Claims

1. A catalyst for preparation of an α,β-unsaturated carboxylic acid by gas phase oxidation of an α,β-unsaturated aldehyde, comprising a shaped support body with an active composition applied thereto, wherein the active composition coverage q

$$q = \frac{Q}{(100-Q)\,S_m}$$

is at most 0.26 mg/mm², where Q is the active composition content of the catalyst in % by weight and S_m is the specific geometric surface area of the shaped support body in mm²/mg and the active composition comprises a catalytically active multielement oxide composition comprising the elements Mo and V, where the molar proportion of the element Mo in the total amount of all elements other than oxygen in the catalytically active multielement oxide composition is 20 mol% to 80 mol%, the molar ratio of Mo present in the catalytically active multielement oxide composition to V present in the catalytically active multielement oxide composition, Mo/V, is 15:1 to 1:1.

2. The catalyst according to claim 1, wherein the proportion by volume p_{vol} of macropores is at least 0.35, where p_{vol} is determined by

$$p_{vol} = \frac{V_{0.26\text{-}2}}{V_{0.02\text{-}6.5}}$$

in which

$V_{0.26\text{-}2}$ is the volume of the pores having mean diameters in the range from 0.26 to 2 µm, and

$V_{0.02\text{-}6.5}$ is the volume of the pores having mean diameters in the range from 0.02 to 6.5 µm.

3. The catalyst according to either of the preceding claims, wherein the shaped support body is a hollow cylindrical shaped support body.

4. The catalyst according to either of the preceding claims, wherein the shaped support body consists of steatite and is essentially nonporous.

5. The catalyst according to claim 3 or 4, wherein the hollow cylindrical shaped support body has a height of 2 to 5 mm and an external diameter of 4 to 8 mm, and the median difference between the external diameter and internal diameter is 1 to 2 mm.

6. The catalyst according to either of the preceding claims, wherein the active composition comprises a multielement oxide of the general formula (II)

$$Mo_{12}V_aW_bCu_cX^4_eX^5_fO_n \qquad (II)$$

in which

X^4 is one or more alkali metals and/or alkaline earth metals,

X^5 is one or more elements from the group of Si, Al, Ti and Zr,

a is a number in the range from 2 to 4,

b is a number in the range from 0 to 3,

c is a number in the range from 0.8 to 3,

e is a number in the range from 0 to 4,

f is a number in the range from 0 to 40, and

n is the stoichiometric coefficient of the element oxygen, which is determined by the stoichiometric coefficients of the elements other than oxygen and the valency thereof in (II).

7. A process for preparing the catalyst according to any of the preceding claims, by coating the shaped support body with the active composition, by mixing a multitude of shaped support bodies, a pulverulent active composition and a liquid binder, without saturating the pulverulent active composition with the liquid binder, in a vessel, wherein the shaped support bodies are initially charged in the vessel and the pulverulent active composition and the liquid binder are added to the vessel separately from one another over the duration of the coating and the duration of the coating operation is less than 30 minutes.

8. The process according to claim 6 or 7, wherein the mixing is effected by continuous movement of the vessel.

9. The process according to claim 8, wherein the movement is a rotational movement.

10. The process according to any of claims 6 to 9, wherein the pulverulent active composition has a numerical proportion of particles having a longest dimension above 50 µm of less than 1%.

11. A process for preparing an α,β-unsaturated carboxylic acid by gas phase oxidation of an α,β-unsaturated aldehyde with molecular oxygen over a fixed catalyst bed, wherein the fixed catalyst bed comprises a bed of a catalyst according to any of claims 1 to 6.

12. The process according to claim 11, wherein the fixed catalyst bed comprises at least two successive reaction zones and the bed, at least in the reaction zone closest to the reactor inlet, comprises a catalyst according to any of claims 1 to 6.

13. The process according to claim 11 or 12, wherein the fixed catalyst bed comprises at least two successive reaction zones and the bed, at least in the reaction zone in which the highest local temperature occurs, comprises a catalyst according to any of claims 1 to 6.

14. The process according to claim 11 to 13, wherein, from a certain operating time, to restore the quality of the bed, not the entire spent bed but only the portion of the bed in which the highest local temperature occurs is removed and replaced by a fresh bed.

15. The process according to claim 11 to 14 for preparation of acrylic acid by gas phase oxidation of acrolein.

The invention claimed is:

1. A catalyst for the preparation of an α,β-unsaturated carboxylic acid by gas phase oxidation of an α,β-unsaturated aldehyde, comprising a shaped support body with an active composition applied thereto, wherein the active composition coverage q

$$q = \frac{Q}{(100 - Q)S_m}$$

is at most 0.3 mg/mm^2, where Q is the active composition content of the catalyst in % by weight and S_m is the specific geometric surface area of the shaped support body in mm^2/mg.

2. The catalyst according to claim **1**, wherein the proportion by volume p_{vol} of macropores is at least 0.35, where p_{vol} is determined by

$$p_{vol} = \frac{V_{0.26-2}}{V_{0.02-6.5}}$$

in which

$V_{0.26-2}$ is the volume of the pores having a mean diameter of from 0.26 to 2 μm, and

$V_{0.02-6.5}$ is the volume of the pores having a mean diameter of from 0.02 to 6.5 μm.

3. The catalyst according to claim **1**, wherein the shaped support body is a hollow cylindrical shaped support body.

4. The catalyst according to claim **1**, wherein the shaped support body comprises steatite and is essentially nonporous.

5. The catalyst according to claim **3**, wherein the hollow cylindrical shaped support body has a height of from 2 to 5 mm and an external diameter of from 4 to 8 mm, and the median difference between the external diameter and internal diameter is from 1 to 2 mm.

6. The catalyst according to claim **1**, wherein the active composition comprises a multielement oxide of formula (II)

$$Mo_{12}V_aW_bCu_cX^4_eX^5_fO_n \quad \text{(II)},$$

in which

X^4 is one or more alkali metals and/or alkaline earth metals,

X^5 is one or more elements from the group consisting of Si, Al, Ti and Zr,

a is a number in the range from 2 to 4,

b is a number in the range from 0 to 3,

c is a number in the range from 0.8 to 3,

e is a number in the range from 0 to 4,

f is a number in the range from 0 to 40, and

n is the stoichiometric coefficient of the element oxygen, which is determined by the stoichiometric coefficients of the elements other than oxygen and the valency thereof in (II).

7. A method for preparing the catalyst according to claim **1**, said method comprising

coating the shaped support body with the active composition,

wherein the coating comprises mixing a multitude of shaped support bodies, a pulverulent active composition and a liquid binder, without saturating the pulverulent active composition with the liquid binder, in a vessel, wherein the duration of the coating operation is less than 30 minutes.

8. The method according to claim **7**, wherein the shaped support bodies are initially charged in the vessel and the pulverulent active composition and the liquid binder are added to the vessel separately from one another over the duration of the coating.

9. The method according to claim **7**, wherein the mixing is effected by continuous movement of the vessel.

10. The method according to claim **9**, wherein the movement is a rotational movement.

11. The method according to claim **7**, wherein the pulverulent active composition has a numerical proportion of particles having a longest dimension above 50 μm of less than 1%.

12. A method for preparing an α,β-unsaturated carboxylic acid by gas phase oxidation of an α,β-unsaturated aldehyde with molecular oxygen over a fixed catalyst bed, wherein the fixed catalyst bed comprises a bed of the catalyst according to claim **1**.

13. The method according to claim **12**, wherein the fixed catalyst bed comprises at least two successive reaction zones, and the bed, at least in the reaction zone that is closest to the reactor inlet, comprises the catalyst.

14. The method according to claim **12**, wherein the fixed catalyst bed comprises at least two successive reaction zones, and the bed, at least in the reaction zone in which the highest local temperature occurs, comprises the catalyst.

15. The method according to claim **12**, wherein, after a certain operating time, a portion of the bed in which the highest local temperature occurs is removed and replaced by a fresh bed.

16. The method according to claim **12**, wherein the α,β-unsaturated aldehyde is acrolein and the α,β-unsaturated carboxylic acid is acrylic acid.

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