The first oligomerization 1 forms a first oligomerizate $C_2$, $C_{2+}$ comprising the oligomers $C_{2+}$ and unconverted ethene $C_2$. In a first distillation column a fraction $C_2$, $C_4$ comprising the unconverted ethene and the ethene dimers are removed overhead while the olefins having more than four carbon atoms $C_{4+}$ are withdrawn from the bottom of the first distillation column 2.

In a second distillation column 3 the unconverted ethene $C_2$ is withdrawn overhead, recycled and mixed with freshly provided feed mixture.

A $C_4$ fraction $C_4$ comprising 1-butene, cis-2-butene and trans-2-butene is withdrawn from the bottom of the second distillation column 3. Thermal separation thereof is readily possible and is effected in a third distillation column 4. Obtained at the top of the third distillation column 4 is a third target fraction 1B comprising the 1-butene.

The two 2-butenes remain in the bottom of the third distillation column 4 and are withdrawn there as second intermediate 2B. The second intermediate 2B is subjected to a second oligomerization 5 to generate a second oligomerizate $C_8$, $C_{8+}$. This comprises sought-after octenes $C_8$, for example di-n-butene, and olefins having more than eight carbon atoms $C_{8+}$.

The second oligomerization 5 is effected in the presence of the solid body which comprises at least two components, wherein the first component comprises at least one element selected from Ni, Cr, Fe, Ti which is present in metallic and/or oxidic and/or hydridic form and wherein the second component comprises at least one metal oxide selected from $Al_2O_3$, $SiO_2$, $TiO_2$, $ZrO_2$.

The octenes are obtained from the second oligomerizate $C_8$, $C_{8+}$ as a first target fraction $C_8$ using a fourth distillation column at the top thereof. In the bottom thereof are the olefins having more than eight carbon atoms $C_{8+}$ which are discharged from the process as high boilers.

Back to the first distillation column 2, at the bottom of which are the olefins having more than four carbon atoms $C_{4+}$ which were formed in the ethene oligomerization 1. This includes a $C_6$ fraction $C_6$ which comprises at least 1-hexene, 3-methyl-cis-2-pentene, 3-methyl-trans-2-pentene and also 2-hexene, 3-hexene and 2-ethyl-1-butene. The $C_6$ fraction $C_6$ is obtained at the top of a fifth distillation column 7 and then subjected to an etherification 8.

The etherification is effected with methanol MeOH over an acidic ion exchange resin. In the etherification 8,2-ethyl-1-butene, 3-methyl-cis-2-pentene, 3-methyl-trans-2-pentene are selectively reacted with the methanol to afford 3-methyl-3-methoxypentane. This ether is also known as methyl tert-hexyl ether (MTHxE). The first reaction mixture 1H, 2H, 3H, MTHxE withdrawn from the etherification 8 comprises not only MTHxE but also unconverted 1-hexene 1H and also 2-hexene

**Claims**

1. Process for producing at least 1-hexene and octene from ethene comprising the steps of:

a) providing a feedstock mixture comprising ethene;

b) subjecting the ethene to a first oligomerization to obtain a first oligomerizate which comprises olefins having less than six carbon atoms, at least the $C_6$ olefins 1-hexene, 3-methyl-cis-2-pentene, 3-methyl-trans-2-pentene and olefins having more than six carbon atoms,

c) distillative workup of the first oligomerizate to obtain a $C_6$ fraction which comprises at least 1-hexene, 3-methyl-cis-2-pentene, 3-methyl-trans-2-pentene,

d) subjecting the $C_6$ fraction to an etherification by addition of an alcohol in the presence of a heterogeneous catalyst to obtain a first reaction mixture comprising at least 1-hexene and 3-methyl-3-methoxypentane;

e) distillative workup of the first reaction mixture to obtain a first target fraction comprising 1-hexene and an ether fraction at least comprising 3-methyl-3-methoxypentane;

f) wherein the ether fraction is subjected to a cleavage reaction to obtain a cleavage product which comprises 3-methyl-cis-2-pentene, 3-methyl-trans-2-pentene and the alcohol;

g) wherein the alcohol is removed from the cleavage product by distillation and reused in the etherification;

h) wherein a first intermediate comprising at least 3-methyl-cis-2-pentene, 3-methyl-trans-2-pentene is removed from the cleavage product by distillation;

i) wherein the first intermediate is reacted with ethene to obtain a second reaction mixture which comprises olefins having at least eight carbon atoms;

k) and wherein a second target fraction comprising octene is obtained from the second reaction mixture by distillation.

2. Process according to Claim 1, wherein not only 1-hexene and octene but also 1-butene are produced as follows:

a) the first oligomerization is performed such that the first oligomerizate further comprises 1-butene, cis-2-butene and trans-2-butene;

b) distillative workup of the first oligomerizate affords a $C_4$ fraction which comprises 1-butene, cis-2-butene and trans-2-butene;

c) the $C_4$ fraction is separated by distillation into a third target fraction comprising 1-butene and into a second intermediate which comprises cis-2-butene and trans-2-butene;

d) the second intermediate is subjected to a second oligomerization to obtain a second oligomerizate which comprises olefins having at least eight carbon atoms;

e) the second oligomerizate is worked up by distillation together with the second reaction mixture to obtain the second target fraction.

3. Process according to Claim 1, wherein the distillative workup of the first oligomerizate affords a $C_{6+}$ fraction which comprises olefins having more than six carbon atoms and in that the $C_{6+}$ fraction is worked up by distillation together with the second reaction mixture to obtain the second target fraction.

4. Process according to Claim 2, wherein the distillative workup of the first oligomerizate affords a $C_{6+}$ fraction which comprises olefins having more than six carbon atoms and in that the $C_{6+}$ fraction is worked up by distillation together with the second reaction mixture and with the second oligomerizate to obtain the second target fraction.

5. Process according to any of Claims 1 to 4, wherein the feedstock mixture comprises more than 95 wt% of ethene and that the reaction conditions of the first oligomerization are chosen such that the first oligomerization is effected in the gas phase in the presence of a heterogeneous catalyst.

6. Process according to any of Claims 1 to 4, wherein the feedstock mixture comprises less than 25 wt% of ethene, in that the feedstock mixture comprises more than 75 wt% of a solvent, wherein the reaction conditions of the first oligomerization and the concentration of the ethene in the solvent are chosen such that the first oligomerization is effected in the liquid phase and the ethene is fully dissolved in the liquid solvent.

7. Process according to Claim 5 or 6, wherein ethene unconverted in the first oligomerization is removed by distillation from the first oligomerizate and recycled into the first oligomerization.

8. Process according to any of Claims 1 to 4, wherein the feedstock mixture comprises not only ethene but also olefins having four carbon atoms, wherein the reaction conditions of the first oligomerization and the composition of the feedstock mixture are chosen such that the first oligomerization is effected in the liquid phase and the ethene is fully dissolved in the olefins having four carbon atoms.

9. Process according to any of Claims 1 to 4, wherein the feedstock mixture comprises not only ethene but also olefins having six carbon atoms, wherein the reaction conditions of the first oligomerization and the composition of the feedstock mixture are chosen such that the first oligomerization is effected in the liquid phase and the ethene is fully dissolved in the olefins having six carbon atoms.

10. Process according to any of Claims 1 to 4, wherein the feedstock mixture comprises not only ethene but also olefins having four carbon atoms and olefins having six carbon atoms, wherein the reaction conditions of the first oligomerization and the composition of the feedstock mixture are chosen such that the first oligomerization is effected in the liquid phase and the ethene is fully dissolved in the olefins having four and six carbon atoms.

11. Process according to any of Claims 1 to 10, wherein a solid body comprising at least two components is employed as a heterogeneous catalyst in one or more of the following reactions:

- in the first oligomerization;
- in the second oligomerization;
- in the reaction of the second intermediate with ethene;

wherein the first component comprises at least one element selected from Ni, Cr, Fe, Ti which is present in metallic and/or oxidic and/or hydridic form and wherein the second component comprises at least one metal oxide selected from $Al_2O_3$, $SiO_2$, $TiO_2$, $ZrO_2$.

12. Process according to Claim 11, wherein the reaction of the second intermediate with ethene is effected in the presence of said catalyst, wherein this reaction is effected at a temperature between 20°C and 150°C and at a pressure between $1*10^5$ Pa and $50*10^5$ Pa, wherein the quantitative ratio of the ethene to the second intermediate is chosen such that the second intermediate is present in the liquid phase and the ethene is fully dissolved therein.

13. Process according to any of Claims 1 to 12, wherein the cleavage reaction is effected in the gas phase at a pressure of $1*10^5$ Pa to $25*10^5$ Pa and a temperature of 130°C to 350°C in the presence of a solid body having the following composition which sums to 100 wt%:

- silicon dioxide: 61 wt% to 74 wt%;
- aluminum oxide: 19 wt% to 23 wt%;
- magnesium oxide: 10 wt% to 12 wt%;
- sum of other substances: 0 to 10 wt%.

14. Process according to any of Claims 1 to 13, wherein the etherification is effected in the liquid phase at a pressure of $1*10^5$ Pa to $7*10^5$ Pa and a temperature of 50°C to 130°C in the presence of a polystyrene-divinylbenzene copolymer bearing sulfonic acid groups or carboxylic acid groups.