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(54) Title: PROCESS FOR THE POLYMERIZATION OF OLEFINS

(57) Abstract: Process for the polymerization of olefins $\text{CH}_2=\text{CHR}$, in which R is hydrogen or a hydrocarbon radical with 1-12 carbon atoms, carried out in the presence of a catalyst component (A) comprising Mg, Ti and halogen as essential elements and of a catalyst component (B) capable to produce, under the same polymerization conditions, a polymer with an average particle size lower than that obtainable with the said catalyst component A. The said process provides polymers with increased bulk density.



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PROCESS FOR THE POLYMERIZATION OF OLEFINS

The present invention relates to a process for the polymerization of olefins $\text{CH}_2=\text{CHR}$, in which R is hydrogen or a hydrocarbonyl radical with 1-12 carbon atoms, directed to obtain polymer with increased bulk density, and to certain catalyst mixtures suited for the use in said process. In particular the present invention relates to the use, in said polymerization process, of mixture of catalyst components able to form polymer fractions with different average particle size. Ziegler-Natta catalysts based on Mg, Ti and halogen are very well known in the art and are commonly used in the industrial plants for the olefin polymerization. This ample category comprises specific grades of catalysts that, in dependence of their peculiarities are used in the preparation of specific kinds of polymers. As a general rule, the desired catalysts are those that are able to give the target polymer properties while allowing the plant to keep a high productivity. One of the parameters hinting at a high productivity is the bulk density of the polymer. Generally speaking, the higher is the bulk density of the polymer the higher is the productivity of the plant. In certain cases however, it is not possible to use the catalysts capable to give high bulk density because either they are not able to impart to the polymers other desired properties or they are not suited to a given particular polymerization process. This problem for example may arise when an heterophasic copolymer is to be produced, with the same catalyst, in two sequential polymerization step. An heterophasic polymer is a polymer comprised of a crystalline polyolefin phase (matrix) within which an amorphous phase (generally a propylene/ethylene and/or alpha-olefin copolymer) is dispersed. In this case, instead of a catalyst giving high bulk density, the suitable catalyst should have a certain porosity in order to generate a porous crystalline matrix within which the amorphous phase can grow without giving rise to fouling phenomena. As a result, the target polymers are produced with a productivity of the plant below the maximum obtainable.

The applicant has now found that by employing specific catalyst mixtures it is possible to enhance the bulk density of the polymers and therefore the productivity of the polymerization processes while at the same time retaining the desired properties of the polymers. It is therefore an object of the present invention a process for the polymerization of olefins $\text{CH}_2=\text{CHR}$, in which R is hydrogen or a hydrocarbon radical with 1-12 carbon atoms, carried out in the presence of a catalyst component (A)

comprising Mg, Ti and halogen as essential elements and of a catalyst component (B) capable to produce, under the same polymerization conditions, a polymer with an average particle size lower than that obtainable with the said catalyst component A. Preferably the average particle size of the polymer obtained with the catalyst (B) is at least 25% lower than that of the polymer obtained from (A) and more preferably at least 40% lower than that of the polymer obtained from (A). The catalyst component (B) can be chosen among the catalyst components known in the art provided that it is capable to give the polymer with the suitable diameter. Preferably, also the catalyst component (B) comprises Mg, Ti and halogen as essential elements. In a first particular embodiment of the present invention the catalyst component (B) has substantially the same features as the catalyst component (A) except for a lower activity under the same polymerization conditions. The said activity in particular is preferably at least 20% lower than that of (A) and more preferably at least 30% lower.

The applicant in fact, has found that the lower activity catalyst during the same polymerization time and conditions leads to a polymer with a smaller particle size. Consequently, the overall bulk density of the polymer (as obtained from the catalyst components A+B) results increased with respect of that obtainable by the use of (A) only. In a second particular embodiment of the present invention, the polymerization process is carried out with a catalyst mixture of catalyst components (A) and (B) both of them comprising Mg, Ti and halogen as essential elements and characterized by the fact that (B) is present in an amount ranging from 1 to 60 % b.w. of the total (A+B) preferably from 10 to 55%b.w. and has a lower average diameter with respect to the catalyst A. Preferably, the difference between the average diameter of the two catalysts component is such that the average diameter of the catalyst component fraction B is equal to, or lower than, 75% of the value of the average diameter of the catalyst component fraction A. Preferably the average diameter of B is lower than 50% of the average diameter of A. In a preferred aspect of this embodiment the average particle diameter of the catalyst component B is from 5 to 60 μ m and preferably from 5 to 40 μ m while the range for the catalyst component A is from 30 to 200 μ m and preferably from 30 to 120 μ m and more preferably from 30 to 90 μ m. When the invention is operated under this embodiment it is preferable that the two catalyst components have the substantial same activity. The present invention is particularly effective when the catalyst components A and B have a narrow particle size distribution (PSD). The breath of the PDS can be calculated

according to the formula $\frac{P90 - P10}{P50}$, wherein P90 is the value of the diameter such that 90% of the total particles have a diameter lower than that value; P10 is the value of the diameter such that 10% of the total particles have a diameter lower than that value and P50 is the value of the diameter such that 50% of the total particles have a diameter lower than that value. For the purpose of the present invention, it would be preferable that both the catalyst components A and B have a PSD calculated with the above formula lower than 1.8 and preferably lower than 1.2. In the case that the polymerization process is directed, at least in part, to the preparation of a porous polymer, it is preferred using, in the second particular embodiment, a catalyst component (B) having a porosity, determined with the mercury method, lower than that of the catalyst component (A) and in particular within the range specified below. In a preferred embodiment of the present invention the catalysts A and B comprise titanium compounds having at least a Ti-halogen bond and a Mg dihalide. The magnesium halide is preferably MgCl_2 in active form which is widely known from the patent literature as a support for Ziegler-Natta catalysts. Patents USP 4,298,718 and USP 4,495,338 were the first to describe the use of these compounds in Ziegler-Natta catalysis. It is known from these patents that the magnesium dihalides in active form used as support or co-support in components of catalysts for the polymerization of olefins are characterized by X-ray spectra in which the most intense diffraction line that appears in the ASTM-card reference of the spectrum of the non-active halide is diminished in intensity and broadened. In the X-ray spectra of preferred magnesium dihalides in active form said most intense line is diminished in intensity and replaced by a halo whose maximum intensity is displaced towards lower angles relative to that of the most intense line. The preferred titanium compounds used in the catalyst component of the present invention are the halides of Ti, in particular among those in which the Ti has valence 4, TiCl_4 , and among those in which the Ti has valence lower than 4 TiCl_3 ; furthermore, can also be used Ti-haloalcoholates of formula $\text{Ti}(\text{OR}^I)_n\text{-}_y\text{X}_y$, where n is the valence of titanium, y is a number between 1 and n, X is halogen, preferably chlorine, and R^I is a C1-C15 hydrocarbon group optionally containing an heteroatom. In addition to the titanium compound and the Mg dihalide, the catalysts components can also contain, and this is especially preferred in the case of the preparation of stereoregular polymers, one or more (internal) electron donor compounds. The electron donor compound (d) can be selected from ethers, esters of organic mono or

bicarboxylic acids, such as phthalates, benzoates, glutarates, succinates, ketones and amines. Preferably, it is selected from 1,3 diethers of the type disclosed in EP 361494 and EP728769, and esters of organic mono or bicarboxylic acids in particular aliphatic or aromatic phthalates. Among this last class, particularly preferred compounds are the alkyl esters of the phthalic acids.

The preparation of the solid catalyst components can be carried out according to several methods known in the art. According to a preferred method, the solid catalyst component can be prepared by reacting a titanium compound of formula $\text{Ti}(\text{OR})_n\text{X}_y$, where n is the valence of titanium and y is a number between 1 and n , preferably TiCl_4 , with a magnesium chloride deriving from an adduct of formula $\text{MgCl}_2 \cdot p\text{ROH}$, where p is a number between 0,1 and 6, preferably from 2 to 3,5, and R is a hydrocarbon radical having 1-18 carbon atoms. The adduct can be suitably prepared in spherical form by mixing alcohol and magnesium chloride in the presence of an inert hydrocarbon immiscible with the adduct, operating under stirring conditions at the melting temperature of the adduct (100-130°C). The average size of the droplets of the molten adduct can be chosen for example by controlling the stirring conditions. Generally, the more vigorous and intense is the stirring the lower is the average diameter of the droplets. When the emulsion is quickly quenched, the droplets of the adduct solidify in form of spherical particles having a size substantially corresponding to that of the droplets. The control of the stirring and quenching conditions also ensures that solid spherical adducts with having a narrow particle size distribution according to the present invention are obtained. Examples of spherical adducts prepared according to this procedure are described in USP 4,399,054 and USP 4,469,648. The so obtained adduct can be directly reacted with the Ti compound or it can be previously subjected to thermal controlled dealcoholation (80-130°C) so as to obtain an adduct in which the number of moles of alcohol is generally lower than 3 preferably between 0,1 and 2,5. The reaction with the Ti compound can be carried out by suspending the adduct (dealcoholated or as such) in cold TiCl_4 (generally 0°C); the mixture is heated up to 80-130°C and kept at this temperature for 0,5-2 hours. The treatment with TiCl_4 can be carried out one or more times. The internal electron donor can be added during the treatment with TiCl_4 . The treatment with the electron donor compound can be repeated one or more times. The preparation of catalyst components in spherical form is described for example in European Patent Applications EP-A-395083, EP-A-553805, EP-A-553806, EPA-601525 and WO98/44009. The solid catalyst components obtained according to the

above method show a surface area (by B.E.T. method) generally between 20 and 500 m²/g and preferably between 50 and 400 m²/g, and a total porosity (by B.E.T. method) higher than 0,2 cm³/g preferably between 0,2 and 0,6 cm³/g. The porosity (Hg method) due to pores with radius up to 10.000Å generally ranges from 0.3 to 1.5 cm³/g, preferably from 0.45 to 1 cm³/g.

The catalyst components with a very high surface area (over 300 m²/g) can be obtained by directly treating the spherical solid particles of the adduct with a dealcoholating agent such as TiCl₄. It is a preferred aspect of the present invention under the second particular embodiment that the solid catalyst component (B) having a lower average diameter with respect to the catalyst component (A) is also characterized by a higher surface area with respect to the catalyst component (A) and in particular by a surface area higher than 250 m²/g. The catalyst components having a high porosity determined with the Hg method can be obtained by reacting a titanium compound with a MgCl₂ adduct disclosed above which has been subject to a thermal controlled dealcoholation treatment under hot gaseous stream. Higher porosity is generally obtained by removal of high amounts of alcohol from the starting adduct. As previously mentioned, particularly when a porous polymer is to be produced, it has been found suitable to have the catalyst component (A) with a porosity (Hg method due to pores with a diameter up to 10,000Å) higher than 0.6 cm³/g and preferably higher than 1 cm³/g and, correspondingly, a catalyst component (B) with a porosity lower than (A) and in particular in the range 0.1-0.7. In any of the preparation methods described above the desired electron donor compound can be added as such or, in an alternative way, it can be obtained *in situ* by using an appropriate precursor capable to be transformed in the desired electron donor compound by means, for example, of known chemical reactions such as esterification, transesterification etc. The solid catalyst components (A) and (B) are converted into catalysts for the polymerization of olefins by reacting them with suitable co-catalysts like the organometallic compounds of the metals belonging to groups 1-2 and 13 of the Table of Elements (new notation) optionally in the presence of an external electron donor. Among organometallic compounds, organoaluminum compounds are preferred.

Particularly preferred are the alkyl-Al compound selected from the trialkyl aluminum compounds such as for example triethylaluminum, triisobutylaluminum, tri-n-butylaluminum, tri-n-hexylaluminum, tri-n-octylaluminum. It is also possible to use mixtures of trialkylaluminum's with alkylaluminum halides, alkylaluminum hydrides or

alkylaluminum sesquichlorides such as AlEt_2Cl and $\text{Al}_2\text{Et}_3\text{Cl}_3$. The external electron donor can be of the same type or it can be different from the internal electron donor compound present in the solid catalyst component. Suitable external electron-donor compounds include silicon compounds, ethers, esters such as ethyl 4-ethoxybenzoate, amines, heterocyclic compounds and particularly 2,2,6,6-tetramethyl piperidine, and ketones. One particular class of preferred external donor compounds is that of silicon compounds of formula $\text{R}_a^5\text{R}_b^6\text{Si}(\text{OR}^7)_c$, where a and b are integer from 0 to 2, c is an integer from 1 to 3 and the sum (a+b+c) is 4; R^5 , R^6 , and R^7 , are alkyl, cycloalkyl or aryl radicals with 1-18 carbon atoms optionally containing heteroatoms. Particularly preferred are the silicon compounds in which a is 1, b is 1, c is 2, at least one of R^5 and R^6 is selected from branched alkyl, cycloalkyl or aryl groups with 3-10 carbon atoms optionally containing heteroatoms and R^7 is a C_1 - C_{10} alkyl group, in particular methyl. Examples of such preferred silicon compounds are methylcyclohexyldimethoxysilane, diphenyldimethoxysilane, methyl-t-butyldimethoxysilane, dicyclopentyldimethoxysilane, 2-ethylpiperidiny-2-t-butyldimethoxysilane, 1,1,1-trifluoropropyl-metil-dimethoxysilane and 1,1,1-trifluoropropyl-2-ethylpiperidiny-dimethoxysilane. Moreover, are also preferred the silicon compounds in which a is 0, c is 3, R^6 is a branched alkyl or cycloalkyl group, optionally containing heteroatoms, and R^7 is methyl. Examples of such preferred silicon compounds are cyclohexyltrimethoxysilane, t-butyltrimethoxysilane and hexyltrimethoxysilane. The electron donor compound (c) is used in such an amount to give a molar ratio between the organoaluminum compound and said electron donor compound (c) of from 0.1 to 500, preferably from 1 to 300 and more preferably from 3 to 100. As previously indicated, the said catalyst are suitable for preparing a broad range of polyolefin products. They are particularly suitable for preparing linear low density polyethylenes (LLDPE, having a density lower than 0.940 g/cm^3) and very-low-density and ultra-low-density polyethylenes (VLDPE and ULDPE, having a density lower than 0.920 g/cm^3 , to 0.880 g/cm^3) consisting of copolymers of ethylene with one or more alpha-olefins having from 3 to 12 carbon atoms, having a mole content of units derived from ethylene of higher than 80%. However, they can also be used to prepare, for example, high density ethylene polymers (HDPE, having a density higher than 0.940 g/cm^3), comprising ethylene homopolymers and copolymers of ethylene with alpha-olefins having 3-12 carbon atoms; elastomeric copolymers of ethylene and propylene and elastomeric terpolymers of ethylene and propylene with smaller proportions of a diene having a content by weight of

units derived from ethylene of between about 30 and 70%; isotactic polypropylenes and crystalline copolymers of propylene and ethylene and/or other α -olefins having a content of units derived from propylene of higher than 85% by weight; impact resistant polymers of propylene obtained by sequential polymerization of propylene and mixtures of propylene with ethylene, containing up to 30% by weight of ethylene; copolymers of propylene and 1-butene having a number of units derived from 1-butene of between 10 and 40% by weight. In view of the above, it constitutes a further object of the present invention a process for the (co)polymerization of olefins $\text{CH}_2=\text{CHR}$, in which R is hydrogen or a hydrocarbyl radical with 1-12 carbon atoms, carried out in the presence of the catalyst described above. The olefins can be selected in particular from ethylene, propylene, butene-1, 4-methyl-1-pentene, hexene-1, octene-1. The polymerization of propylene alone or in mixture with butene, hexene-1 or octene-1 is especially preferred. The polymerization process in the presence of catalysts obtained from the catalytic components of the invention can be carried out according to known techniques either in liquid or gas phase using for example the known technique of the fluidized bed or under conditions wherein the polymer is mechanically stirred.

Particularly preferred is the polymerization of propylene carried out in liquid phase using, liquid propylene as polymerization medium. The catalyst of the present invention can be used as such in the polymerization process by introducing it directly into the reactor. However, it constitutes a preferential embodiment the prepolymerization of the catalyst with an olefin. In particular, it is especially preferred pre-polymerizing ethylene, or propylene or mixtures thereof with one or more α -olefins, said mixtures containing up to 20% by mole of α -olefin, forming amounts of polymer from about 0.1 g per gram of solid component up to about 1000 g per gram of solid catalyst component. The pre-polymerization step can be carried out at temperatures from 0 to 80°C preferably from 5 to 50°C in liquid or gas-phase. The pre-polymerization step can be performed in-line as a part of a continuous polymerization process or separately in a batch process. The batch pre-polymerization of the catalyst of the invention with ethylene in order to produce an amount of polymer ranging from 0.5 to 20 g per gram of catalyst component is particularly preferred. Examples of gas-phase processes wherein it is possible to use the spherical components of the invention are described in WO92/21706, USP 5,733,987 and WO93/03078. In this processes a pre-contacting step of the catalyst components, a pre-polymerization step and a gas phase polymerization step in one or more reactors in a series

of fluidized or mechanically stirred bed are comprised. Therefore, in the case that the polymerization takes place in gas-phase, the process of the invention is suitably carried out according to the following steps:

- (a) contact of the catalyst components in the absence of polymerizable olefin or optionally in the presence of said olefin in amounts not greater than 20 g per gram of the solid component (A);
- (b) pre-polymerization of ethylene or mixtures thereof with one or more α -olefins, said mixtures containing up to 20% by mole of α -olefin, forming amounts of polymer from about 0.1 g per gram of solid component (A) up to about 1000 g per gram;
- (c) gas-phase polymerization of one or more olefins $\text{CH}_2=\text{CHR}$, in which R is hydrogen or a hydrocarbon radical having 1-10 carbon atoms, in one or more fluidized or mechanically stirred bed reactors using the pre-polymer-catalyst system coming from (b).

As mentioned above, the pre-polymerization step can be carried out separately in batch. In this case, the pre-polymerized catalyst is pre-contacted according to step (a) with the aluminum alkyl and then directly sent to the gas-phase polymerization step (c). The molecular weight of the polymer is normally controlled using hydrogen or other agents capable to regulate the Molecular Weight. If needed the polymerization process of the invention can be performed in two or more reactors working under different conditions and optionally by recycling, at least partially, the polymer which is formed in the second reactor to the first reactor. As an example the two or more reactors can work with different concentrations of molecular weight regulator or at different polymerization temperatures or both. The following examples are given in order to further describe the present invention in a non-limiting manner.

CHARACTERIZATION

The properties are determined according to the following methods:

Melt Index: measured at 190°C according to ASTM D-1238 condition "E" (load of 2.16 Kg) and "F" (load of 21.6 Kg);

Porosity and surface area with nitrogen: are determined according to the B.E.T. method (apparatus used SORPTOMATIC 1900 by Carlo Erba).

-Porosity and surface area with mercury for catalyst components:

The measure is carried out using a "Porosimeter 2000 series" by Carlo Erba.

The porosity is determined by absorption of mercury under pressure. For this determination use is made of a calibrated dilatometer (diameter 3 mm) CD₃ (Carlo Erba) connected to a reservoir of mercury and to a high-vacuum pump ($1 \cdot 10^{-2}$ mbar). A weighed amount of sample is placed in the dilatometer. The apparatus is then placed under high vacuum (<0.1 mm Hg) and is maintained in these conditions for 20 minutes. The dilatometer is then connected to the mercury reservoir and the mercury is allowed to flow slowly into it until it reaches the level marked on the dilatometer at a height of 10 cm. The valve that connects the dilatometer to the vacuum pump is closed and then the mercury pressure is gradually increased with nitrogen up to 140 kg/cm^2 . Under the effect of the pressure, the mercury enters the pores and the level goes down according to the porosity of the material.

The porosity (cm^3/g), both total and that due to pores up to $10,000 \text{ \AA}$, the pore distribution curve, and the average pore size are directly calculated from the integral pore distribution curve which is function of the volume reduction of the mercury and applied pressure values (all these data are provided and elaborated by the porosimeter associated computer which is equipped with a "MILESTONE 200/2.04" program by C. Erba.

Porosity and surface area with mercury for polymers:

The same method and apparatus disclosed for the catalyst has been used with the difference that the mercury pressure is gradually increased with nitrogen up to 2.5 Kg/cm^2 .

Average Particle Size of the catalyst

Determined by a method based on the principle of the optical diffraction of monochromatic laser light with the "Malvern Instr. 2600" apparatus. The average size is given as P50.

Average Particle Size of the polymers

Determined through the use Tyler Testing Sieve Shaker RX-29 Model B available from Combustion Engineering Endecott provided with a set of six sieves, according to ASTM E-11-87, of number 5, 7, 10, 18, 35, and 200 respectively.

EXAMPLES

Preparation of the solid catalyst component A

Preparation of the spherical support ($\text{MgCl}_2/\text{EtOH}$ adduct)

The adduct of magnesium chloride and alcohol was prepared according to the method described in Example 2 of US patent 4,399,054, but operating at 900 rpm instead of 10,000 rpm. The adduct contains approximately 3 mol of alcohol. The alcohol was removed from

the product thus obtained at temperatures that gradually increased from 50°C to 100°C in nitrogen current until the alcohol content was reduced to 2.1 moles per mole of MgCl_2 . The dealcoholated support had an average size of approximately 50 μm .

Preparation of the Solid Catalyst Component

Into a 2 L four-necked glass reactor, equipped with a mechanical stirrer and a thermometer, purged with nitrogen, 1500 mL of TiCl_4 were introduced and cooled at 0°C. While stirring, 90 g of microspheroidal $\text{MgCl}_2 \cdot 2.1\text{C}_2\text{H}_5\text{OH}$ and diisobutylphthalate was added, so that Mg/DIBP molar ratio was 10.5. The temperature was raised to 100°C and maintained for 60 min. Then, the stirring was discontinued, the solid product was allowed to settle at 100 °C for 15 minutes and the supernatant liquid was siphoned off. Then 1500 mL of fresh TiCl_4 were added on the solid product. The mixture was reacted at 120 °C for 30 min and then the stirring was stopped and the reactor cooled to 100°C; the solid product was allowed to settle at 100 °C for 15 min and the supernatant liquid was siphoned off. The solid was washed with 6×600 mL of anhydrous hexane three times at 60 °C and three times at room temperature. Finally, the solid was dried under vacuum, analyzed and tested.

Preparation of the solid catalyst component B

Preparation of the spherical support ($\text{MgCl}_2/\text{EtOH}$ adduct)

The adduct of magnesium chloride and alcohol was prepared according to the method described in Example 2 of US patent 4,399,054, but operating at 2500 rpm instead of 10,000 rpm. The adduct containing approximately 3 mol of alcohol had an average size of approximately 21 μm .

Preparation of the Solid Catalyst Component

Into a 2 L four-necked glass reactor, equipped with a mechanical stirrer and a thermometer, purged with nitrogen, 1500 mL of TiCl_4 were introduced and cooled at 0°C. While stirring, 75 g of microspheroidal $\text{MgCl}_2 \cdot 2.8\text{C}_2\text{H}_5\text{OH}$ and diisobutylphthalate was added, so that Mg/DIBP molar ratio was 13. The temperature was raised to 100°C and maintained for 60 min. Then, the stirring was discontinued, the solid product was allowed to settle at 100 °C for 15 minutes and the supernatant liquid was siphoned off. Then 1500 mL of fresh TiCl_4 were added on the solid product. The mixture was reacted at 120 °C for 30 min and then the stirring was stopped and the reactor cooled to 100°C; the solid product was allowed to settle at 100 °C for 15 min and the supernatant liquid was siphoned off. The solid was washed with 6×600 mL of anhydrous hexane three times at 60 °C and three times at room temperature. Finally, the solid was dried under vacuum, analyzed and tested.

Example 1**Preparation of the solid catalyst component mixture A/B and polymerization test**

In a 4-liter autoclave, purged with nitrogen flow at 70 °C for one hour, 75 ml of anhydrous hexane containing 800mg of AlEt_3 , 56.4 mg of cyclohexylmethyldimethoxysilane, 7.9 mg of component A and 2.1 mg of component B were introduced in propylene flow at 30 °C. The autoclave was closed. 1.5 NI of hydrogen were added and then, under stirring, 1.2 Kg of liquid propylene were fed. The temperature was raised to 70°C in five minutes and the polymerization was carried out at this temperature for two hours. The non-reacted propylene was removed, the polymer was recovered and dried at 70 °C under vacuum for three hours and, then, weighed. The BDP and the APS of the polymer were measured and reported in Table 1.

Examples 2-4

The polymerization of Example 1 was repeated using the quantities of catalyst A and B reported in Table 1.

Comparison Example 1

The same procedure disclosed in Example 1 was repeated with the difference that 10 mg of component A were used.

Comparison Example 2

The same procedure disclosed in Example 1 was repeated with the difference that 10 mg of component B were used.

Table 1

Example	Amount of Catalyst A/B (mg/mg)	B.D. (g/cc)	A.P.S. (polymer) (μm)	Porosity (polymer) (cc/g)
<u>1</u>	7.9/2.1	0.466	1800	n.a
<u>2</u>	7.7/2.3	0.465	n.a	n.a
<u>3</u>	5.9/4.1	0.481	1550	0.055
<u>4</u>	4.9/5.1	0.475	n.a	n.a
<u>Comp. 1</u>	10/0	0.453	2100	0.09
<u>Comp. 2</u>	0/10	0.483	950	0.006

B.D= Bulk Density

APS= Average Particle Size

CLAIMS

1. Process for the polymerization of olefins $\text{CH}_2=\text{CHR}$, in which R is hydrogen or a hydrocarbon radical with 1-12 carbon atoms, carried out in the presence of a catalyst component (A) comprising Mg, Ti and halogen as essential elements and of a catalyst component (B) capable to produce, under the same polymerization conditions, a polymer with an average particle size lower than that obtainable with the said catalyst component A.
2. Process according to claim 1 in which the catalyst components (A) and (B) are reacted with organometallic compounds of the metals belonging to groups 1, 2 and 13 of the Table of Elements.
3. Process according to claim 1 in which the average particle size of the polymer obtained with the catalyst (B) is at least 25% lower than that of the polymer obtained from (A).
4. Process according to claim 3 in which the average particle size of the polymer obtained with the catalyst (B) is at least 40% lower than that of the polymer obtained from (A).
5. Process according to claim 1 in which also the catalyst component (B) comprises Mg, Ti and halogen as essential elements.
6. Process according to claim 1 in which the catalyst component (B) has a lower activity with respect to (A).
7. Process according to claim 6 in which the catalyst component (B) has an activity at least 20% lower than that of (A).
8. Process according to claim 7 in which the catalyst component (B) has an activity at least 30% lower than that of (A).
9. Process according to claim 1 in which both of (A) and (B) comprise Mg, Ti and halogen as essential elements; (B) is present in an amount ranging from 1 to 60 % b.w. of the total (A+B) and is further characterized by a lower average diameter with respect to A.
10. Process according to claim 9 in which the average diameter of the catalyst component fraction B is equal to, or lower than, 75% of the value of the average diameter of the catalyst component fraction A.
11. Process according to claim 9 in which the average diameter of B is equal to, or lower than, 50% of the value of the average diameter of A.

12. Process according to claim 1 in which the catalyst components A and B have a PSD, according to the formula $\frac{P90 - P10}{P50}$, wherein P90 is the value of the diameter such that 90% of the total particles have a diameter lower than that value; P10 is the value of the diameter such that 10% of the total particles have a diameter lower than that value and P50 is the value of the diameter such that 50% of the total particles have a diameter lower than that value, lower than 1.8.
13. Process according to claim 1 in which the catalyst component (B) has a porosity, determined with the mercury method, lower than that of the catalyst component (A).
14. Process according to claim 1 in which the olefin $\text{CH}_2=\text{CHR}$ is selected from the group consisting of ethylene, propylene, butene-1, hexene-1, octene-1 and their mixtures.
15. Catalyst component for the polymerization of olefins $\text{CH}_2=\text{CHR}$, in which R is hydrogen or a hydrocarbon radical with 1-12 carbon atoms, comprising at least two catalyst component fractions A and B both of them comprising Mg, Ti and halogen as essential elements said catalyst component containing from 1 to 60 % b.w. of the fraction B which has a lower average diameter with respect to the catalyst A.
16. Process according to claim 1 for the polymerization of propylene optionally in mixture with butene, hexene-1 or octene-1, said process being carried out in liquid phase using, liquid propylene as polymerization medium.
17. Catalyst according to claim 16 characterized by the fact that the difference between the average diameter of the catalysts component fractions is such that the average diameter of the catalyst component fraction B is equal to, or lower than, 75% the value of the average diameter of the catalyst component fraction A.
18. Catalyst component according to claim 16 in which both the catalyst components A and B have a PSD calculated according to the above formula of claim 12 lower than 1.8.
19. Catalyst component according to claim 16 in which the average particle diameter of the catalyst component B is from 5 to 60 μm while the range for the catalyst component A is from 30 to 200 μm .
20. Catalyst component according to claim 16 in which both fractions (A) and (B) comprise a Ti halide or haloalcoholate of formula $\text{Ti}(\text{OR})^I_{n-y}\text{X}_y$, where n is the

valence of titanium, y is a number between 1 and n , X is halogen, and R^1 is a C1-C15 hydrocarbon group optionally containing an heteroatom, supported on a $MgCl_2$.

21. Catalyst component according to claim 20 characterized by further comprising an internal electron donor selected from the group consisting of ethers, esters of organic mono or dicarboxylic acids, ketones, amines and their mixtures.
22. Catalyst components according to claim 21 in which the internal electron donor is an ester of organic mono or dicarboxylic acid selected from phthalates, benzoates, glutarates, and succinates.
23. Catalyst components according to claim 21 in which the internal electron donor is a 1,3 diether.
24. Catalyst components according to claim 16 characterized by the fact that both the catalyst fractions A and B are prepared by reacting a titanium compound of formula $Ti(OR)_{n-y}X_y$, where n is the valence of titanium and y is a number between 1 and n , preferably $TiCl_4$, with an adduct of formula $MgCl_2 \cdot pROH$, where p is a number between 0,1 and 6, preferably from 2 to 3,5, and R is a hydrocarbon radical having 1-18 carbon atoms.
25. Catalyst components according to claim 16 characterized in that the solid catalyst component fraction B has a porosity (Hg method due to pores with a diameter up to 10,000Å) lower than that of the catalyst fraction A.
26. Catalyst components according to claim 25 in which catalyst component (A) has a porosity higher than 0.6 cm³/g and the catalyst component (B) has a porosity in the range 0.1-0.7.
27. Catalyst for the polymerization of olefins obtained by reacting a catalyst component according to claim 15 with organometallic compounds of the metals belonging to groups 1-3 of the Table of Elements optionally in the presence of an electron donor compound.

INTERNATIONAL SEARCH REPORT

International Application No

PCT/EP 02/14111

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 C08F10/00 C08F4/642

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 C08F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 01 32307 A (PHILLIPS PETROLEUM CO ;GEERTS ROLF L (US); SMITH JAMES L (US); MCD) 10 May 2001 (2001-05-10) example 3 ---	1-11
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☒ Further documents are listed in the continuation of box C.☒ Patent family members are listed in annex.

* Special categories of cited documents:

- *A* document defining the general state of the art which is not considered to be of particular relevance
- *E* earlier document but published on or after the international filing date
- *L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- *O* document referring to an oral disclosure, use, exhibition or other means
- *P* document published prior to the international filing date but later than the priority date claimed

- *T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- *X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- *Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- *Z* document member of the same patent family

Date of the actual completion of the international search

27 March 2003

Date of mailing of the international search report

03/04/2003

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INTERNATIONAL SEARCH REPORT

International Application No.

PCT/EP 02/14111

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Y	US 4 399 054 A (FERRARIS MARIO ET AL) 16 August 1983 (1983-08-16) the whole document ---	1-11
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FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

Continuation of Box I.2

Claims Nos.: 12-27

1. Independent claim 1 is defined by reference to a result to be achieved and as such remains totally silent about any technical process features (Article 6 PCT). Further according to the description only Ziegler catalyst are meant to be used in the claimed process. A catalyst containing Ti, Mg and halogen as presently disclosed in present claim 1 could also encompass metallocenes catalyst for example. Therefore present claim 1 is too unclear and too broad with regard to the scope of the description.

Consequently, the search has been carried out for those parts of the claims which appear to be clear, supported and disclosed, namely: the examples.

2. All the documents cited in the search report indicates that the polymerization results (e.g. bulk density) are depending from a range of properties from the catalyst, e.g. porosity, shape, size, reaction conditions and of course the catalyst type in conjunction with the polymerization conditions.

Taking only the activity of the respective catalyst, as disclosed in present claims 6-8 is not enough for the skilled man to reach the wanted effect of the invention, namely the improvement of the bulk density. The same remark applies if the diameter of the catalyst particle is taken into consideration, as disclosed in present claims 9-11. Etc...

3. In the examples only one specific Ziegler Natta catalyst is disclosed wherein the latter is prepared as solid particulate with two different sizes. There is no information about the particle size distribution, neither about the porosity. Therefore present claims 12 and 13 are not supported but the examples the applicant failed to show any effect related the scope of these claims. Therefore a search for these claims is not meaningful.

4. Further every kind of Ziegler Natta catalyst comprising Mg, Ti and halogen and prepared in particulate form can be fractionated in two parts, one with a low particle diameter and the second with a high particle diameter, this in order to fulfill the requirement of present claim 15. Therefore there is no meaningful search possible for the present claims 15-27.

The applicant's attention is drawn to the fact that claims, or parts of claims, relating to inventions in respect of which no international search report has been established need not be the subject of an international preliminary examination (Rule 66.1(e) PCT). The applicant is advised that the EPO policy when acting as an International Preliminary Examining Authority is normally not to carry out a preliminary examination on matter which has not been searched. This is the case irrespective of whether or not the claims are amended following receipt of the search report or during any Chapter II procedure.

INTERNATIONAL SEARCH REPORT

International application No.
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Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☒ Claims Nos.: 12-27
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:
see FURTHER INFORMATION sheet PCT/ISA/210
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

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International Application No

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International Application No

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