Claims

1. Process for hydroformylating C2 to C5 olefins, wherein the hydroformylation comprises one or more hydroformylation steps, wherein

in at least one hydroformylation step a feed mixture comprising the C2 to C5 olefins is subjected to a hydroformylation with synthesis gas in the presence of a catalyst system comprising a metal from group 8 or 9 of the Periodic Table of the Elements, at least one organic phosphorus-containing ligand and a stabilizer, in a reaction zone, wherein the feed mixture and the synthesis gas are passed over a support composed of a porous ceramic material on which the catalyst system is in heterogenized form,

the catalyst system does not comprise any ionic liquid; and

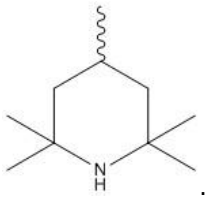
the support is a monolith, i.e. a block of a ceramic material, to which a washcoat composed of the same or a different ceramic material with respect to the ceramic material of the support is applied;

wherein the organic phosphorus-containing ligand in the hydroformylation catalyst system has the general formula (VI)

$$R' - A - R'' - A - R''' \qquad (VI)$$

where R', R'' and R''' are each organic radicals, with the proviso that R' and R''' are not identical, and each A is a bridging –O-P(-O)$_2$- group, where two of the three oxygen atoms -O- are respectively bonded to R' radical and R''' radical; and

wherein the stabilizer is an organic amine compound containing at least one 2,2,6,6-tetramethylpiperidine unit of formula (I):



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2. Process according to Claim 1, wherein a gaseous output comprising at least a portion of the product aldehydes formed and at least a portion of the unconverted olefins is withdrawn continuously from the reaction zone and the gaseous output is subjected to a physical separation step in which the gaseous output is separated into at least one phase rich in unconverted olefins and at least one phase rich in product aldehyde.

3. Process according to any of Claims 1 to 2, wherein the porous ceramic material of which the support consists is selected from the group consisting of a silicate ceramic, an oxidic ceramic, a nitridic ceramic, a carbidic ceramic, a silicidic ceramic and mixtures thereof.

4. Process according to Claim 3, wherein the silicate ceramic is selected from aluminosilicate, magnesium silicate, and mixtures thereof, for example bentonite; the oxidic ceramic is selected from γ-alumina, α-alumina, titanium dioxide, beryllium oxide, zirconium oxide, aluminium titanate, barium titanate, zinc oxide, iron oxides (ferrites) and mixtures thereof; the nitridic ceramic is selected from silicon nitride, boron nitride, aluminium nitride and mixtures thereof; the carbidic ceramic is selected from silicon carbide, boron carbide, tungsten carbide or mixtures thereof; and the silicidic ceramic is molybdenum silicide.

5. Process according to Claim 3, wherein the porous ceramic material of which the support consists is a carbidic ceramic.

6. Process according to Claim 4, wherein the carbidic ceramic is selected from silicon carbide, boron carbide, tungsten carbide or mixtures thereof.

7. Process according to any of Claims 1 to 5, wherein the amount of the washcoat on the support is $\leq$ 20% by weight, based on the total amount of the support.

8. Process according to any of Claims 1 to 7, wherein the support composed of the ceramic material has one or more channels in main through-flow direction.

9. Process according to any of Claims 1 to 8, wherein the hydroformylation step is conducted at a temperature in the range from 65 to 200°C.

10. Process according to any of Claims 1 to 9, wherein the pressure in the hydroformylation step is not greater than 35 bar.