Claims

1. An alkoxycarbonylation process for preparing an ester by carbonylation of a C2 to C16 alkene or isoalkene, wherein the alkoxycarbonylation process comprises the following steps:

a) carbonylating a C2 to C16 alkene or isoalkene having at least one olefinic double bond with carbon monoxide and with an alcohol wherein the alcohol that is a mono- or polyol (two or more OH groups) have from 1 to 50 carbon atoms or is a mixture of two or more mono- and/or polyols and which, when it is a monool, is used in a molar ratio to the C2 to C16 hydrocarbon (alcohol:C2 to C16 hydrocarbon) of from 2 to 20 or which, when it is a polyol, is used in a molar ratio to the alkene or isoalkene used (alkene or isoalkene:polyol) of from 2 to 20, in the presence of a homogeneous catalyst system comprising at least one metal of groups 8 to 10 of the periodic table of the elements or a compound thereof, a phosphorus-containing ligand and an acid, in a reaction zone of step a) to obtain a liquid product mixture that comprises at least the ester formed by the reaction, the homogeneous catalyst system, low boilers, high boilers and unreacted alcohols of step a);

b) carrying out a membrane separation with a membrane material to separate the homogeneous catalyst system from the liquid product mixture, whereby the homogeneous catalyst system and unreacted alcohol of step a), are enriched in a retentate and the ester formed in step a) is enriched in a permeate,

wherein the membrane material used is an OSN (organic solvent nanofiltration) comprising a separation-active layer comprising a PEEK (polyether ether ketone) polymer, and a porous backing and the membrane material is stable in the presence of the acid of the catalyst system and not destroyed for at least 300 hours wherein the acid in the catalyst system is a Brønsted acid having a pKa <5 or a Lewis acid, and the membrane material has a membrane retention R for the ligand of the homogeneous catalyst system is at least 75%, and worsens by not more than 30 percentage points; or a relative permeability P_{rel} value between 30% and 300%, and the retentate is recycled into the reaction zone and wherein on recycling the retentate, a purge stream is removed from the retentate;

c) working up the permeate by means of one or more separation steps selected from thermal separation, extraction, crystallization or membrane separation, by means of one or more distillation steps, for removing the ester formed in step a) and for removing the unreacted C2 to C16 alkene or isoalkene having at least one olefinic double bond and/or

the unreacted alcohol and recycling of the unreacted C2 to C16 alkene or isoalkene having at least one olefinic double bond and/or the unreacted alcohol of step a) into the reaction zone of step a);

and wherein the molar ratio of the Brønsted acid to ligand is from 1:1 to 15:1, and the molar ratio of Lewis acid to ligand is from 1:1 to 20:1.

2. The alkoxycarbonylation process according to Claim 1, wherein the membrane material has the following two characteristics:

- the membrane retention R for the ligand of the homogeneous catalyst system is at least 85%, and worsens by not more than 30 percentage points; or
- the relative permeability P_{rel} has a value between 30% and 300%; and
- the acid in the catalyst system is selected from the group consisting of a Brønsted acid having a pKa <3 and a Lewis acid, wherein the molar ratio of the Bronsted acid to ligand is from 1:1 to 10:1, and the molar ratio of Lewis acid to ligand is from 2:1 to 15:1.

3. The alkoxycarbonylation process according to Claim 1, wherein the PEEK polymer has a degree of sulfonation of less than 20%.

4. The alkoxycarbonylation process according to Claim 3, wherein the PEEK polymer has a degree of sulfonation of less than 10%.

5. The alkoxycarbonylation process according to Claim 1, wherein the alcohol used in step a) is selected from the group consisting of ethanol, 1-propanol, 1-butanol, 1-pentanol, 1-hexanol, 2-propanol, tert-butanol, and 3-pentanol.

6. The alkoxycarbonylation process according to Claim 5, wherein the alcohol used in step a) is selected from the group consisting of ethanol, 1-propanol, 1-butanol, 1-pentanol, 1-hexanol, 2-propanol, tert-butanol, 3-pentanol, and 2-propylheptanol.

7. The alkoxycarbonylation process according to Claim 1, wherein the C2 to C16 alkene or isoalkene having at least one olefinic double bond that is used in step a) is an n- or isoalkene having 2 to 16 carbon atoms.

8. The alkoxycarbonylation process according to Claim 1, wherein the metal of groups 8 to 10 of the periodic table of the elements or a compound thereof in the homogeneous catalyst system in step a) is palladium or a compound thereof.

9. The alkoxycarbonylation process according to Claim 1, wherein the phosphorus ligand in the homogeneous catalyst system has a bidentate structure.

10. The alkoxycarbonylation process according to Claim 1, wherein the acid in the catalyst system in step a) is a Brønsted acid having a pKa ≤ 5, or a Lewis acid having a Lewis acid unit (LAU) value of more than 25.

11. The alkoxycarbonylation process according to Claim 1, wherein the acid in the catalyst system in step a) is a Brønsted acid or a Lewis acid, the Brønsted acid being perchloric acid, sulfuric acid, phosphoric acid, methylphosphonic acid or a sulfonic acid, and the Lewis acid being aluminium triflate, aluminium chloride, aluminium hydride, trimethylaluminium, tris(pentafluorophenyl)borane, boron trifluoride, boron trichloride or a mixture thereof.

12. The alkoxycarbonylation process according to Claim 1, wherein the reaction zone of step a) includes at least one reactor.

13. The alkoxycarbonylation process according to Claim 2, wherein the acid in the catalyst system in step a) is a Brønsted acid having a pKa ≤ 3, or a Lewis acid having an LAU value of more than 25,
wherein the molar ratio of the Bronsted acid to ligand is from 3:1 to 5:1, and the molar ratio of Lewis acid to ligand is from 5:1 to 10:1.

14. The alkoxycarbonylation process according to Claim 1, wherein the membrane material according to the invention exhibits the following two characteristics:
- the membrane retention R for the ligand of the homogeneous catalyst system is at least 85%, and worsens by not more than 20 percentage points; or
- the relative permeability P_{rel} has a value between 50% and 150%.

15. The alkoxycarbonylation process according to Claim 1, wherein the membrane material according to the invention exhibits the following two characteristics:
- the membrane retention R for the ligand of the homogeneous catalyst system is at least 90%, and worsens by not more than 10 percentage points; or
- the relative permeability P_{rel} has a value between 75% and 125%.

16. The alkoxycarbonylation process according to Claim 1, wherein the acid in the catalyst system in step a) is a Brønsted acid having a pKa ≤ 3, or a Lewis acid having an LAU value of more than 25.

17. The alkoxycarbonylation process according to Claim 2, wherein the PEEK polymer has a degree of sulfonation of less than 20%.

18. The alkoxycarbonylation process according to Claim 17, wherein the PEEK polymer has a degree of sulfonation of less than 20%.