Claims

1. A process for producing methacrylic acid or a methacrylic acid ester, comprising the steps of
a) producing acrolein,
b) reacting the acrolein of process step a) with hydrogen to produce propanal,
c) reacting the propanal of process step b) with formaldehyde to produce methacrolein and
d) oxidizing methacrolein in the presence of an oxygen containing gas and optionally an alcohol to methacrylic acid or a methacrylic acid ester.

2. ~~A~~The process according to claim 1, wherein the acrolein of step a) is derived from a C3 based raw material, and the C3 based raw material is evaporated and thereafter converted in the presence of a heterogeneous contact and of a co feed gas comprising at least one of the components selected from hydrogen, oxygen and water.

3. ~~A~~The process according to any one of the claims 1 or 2, wherein in process step a) as the C3 raw material glycerol is evaporated and converted to acrolein in the presence of water and optionally hydrogen, and the gaseous acrolein obtained in process step a) is not condensed and directly converted in process step b) without intermediate isolation of the acrolein.

4. ~~A~~The process according to any one of the claims 1 to 3, wherein the product of process step b) is condensed and hereby separated from a gas stream comprising hydrogen and at least two of the components water, carbon monoxide, carbon dioxide, ethane, ethylene and propane, and in that at least a part of the gas stream is recycled by using the gas stream as a co feed in at least one of the process steps a) or b).

5. ~~A~~The process according to any one of the claims 1 to 2, wherein the acrolein of process step a) is produced from the oxidation of propylene in gas phase at a temperature between 300 and 400 °C in the presence of a catalyst comprising Bismuth and Molybdenum.

6. ~~A~~The process according to claim 5, wherein the acrolein of process step a) is hydrogenated in the presence of acrylic acid which is formed in process step a) as a byproduct and that this acrylic acid is

hydrogenated to propionic acid in process step b).

7. ~~A~~The process according to claim 6, wherein the acrylic acid and/or the propionic acid react as a co catalyst in process step c).

8. ~~A~~The process according to any one of the claims 1 to 7, wherein the acrolein of process step a) is separated from acrylic acid by extraction and/or distillation whereby the obtained acrolein is used in process step b).

9. ~~A~~The process according to claim 3, wherein the acrolein of process step a) comprising glycerol as C3 component is hydrogenated in process step b) in the presence of hydroxyl acetone which is a byproduct formed out of glycerol and that this hydroxyl acetone is either reacted in process step d) to acetole methacrylate or in process step c) to hydroxylmethyl vinyl ketone.

10. ~~A~~The process according to claim 3, wherein the intermediate acrolein of process step a) before being hydrogenated in process step b) or propanal of process step b) before being condensed in the presence of formaldehyde in process step c) is ~~substantially~~ purified from hydroxyl acetone.

11. ~~A~~The process according to any one of the preceding claims, wherein the intermediates of at least one of the process steps a), b) and/or c) is ~~substantially~~ separated from hydroxyl acetone or hydroxymethyl vinyl ketone.

12. ~~A~~The process according to any one of the preceding claims, wherein process step c) is carried out in the presence of from 0.1 to 20 mol % of an organic base, preferably a secondary amine, and from 0.1 to 20 mol % of an acid, preferably an organic acid, based in each case on propanal, more preferably, the molar ratio of the acid to the organic base ranges from 20:1 to 1:20.

13. ~~A~~The process according to any one of the preceding claims, wherein process step d) is an oxidative esterification of methacrolein which is carried out in a liquid phase at a pressure of from 1 to 100 bar, and in the presence of a heterogeneous noble-metal-comprising catalyst comprising a metal and/or a metal oxide.

14. The process according to claim 13, wherein the heterogeneous oxidation catalyst comprises one or more ultra-finely dispersed metals with an average particle size of less than 20 nm selected from the group consisting of gold, palladium, ruthenium, rhodium and silver.

15. ~~A~~The process according to any one of the preceding claims, wherein process steps a) and b) are carried out simultaneously in one reactor.

16. The process according to any one of the preceding claims, wherein process step b) is carried out in the presence of a noble metal catalyst and hydrogen.