Claims

1. Process for continuously performing a Mannich reaction in which methacrolein is prepared from formaldehyde and propionaldehyde as reactants using at least one acid and at least one organic base as catalysts, wherein

   the reaction is carried out in a continuously operated tubular reactor or plate reactor using temperature gradients, wherein an inlet temperature of a reactor feed of the reactants and catalysts into the reactor is between 100 and less than 150°C and the temperature of the reaction mixture at the outflow of the reactor is at most 180°C,

   wherein a water content in the reactor feed is greater than 45% by weight and at most 85% by weight,

   wherein an amount of organic base in the reactor feed, comprising a pure base and also a respective base part in salts with the acid and in the base-containing intermediates of the Mannich reaction, is more than 5 mol% based on propionaldehyde,

   wherein an internal pressure of the reactor is adjusted such that this is greater than the boiling pressure of the reaction mixture

   and wherein a residence time of the reaction mixture in the reactor is between 1 and 30 s.

2. Process according to Claim 1, wherein the feed has a ratio of propionaldehyde to formaldehyde between 0.75 to 1 mol and 1 to 0.8 mol.

3. Process according to Claim 1 or 2, wherein at least 20% of the total amount of organic base in the feed originate from the fresh feed, and that the feed comprises between 1 and 1.5 mol of acid based on one mole of organic base.

4. Process according to Claim 3, wherein the organic base is a secondary amine, preferably dimethylamine and the acid is formic acid, acetic acid and/or propionic acid.

5. Process according to at least one of Claims 1 to 4, wherein the maximum temperature in the reactor is at most 170°C.

6. Process according to at least one of Claims 1 to 5, wherein the inlet temperature in the reactor is between 110 and 140°C, and the temperature of the reaction mixture in the outflow is between 155 and 170°C.

7. Process according to at least one of Claims 1 to 6, wherein the reactor is a tubular reactor in the form of a shell-and-tube reactor, and that the individual tube has an internal diameter between 4 and 20 mm.

8. Process according to at least one of Claims 1 to 7, wherein the tubular reactor is perfused at a superficial flow velocity between 0.3 and 2.0 m/s and optionally has a static mixer.

9. Process according to at least one of Claims 1 to 8, wherein the methacrolein concentration of the reaction mixture at the outflow is between 20 and 50% by weight.

10. Process according to at least one of Claims 1 to 9, wherein the reacted reaction solution after removal at the outlet is distilled in a column and the methacrolein is subsequently separated in a phase separation vessel from the separated aqueous phase, wherein said aqueous phase is wholly or partly fed back into the column.

11. Process according to Claim 10, wherein at least 20% by weight of the aqueous phase from the bottoms of the column are recycled into the inlet of the tubular reactor.

12. Process according to at least one of Claims 1 to 11, wherein the residence time of the reaction mixture in the reactor is between 5 and 15 s.

13. Process according to at least one of Claims 1 to 12, wherein the methacrolein is purified by means of at least one distillation and at least one phase separation and is subsequently converted to methacrylic acid in a gas phase oxidation.

14. Process according to at least one of Claims 1 to 12, wherein the methacrolein is purified by means of at least one distillation and at least one phase separation and is subsequently converted to methyl methacrylate by oxidative esterification.