol% of acid, based in each case on propanal.

3. Process according to claim 1 or 2, characterized in that step A) is carried out at a temperature of from 100 to 300 °C.

4. Process according to at least one of the preceding claims, characterized in that step A) is carried out at a pressure of from 5 to 100 bar.

5. Process according to at least one of the preceding claims, characterized in that the heterogeneous oxidation catalyst used according to step B) for the oxidative esterification reaction comprises one or more ultra-finely dispersed metals with an average particle size of < 20 nm selected from the group consisting of gold, palladium, ruthenium, rhodium and silver.

6. Process according to at least one of the preceding claims, characterized in that the heterogeneous oxidation catalyst used according to step B) for the oxidative esterification reaction comprises one or more members of the group consisting of lithium, sodium, potassium, calcium, magnesium, scandium, yttrium, lanthanum and other lanthanoids with atomic numbers from 58 to 71, silicon, titanium, zirconium, hafnium, vanadium, niobium, tantalum, chromium, molybdenum, tungsten, manganese, rhenium, iron, ruthenium, osmium, cobalt, rhodium, iridium, nickel, palladium, platinum, copper, silver, gold, zinc, cadmium, boron, aluminium, gallium, indium, thallium, germanium, tin, lead, antimony, bismuth, tellurium, these being respectively present in metallic and/or oxidized form.

7. Process according to at least one of claims 2 to 6, characterized in that the reaction of propanal with formaldehyde to give methacrolein according to step A) uses a secondary amine as organic base.

8. Process according to at least one of claims 2 to 7, characterized in that step A) uses at least one organic acid.

9. Process according to at least one of claims 2 to 8, characterized in that the molar ratio of acid to organic base is in the range from 20:1 to 1:20.

10. Process according to at least one of the preceding claims, characterized in that the reaction according to step A) is carried out with a residence time in the range from 0.1 to 300 seconds.

11. Process according to at least one of the preceding claims, characterized in that the reaction according to step B) is carried out with a pressure in the range from 2 to 50 bar.

12. Process according to at least one of the preceding claims, characterized in that the oxidative esterification reaction according to step B) is carried out with a temperature in the range from 10 to 200 °C.

13. Process according to at least one of the preceding claims, characterized in that the oxidative esterification reaction according to step B) takes place with a molar ratio of methanol to methacrolein in the range from 1:1 to 50:1.

~~14. Process according to at least one of the preceding claims, characterized in that steps A) and B) are carried out in a continuous process.~~

14~~15~~. Process according to at least one of the preceding claims, characterized in that the reactor volume in step A) is smaller than the reactor volume in step B) and the ratio of the two reactor volumes is in the range from 1:1000 to 1:100.

15~~16~~. Process according to at least one of the preceding claims, characterized in that the total amount of separately added water in the two steps A) and B) during the conduct of the reaction is not greater than 100 mol%, based on methacrolein.

16~~17~~. Process according to at least one of the preceding claims, characterized in that no water at all is separately added in the two steps A) and B) during the conduct of the reaction.