

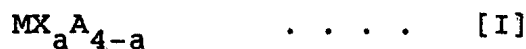


AU9185883

(12) PATENT ABRIDGMENT (11) Document No. AU-B-85883/91
 (19) AUSTRALIAN PATENT OFFICE (10) Acceptance No. 644020

- (54) Title
PRODUCTION OF LINEAR ALPHA-OLEFIN
- International Patent Classification(s)
 (51)⁵ **C07C 002/30**
- (21) Application No. : **85883/91** (22) Application Date : **16.10.91**
- (30) Priority Data
- (31) Number (32) Date (33) Country
2-279203 19.10.90 JP JAPAN
- (43) Publication Date : **11.06.92**
- (44) Publication Date of Accepted Application : **02.12.93**
- (71) Applicant(s)
IDEMITSU PETROCHEMICAL CO., LTD.
- (72) Inventor(s)
YASUSHI SHIRAKI; TAKAO TAMURA
- (74) Attorney or Agent
PHILLIPS ORMONDE & FITZPATRICK , 367 Collins Street, MELBOURNE VIC 3000
- (56) Prior Art Documents
US 4486615
AU 598676 16978/88 C08F 4/64 C07C 2/22
AU 582169 44679/85 C08F 4/56
- (57) Claim

1. A process for producing a linear α -olefin which contains an olefin having 4 to 18 carbon atoms as a main component by the oligomerization of ethylene, which includes carrying out the oligomerization in the presence of catalyst composed of (A) zirconium halide represented by the formula [I]



(where M denotes a zirconium atom; each of X and A denotes a chlorine atom, bromine atom, or iodine atom where X and A may be the same or different from each other; and a denotes zero or an integer from 1 to 4), (B) a mixture of an organoaluminium compound represented by the formula [II]



(11) AU-B-85883/91
(10) 644020

-2-

(where R denotes an alkyl group having 1 to 20 carbon atoms; Q denotes a chlorine atom, bromine atom, or iodine atom; c and d are numbers selected from 1, 1.5, and 2, with $c + d = 3$, and an organoaluminium compound represented by the formula [III]



(where R' denotes an alkyl group having 1 to 20 carbon atoms), and (C) at least one alcohol selected from the group consisting of methanol and ethanol, wherein the alcohol (C) is added after mixing the zirconium halide (A) represented by the formula [I] and the mixture (B) of the organoaluminium compound represented by the formula [II] and the organoaluminium compound represented by the formula [III].

PRODUCTION OF LINEAR α -OLEFIN

BACKGROUND OF THE INVENTION

1. Field of the Invention:

The present invention relates to a process for producing a linear α -olefin, more particularly, to a process for producing a high-purity linear α -olefin.

2. Description of the Prior Art:

A linear α -olefin is useful as a comonomer for modification of polyolefins or as a raw material for plasticizers and surface active agent. In particular, a linear α -olefin having 6 to 18 carbon atoms is used in general.

A linear α -olefin of this type is conventionally produced by the oligomerization of ethylene which is accomplished by the aid of a catalyst composed of titanium or zirconium halide and an organoaluminum compound.

It is known that, in a process for producing a linear α -olefin, it is effective to add to the catalyst a sulfur compound, phosphorus compound, or nitrogen compound as a third component, in order to improve the purity of the linear α -olefin. A particularly effective sulfur compound includes dimethyl disulfide, thiophene, and thiourea. However, there is a disadvantage of contaminating a part of said third component into the

linear α -olefin, when the catalyst being incorporated with said third component is used.

In order to eliminate this disadvantage, the present inventors carried out research on a process for producing a high-purity α -olefin free of contaminant. As the result, it was found that sufficient effect can be obtained by the use of a small amount of specific alcohol in place of the sulfur compound as a third component. This finding led to the present invention.

SUMMARY OF THE INVENTION

According to the present invention there is provided a process for producing a linear α -olefin which contains an olefin having 4 to 18 carbon atoms as a main component by the oligomerization of ethylene, which includes carrying out the oligomerization in the presence of catalyst composed of (A) zirconium halide represented by the formula [I]



(where M denotes a zirconium atom; each of X and A denotes a chlorine atom, bromine atom, or iodine atom where X and A may be the same or different from each other; and a denotes zero or an integer from 1 to 4), (B) a mixture of an organoaluminium compound represented by the formula [II]



(where R denotes an alkyl group having 1 to 20 carbon atoms; Q denotes a chlorine atom, bromine atom, or iodine atom; c and d are numbers selected from 1, 1.5, and 2, with $c + d = 3$, and an organoaluminium compound represented by the formula [III]



(where R' denotes an alkyl group having 1 to 20 carbon



atoms), and (C) at least one alcohol selected from the group consisting of methanol and ethanol, wherein the alcohol (C) is added after mixing the zirconium halide (A) represented by the formula [I] and the mixture (B) of the
5 organoaluminium compound represented by the formula [II] and the organoaluminium compound represented by the formula [III].

DETAILED DESCRIPTION OF THE INVENTION

10

Accordingly, the catalyst used in the process is composed of the following three components.

Component (A) : zirconium halide

Component (B) : a mixture of two organoaluminum compounds
15 as defined above, and

Component (C) : at least one selected from methanol and ethanol.

The zirconium halide as component (A) is represented by the formula [I] below.

20 MX_aA_{4-a} . . . [I]

(where M denotes a zirconium atom; each of X and A denotes a chlorine atom, bromine atom, or iodine atom wherein X and A may be the same or different from each other; and a
25 denotes zero or an integer from 1 to 4).

There are no restrictions on component (A) so long as it is a compound which satisfies the formula [I]. Typical examples of the compound include $ZrCl_4$, $ZrBr_4$, ZrI_4 , $ZrBrCl_3$, $ZrBrCl_2$, etc. Among these compounds,
30 zirconium halide is preferable, and $ZrCl_4$ is particularly preferable. The zirconium halides represented by the formula [I] may be used alone or in combination with one another or more.

The organoaluminum compound as component (B) is a
35 mixture of a compound represented by the formula [II] below and a compound represented by the formula [III] below.

AlR_cQ_d . . . [II]



(where R denotes an alkyl group having 1 to 20 carbon atoms; Q denotes a chlorine atom, bromine atom, or iodine atom; c and d are numbers selected from 1, 1.5, and 2, with $c + d = 3$.)

5



(Where R' denotes an alkyl group having 1 to 20 carbon atoms.)

10

15

20

25

30

35



Examples of the compound represented by the formula [II] include $\text{Al}(\text{C}_2\text{H}_5)\text{Cl}_2$, $\text{Al}(\text{C}_2\text{H}_5)\text{Br}_2$, and $\text{Al}(\text{C}_2\text{H}_5)\text{I}_2$ (in case of $c = 1$ and $d = 2$); and $\text{Al}(\text{CH}_3)_{1.5}\text{Cl}_{1.5}$, $\text{Al}(\text{CH}_3)_{1.5}\text{Br}_{1.5}$, $\text{Al}(\text{C}_2\text{H}_5)_{1.5}\text{Cl}_{1.5}$, $\text{Al}(\text{C}_2\text{H}_5)_{1.5}\text{Br}_{1.5}$, $\text{Al}(\text{C}_2\text{H}_5)_{1.5}\text{I}_{1.5}$, $\text{Al}(\text{C}_3\text{H}_7)_{1.5}\text{Cl}_{1.5}$, $\text{Al}(\text{iso-C}_3\text{H}_7)_{1.5}\text{Cl}_{1.5}$, $\text{Al}(\text{C}_4\text{H}_9)_{1.5}\text{Cl}_{1.5}$, $\text{Al}(\text{iso-C}_4\text{H}_9)_{1.5}\text{Cl}_{1.5}$, $\text{Al}(\text{C}_6\text{H}_{13})_{1.5}\text{Cl}_{1.5}$, $\text{Al}(\text{C}_2\text{H}_5)_{1.5}\text{Br}_{0.5}\text{Cl}$, $\text{Al}(\text{C}_8\text{H}_{17})_{1.5}\text{Cl}_{1.5}$, and $\text{Al}(\text{C}_2\text{H}_5)(\text{CH}_3)_{0.5}\text{Cl}_{1.5}$ (in case of $c = 1.5$ and $d = 1.5$). Preferable of these examples are those in which R is a methyl, ethyl, propyl, or butyl group. The one in which R is an ethyl group is most desirable. Also, preferable of these examples are those in which Q is a chlorine atom. In the case where $c = 2$ and $d = 1$, $\text{Al}(\text{C}_2\text{H}_5)_2\text{Cl}$, $\text{Al}(\text{C}_2\text{H}_5)_2\text{Br}$, and $\text{Al}(\text{C}_2\text{H}_5)_2\text{I}$ are preferable. The compounds represented by the formula [II] may be used alone or in combination with one another or more.

Examples of the compound represented by the formula [III] include $\text{Al}(\text{CH}_3)_3$, $\text{Al}(\text{C}_2\text{H}_5)_3$, $\text{Al}(\text{C}_3\text{H}_7)_3$, $\text{Al}(\text{iso-C}_3\text{H}_7)_3$, $\text{Al}(\text{C}_4\text{H}_9)_3$, $\text{Al}(\text{iso-C}_4\text{H}_9)_3$, $\text{Al}(\text{C}_5\text{H}_{11})_3$, $\text{Al}(\text{C}_6\text{H}_{13})_3$, and $\text{Al}(\text{C}_8\text{H}_{17})_3$. Among these compounds, preferable compounds are those in which R' is a methyl, ethyl, propyl, or butyl group. The compounds represented by the formula [III] may be used alone or in combination with one another or more.

~~In addition, the organoaluminum compound as~~



Preparation of the above-mentioned catalyst components are performed by using an inert solvent, which includes aromatic hydrocarbons with or without substituting halogen atom(s) (such as benzene, toluene, xylene, chlorobenzene, ethylbenzene, dichlorobenzene, and chlorotoluene); aliphatic hydrocarbons (such as pentane, hexane, heptane, octane, nonane, and decane); alicyclic hydrocarbons (such as cyclohexane); naphthenic paraffins (such as decalin); and haloalkanes (such as dichloroethane and dichlorobutane).

According to an embodiment of the present invention, the catalyst components (A) and (B) are used in such amounts that the Al/Zr molar ratio is in the range from 1 to 15. In this embodiment, the compounds [II] and [III] for component (B) are used in such amounts that the molar ratio of compound [ii] to compound [III] is in the range from 2 to 10.

According to the present invention, the above-mentioned catalyst components are combined with component (C), which is an alcohol, for the oligomerization of ethylene. The alcohol is at least one of methanol and ethanol. The alcohol is added after mixing together components A and B. The alcohol should preferably be added in an amount 0.1-6 times (in mol) the amount of component (A), with methanol being 0.1-5 times, preferably 0.3-2.0 times, and ethanol being 0.1-3 times, preferably 0.1-1 time.

The alcohol contributes to the improvement of product purity (α -olefin content) and activity without any adverse effect on the catalytic activity.

The oligomerization of ethylene is usually carried out at a temperature in the range from 100°C to 150°C under a pressure higher than 25 kg/cm²G. The reaction time usually ranges from 15 minutes to 1 hour, depending on the reaction temperature and pressure.

The unreacted ethylene dissolved in the reaction product may be removed therefrom by the method of adiabatic flashing and then the reaction product is preferably subjected to a deactivation treatment of



catalyst. The linear α -olefin is preferably separated from the solvent (not including the catalyst and deactivating agent) by distillation. The recovered ethylene and solvent may be recycled to the reaction system.

5 The alcohol added is easily separated together with deactivating agent such as water, from the reaction product at the time of catalyst deactivation.

 The linear α -olefin of the present invention is

10

15

20

25

30

35



obtained in the form of a mixture of linear α -olefins having 4 or more carbon atoms as the result of ethylene oligomerization. The mixture can be separated into fractions by multistage distillation. In addition, it is possible to obtain selectively a linear α -olefin having a desired number of carbon atoms by appropriately selecting and controlling the reaction conditions.

In the process of the present invention an alcohol is used as the third component in place of sulfur compounds, phosphorus compounds and nitrogen compounds which are used in the conventional process. The alcohol does not contaminate ~~into~~ the desired product, and also it is easily separated from the desired product when the catalyst is deactivated. ^{Then,} ~~Thus,~~ with the process of the present invention, it is possible to produce a linear α -olefin of high purity.

According to the present invention, a process which employs a catalyst incorporated with an alcohol as a third component is provided. In the process of the present invention, the catalyst components are prevented from contaminating ~~into~~ the product and the purity of the product can be improved. Therefore, with the process of the present invention, it is possible to produce effectively a linear α -olefin of extremely high purity. The linear α -olefin is useful as a comonomer for



modification of polyolefins and also as a raw material for plasticizers and surface active agents.

The invention will be described in more detail with reference to the following examples, which are not intended to restrict the scope of the invention.

Example 1

(1) Preparation of catalyst

In a 500-ml flask equipped with a stirrer were introduced 25 mmol of anhydrous zirconium tetrachloride and 250 ml of dried cyclohexane under an atmosphere of argon.

After stirring for 10 minutes, triethyl aluminum

$((C_2H_5)_3Al)$ and ethyl aluminum sesquichloride

$((C_2H_5)_3Al_2Cl_3)$ were added one after the other. The

amounts of triethyl aluminum and ethyl aluminum

sesquichloride were established such that

$(C_2H_5)_3Al_2Cl_3 / (C_2H_5)_3Al = 3.5$ (in molar ratio) and

$\{(C_2H_5)_3Al + (C_2H_5)_3Al_2Cl_3\} / ZrCl_4 = 7$ (in molar ratio).

The reactants were heated with stirring at 70°C for 2 hours under an atmosphere of argon to form a complex.

Thus there was obtained a catalyst solution. Alcohol

was added to the reaction system.

(2) Production of linear α -olefin

In a 1-liter autoclave equipped with a stirrer, which had been dried under an atmosphere of argon, was introduced 260 ml of dried cyclohexane. Into the autoclave was

introduced dried ethylene gas until the pressure reached 30 kg/cm²G. The autoclave was heated to 120°C. During heating, methanol was added in an amount of 0.025 mmol, which is half the amount (in mol) of zirconium tetrachloride. The autoclave at 120°C was supplied with the catalyst solution (containing 0.05 mmol of zirconium tetrachloride) from the catalyst pot attached to the autoclave and then with ethylene gas rapidly until the pressure in the autoclave reached 65 kg/cm²G.

The contents in the autoclave were stirred to start oligomerization reaction. The reaction product was sampled (about 5 cc each) at a predetermined time intervals for analysis by gas chromatography. During the reaction, the above-mentioned pressure was kept by continuously supplying ethylene. Sampling was carried out by receiving the reaction product in a water-containing cooled bottle so that the catalyst is deactivated and the reaction product is not affected by the catalyst after sampling.

The sample of the reaction product was mixed with 1 g of undecane as the internal standard substance for gas chromatography. The resulting solution was freed of water and then dried with anhydrous potassium carbonate. The thus dried sample was used for analysis. The yields of C₄-C₆ fractions were estimated from the Schulz-Flory

distribution because they are inevitably lost to some extent in handling the sample. The results are shown in Table 1.

Example 2

The same procedure as in Example 1 was repeated, except that the amount of methanol was changed to 0.05 mmol, which is equal to the amount (in mol) of zirconium tetrachloride. The results are shown in Table 1.

Example 3

The same procedure as in Example 1 was repeated, except that methanol was replaced by ethanol. The results are shown in Table 1.

Example 4

The same procedure as in Example 3 was repeated, except that the amount ethanol was changed to 0.05 mmol, which is equal to the amount (in mol) of zirconium tetrachloride. The results are shown in Table 1.

Comparative Example 1

The same procedure as in Example 1 was repeated, except that alcohol was not added. The results are shown in Table 1.

Example 5

The same procedure as in Example 1 was repeated, except that the amounts of triethyl aluminum and ethyl aluminum sesquichloride were established such that

$(C_2H_5)_3Al_2Cl_3 / (C_2H_5)_3Al = 2$ (in molar ratio) and
 $\{(C_2H_5)_3Al + (C_2H_5)_3Al_2Cl_3\} / ZrCl_4 = 5$ (in molar ratio).
The results are shown in Table 1.

Example 6

The same procedure as in Example 5 was repeated, except that methanol was replaced by ethanol. The results are shown in Table 1.

~~Example 7~~

Comparative Example 2

The same procedure as in Example 5 was repeated, except that methanol was replaced by isopropanol. The results are shown in Table 1.

Comparative Example 3

The same procedure as in Example 5 was repeated, except that alcohol was not added. The results are shown in Table 1.

No alcohol was detected in all the samples taken from the reaction products in the above Examples and Comparative Examples.





Table 1

Catalyst components	Example 1	Example 2	Example 3	Example 4	Compar. Example 1	Example 5	Example 6	Compar. Example 2	Compar. Example 3
ZrCl ₄ (mmol)	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
EASC (*1) (mmol)	0.272	0.272	0.272	0.272	0.272	0.167	0.167	0.167	0.167
TEA (*2) (mmol)	0.078	0.078	0.078	0.078	0.078	0.083	0.083	0.083	0.083
Al/Zr (*3) (molar ratio)	7	7	7	7	7	5	5	5	5
EASC/TEA (molar ratio)	3.5	3.5	3.5	3.5	3.5	2	2	2	2
Alcohol	methanol	methanol	ethanol	ethanol	—	methanol	ethanol	isoprop- anol	—
Amount of alcohol (mmol)	0.025	0.05	0.025	0.05	—	0.025	0.025	0.025	—

*1 (C₂H₅)₃Al₂Cl₃*2 (C₂H₅)₃Al*3 [(C₂H₅)₃Al + (C₂H₅)₃Al₂Cl₃]/ZrCl₄



Table 1 (cont'd)

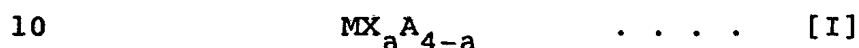
	Example 1	Example 2	Example 3	Example 4	Compar. Example 1	Example 5	Example 6	Compar. Example 2	Compar. Example 3
Activity and (purity) *									
Reaction time, 10 min	2750 (97.5)	2680 (97.6)	2450 (97.3)	2200 (97.8)	2690 (97.1)	4030	3300	2950	3930
Reaction time, 20 min	5560 (96.5)	5460 (96.3)	4950 (96.3)	4380 (95.6)	5450 (95.3)	7720	6730	5030	7830
Reaction time, 30 min	8400 (94.5)	8420 (94.5)	7350 (95.3)	6510 (95.2)	8180 (92.8)	11800 (94.5)	10280 (94.7)	8560 (93.3)	11700 (92.0)
Reaction time, 40 min	10900 (92.8)	10850 (93.0)	9850 (93.6)	8700 (93.5)	11100 (89.3)	15500	13500	10800	15800
Reaction time, 50 min	13750 (90.3)	13700 (90.9)	12400 (91.3)	10320 (91.5)	13650 (86.9)	18800	17100	14100	18500
C ₄ fraction (wt%)	15.1	15.4	16.8	16.9	15.5	7.8	7.9	8.9	8.6
C ₆ fraction (wt%)	15.5	16.5	16.8	16.8	15.8	9.2	9.3	10.3	9.6
C ₈ fraction (wt%)	14.2	14.7	14.9	14.9	14.3	9.5	9.7	10.5	10.2
C ₁₀ -C ₁₈ fraction (wt%)	41.1	40.3	40.2	40.0	40.9	39.5	39.6	40.8	40.4
C ₂₀ ⁺ fraction (wt%)	14.1	12.1	11.3	11.4	13.5	34.0	33.5	29.5	30.9

Activity is expressed in terms of g/g-Zr.

Purity is expressed in terms of the concentration (wt%) of 1-octadecene in the C₁₈ fraction.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

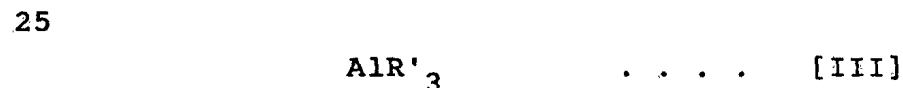
1. A process for producing a linear α -olefin which contains an olefin having 4 to 18 carbon atoms as a main component by the oligomerization of ethylene, which includes carrying out the oligomerization in the presence of catalyst composed of (A) zirconium halide represented by the formula [I]



- (where M denotes a zirconium atom; each of X and A denotes a chlorine atom, bromine atom, or iodine atom where X and A may be the same or different from each other; and a denotes zero or an integer from 1 to 4), (B) a mixture of an organoaluminium compound represented by the formula [II]



- 20 (where R denotes an alkyl group having 1 to 20 carbon atoms; Q denotes a chlorine atom, bromine atom, or iodine atom; c and d are numbers selected from 1, 1.5, and 2, with $c + d = 3$, and an organoaluminium compound represented by the formula [III]



- (where R' denotes an alkyl group having 1 to 20 carbon atoms), and (C) at least one alcohol selected from the group consisting of methanol and ethanol, wherein the alcohol (C) is added after mixing the zirconium halide (A) represented by the formula [I] and the mixture (B) of the organoaluminium compound represented by the formula [II] and the organoaluminium compound represented by the formula [III].



2. A process for producing a linear α -olefin according to claim 1, substantially as herein described with reference to the Examples.

5

DATED: 22 September 1993

PHILLIPS ORMONDE & FITZPATRICK

Attorneys for:

10 IDEMITSU PETROCHEMICAL CO., LTD.

David B Fitzpatrick

15

20

25

30

35



ABSTRACT OF THE DISCLOSURE

Disclosed herein is a process for producing a linear α -olefin by the oligomerization of ethylene, characterized in that the oligomerization is carried out in the presence of a catalyst composed of (A) titanium halide or zirconium halide, (B) an organoaluminum compound, and (C) an alcohol (methanol and/or ethanol). The linear α -olefin has an extremely high purity because it is not contaminated with the catalyst components.