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(54) **PRODUCTION OF HYDROCARBONS FROM A SYNTHESIS GAS**

VERFAHREN ZUR HERSTELLUNG VON KOHLENWASSERSTOFFEN AUS EINEM
SYNTHESEGAS

PRODUCTION D'HYDROCARBURES A PARTIR D'UN GAZ DE SYNTHESE

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Description

[0001] THIS INVENTION relates to the production of hydrocarbons from a synthesis gas, and to catalysts therefor. It relates in particular to a method of treating an untreated catalyst support to form a protected modified catalyst support, to a protected modified catalyst support thus formed, to a method of forming a catalyst from the protected modified catalyst support, to a catalyst thus obtained, to a process for producing hydrocarbons, and to hydrocarbons thus produced.

[0002] WO 99/42214 discloses a method of treating a catalyst support comprising the introduction onto and/or into an untreated catalyst support which is partially soluble in an aqueous acid solution and/or a natural aqueous solution, Si, Zr, Cu, Zn, Mn, Ba, Co, Ni and/or La an a modifying component. Calcination after support modification is necessary to decompose organic groups and to obtain the protected modified support.

[0003] According to a first aspect of the invention, there is provided a method of treating an untreated catalyst support, which method includes contacting an untreated catalyst support which is partially soluble in an aqueous acid solution and/or in a neutral aqueous solution with a modifying component precursor of the formula $\text{Me}(\text{OR})_x$ where Me is a modifying component selected from Si, Zr, Ti, Cu, Zn, Mn, Ba, Co, Ni, Na, K, Ca, Sn, Cr, Fe, Li, Tl, Mg, Sr, Ga, Sb, V, Hf, Th, Ce, Ge, U, Nb, Ta, and W, R is an alkyl or acyl group, and x is an integer having a value of from 1 to 5, thereby to introduce the modifying component onto and/or into the catalyst support and to form a protected modified catalyst support which is less soluble or more inert in the aqueous acid solution and/or the neutral aqueous solution, than the untreated catalyst support, with no calcination of the catalyst support, after treatment thereof with the modifying component precursor, being effected.

[0004] The untreated catalyst support may, in particular, be in particulate form. The modifying component is thus present, in the protected modified catalyst support particles, on the particle surfaces, i.e. the modifying component is chemically bonded to the particle surfaces. The modifying component may be chemically bonded to OH (hydroxyl groups) on the support surfaces.

[0005] By calcination is meant treatment of a catalyst support at an elevated temperature of at least 100°C to decompose organic groups of the modifying component in air, as well as to remove any residual solvent used for impregnation of the modifying component into or onto the catalyst support as hereinafter described. Thus, the present invention is characterized thereby that the protected modified catalyst support is not subjected to heat treatment at 100°C or higher. This naturally does not exclude possibly subjecting the protected modified catalyst support to heat treatment in excess of 100°C during subsequent transformation of the protected modified support into a catalyst precursor or into a catalyst, as hereinafter described.

[0006] The modifying component is thus capable, when present on the catalyst support, of suppressing the solubility of the untreated catalyst support in the aqueous acid solution and/or the neutral aqueous solution.

[0007] In principle, any commercially available dried, eg spray-dried, untreated catalyst support that is partially soluble in an aqueous acid solution and/or in a neutral aqueous solution, can be used. Examples of untreated catalyst supports that can be used are alumina (Al_2O_3), titania (TiO_2), magnesia (MgO) and zinc oxide (ZnO). When the catalyst support is alumina, any suitable alumina support can, in principle, be used. For example, the alumina support may be that obtainable under the trademark Puralox SCCa 2/150 from SASOL Germany GmbH. Puralox SCCa 2/150 (trademark) is a spray-dried alumina support. Similarly, when the catalyst support is titania, any suitable titania support can, in principle, be used. For example, the titania support may be that obtainable under the trademark Degussa P25.

[0008] By 'untreated' in relation to the catalyst support is meant a catalyst support that is partially soluble in an aqueous acid solution and/or in a neutral aqueous solution.

[0009] The contacting of the untreated catalyst support with the modifying component precursor may be by means of impregnation or chemical vapour deposition; however, impregnation is preferred.

[0010] In one embodiment of the invention, the modifying component precursor may be a silicon-based modifying component precursor or an organic silicon compound, eg a silicon alkoxide, so that the modifying component is silicon (Si). The organic silicon compound may then be tetra ethoxy silane ('TEOS', i.e. $\text{Si}(\text{OC}_2\text{H}_5)_4$) or tetra methoxy silane ('TMOS', i.e. $\text{Si}(\text{OCH}_3)_4$).

[0011] When a silicon-based modifying component precursor is used with an alumina catalyst support, it may then be used in a quantity such that the silicon level in the resultant protected modified catalyst support is at least 0.06 Si atoms/nm² of the untreated support, preferably at least 0.13 Si atoms/nm² of the untreated support, and more preferably at least 0.26 Si atoms/nm² of the untreated support.

[0012] The upper limit of the modifying component, eg silicon, in the protected modified catalyst support may be set by parameters such as the porosity of the protected modified catalyst support and/or by the average pore diameter of the protected modified catalyst support. Preferably, the average pore diameter of the protected modified catalyst support as hereinafter described is at least 12nm, as disclosed in ZA 96/2759, which is hence incorporated herein by reference thereto. Additionally, if an objective is to obtain, from the protected modified catalyst support, a catalyst having a composition of 30g Co/100g Al_2O_3 , the untreated Al_2O_3 catalyst support, and also the protected modified catalyst support, must have a pore volume of at least 0.43ml/g, as described in US 5733839, WO 99/42214 and/or WO 00/20116. The

upper limit of the modifying component, e.g. Si, in the protected modified catalyst support is thus to be selected in such a manner that the geometry, e.g. the average pore diameter and porosity, of the protected modified catalyst support is not detrimentally effected to an appreciable extent.

[0013] Thus, when spray-dried Puralox SCCa 2/150 (trademark) alumina is used as the untreated catalyst support, sufficient silicon-based modifying component precursor is used such that the upper limit of silicon in the resultant protected modified catalyst support is 2.8 Si atoms/nm² of untreated catalyst support, preferably 2.5 Si atoms/nm² of untreated catalyst support, as taught in WO 99/42214.

[0014] The maximum amount of silicon that can be added to the untreated catalyst support in one impregnation step is 2.8 Si atoms/nm² of untreated catalyst support.

[0015] When the contacting of the catalyst support with the silicon-based modifying component precursor or organic silicon compound is effected by way of impregnation, the organic silicon compound will be dissolved in an impregnation solvent having a boiling point, at atmospheric pressure, of less than 100°C. The impregnation solvent is typically an organic solvent capable of dissolving the silicon compound, such as ethanol, acetone or propanol. The untreated catalyst support may then be admixed with the resultant solution to form a treatment mixture, and the treatment mixture maintained at an elevated temperature for a period of time to impregnate the modifying agent into and/or onto the catalyst support. The elevated temperature may be at or near the boiling point of the impregnation solvent. The impregnation may be effected at atmospheric pressure, and the period of time for which the impregnation is effected may be from 1 minute to 20 hours, preferably from 1 minute to 5 hours. The excess solvent or solution is then removed, ie the impregnated support is dried, to obtain the protected modified catalyst support. The drying may be effected under a drying pressure or vacuum of 0.01 to 1 bar(a), more preferably 0.01 to 0.3 bar(a), and at a temperature equal to the boiling point of the solvent at the drying pressure, eg using known drier equipment, fitted with a mixing device, and of which the jacket temperature is thus higher than the solvent boiling point. However, the drying temperature will be lower than 100°C.

[0016] In another embodiment of the invention, the modifying component precursor may be a zirconium alkoxide, eg zirconium isopropoxide (Zr(OCH(CH₃)₂)₄), so that the modifying component is zirconium (Zr). The contacting of the untreated catalyst support with the zirconium alkoxide may then be effected in similar fashion to the contacting hereinbefore described for the silicon-based modifying component precursor.

[0017] According to a second aspect of the invention, there is provided a method of treating an untreated catalyst support, which method includes

admixing an untreated catalyst support which is partially soluble in an aqueous acid solution and/or in a neutral aqueous solution, with a solution of a modifying component precursor of the formula Me(OR)_x where Me is a modifying component selected from Si, Zr, Ti, Cu, Zn, Mn, Ba, Co, Ni, Na, K, Ca, Sn, Cr, Fe, Li, Ti, Mg, Sr, Ga, Sb, V, Hf, Th, Ce, Ge, U, Nb, Ta, and W, R is an alkyl or acyl group, and x is an integer having a value of from 1 to 5, in an impregnation solvent having a boiling point, at atmospheric pressure, of less than 100°C, to form a treatment mixture;

maintaining the treatment mixture at or near the boiling point of the impregnated solvent for from 1 minute to 20 hours, to impregnate the catalyst support with the modifying component; and

drying the impregnated support by removing excess solvent or solution under a vacuum, of 0.01 to 1 bar(a), thereby to obtain a protected modified catalyst support which is less soluble or more inert in the aqueous acid solution and/or the neutral aqueous solution than the untreated catalyst support, with no calcination of the catalyst support, after treatment thereof with the modifying component precursor, being effected, and with the modifying component thus being capable, when present in and/or on the protected modified catalyst support, of suppressing the solubility of the protected modified catalyst support in the aqueous solution.

[0018] The method may include washing the protected modified catalyst support to remove any residual solvent, with a slurry comprising the washed catalyst support and washing liquid being formed, and drying the slurry.

[0019] The washing may be effected with an aqueous solution, and may be effected at a temperature of about 60°C for a period of time, eg for about 1 hour.

[0020] The drying of the slurry may be effected at a temperature of about 95°C, and under a vacuum of between 0.03 bar(a) and 0.2 bar(a).

[0021] The invention extends to a protected modified catalyst support, when obtained by the method as hereinbefore described.

[0022] According to a third aspect of the invention, there is provided a method of forming a catalyst precursor, which method comprises mixing a protected modified catalyst support as hereinbefore described, with an aqueous solution of an active catalyst component or its precursor, to form a slurry, and impregnating the protected modified catalyst support with the active catalyst component or its precursor, to form the catalyst precursor.

[0023] The active catalyst component precursor may be cobalt nitrate so that the active catalyst component in and on the catalyst is cobalt. The untreated catalyst support may, as hereinbefore described, be alumina.

[0024] The method of forming the catalyst precursor may be in accordance with that described in US 5733839, WO 99/42214, and/or WO 00/20116. Thus, the mixing of the protected modified catalyst support and the active catalyst component or its precursor aqueous solution, and the impregnating, may comprise subjecting a slurry of the protected

modified catalyst support or carrier, water and the active catalyst component or its precursor to a sub-atmospheric pressure environment, drying the resultant impregnated carrier under a sub-atmospheric pressure environment, and calcining the dried impregnated carrier, to obtain the catalyst precursor, ie to obtain a Fischer-Tropsch catalyst in unreduced form.

[0025] If a higher catalyst cobalt loading is required, then a second or even a third impregnation, drying and calcination step may thereafter be carried out after the first impregnation, drying and calcination step hereinbefore described.

[0026] During the impregnation, a water, soluble precursor salt of platinum (Pt) or palladium (Pd) may be added, as a dopant capable of enhancing the reducibility of the active component. The mass proportion of this dopant, when used, to active catalyst component may be between 0.01:100 and 0.3:100.

[0027] The invention extends also to a catalyst precursor, when obtained by the method as hereinbefore described.

[0028] This, catalyst precursor is thus in unreduced form, and requires reduction or activation before it can be used, ie it requires reduction or activation to be converted to a catalyst. This may be effected by subjecting the precursor to heat treatment under the influence of a reducing gas such as hydrogen, to obtain the catalyst.

[0029] Thus, according to a fourth aspect of the invention, there is provided a method of forming a catalyst, which includes reducing or activating a catalyst precursor as hereinbefore described.

[0030] The invention thus extends also to a catalyst, when obtained by the method as hereinbefore described.

[0031] According to a fifth aspect of the invention, there is provided a process for producing hydrocarbons, which includes contacting a synthesis gas comprising hydrogen and carbon monoxide at an elevated temperature between 180°C and 250°C and an elevated pressure between 10 and 40 bar with a catalyst as hereinbefore described, to obtain hydrocarbons, by means of a slurry phase Fischer-Tropsch reaction of the hydrogen with the carbon monoxide.

[0032] The invention extends also to hydrocarbons, when produced by the process as hereinbefore described.

[0033] It is known that an alumina supported cobalt based slurry phase Fischer-Tropsch catalyst produces a wax product when used in a Fischer-Tropsch reaction of a synthesis gas, comprising hydrogen and carbon monoxide.

[0034] Such catalysts have hitherto preferably been produced by slurry impregnation of an alumina support using an aqueous cobalt nitrate precursor solution, of which the pH can vary between 1 and 6. The alumina support partially dissolves in aqueous acid, as well as neutral aqueous solutions. After dissolution, the aluminium ions can, in the presence of cobalt ions:

(i) re-precipitate as hydrotalcite-like structures, eg $\text{Co}_6\text{Al}_2\text{CO}_3(\text{OH})_{16}\cdot 4\text{H}_2\text{O}$; and/or

(ii) re-precipitate as boehmite (AlOOH).

These re-precipitated aluminium structures are postulated to be physically bonded and loosely adsorbed to the original alumina surface. The formation of irregular structures on the surfaces of supports present after impregnation of, respectively, alumina with an aqueous nickel nitrate solution, magnesia with an aqueous ruthenium chloride solution and titania with an aqueous platinum chloride solution is also found. This phenomenon is thus not limited to alumina (Al_2O_3), but can also be found when using alternative supports such as magnesia (MgO), titania (TiO_2) or zinc oxide (ZnO).

[0035] A serious problem that can arise when such catalysts, which are thus prepared on untreated catalyst supports, are used, as observed during larger scale pilot plant Fischer-Tropsch synthesis runs, is the undesired high cobalt content of the wax product. Testing of the slurry phase Fischer-Tropsch synthesis process, using the known untreated alumina supported cobalt catalyst, can result in the wax product containing more than 50 mass ppm cobalt, even after secondary ex-situ filtration through a Whatmans 42 (trademark) filter paper (hereinafter referred to as "secondary filtered wax product". During slurry impregnation of an untreated alumina support, using an aqueous cobalt nitrate solution, cobalt nitrate will also deposit on the loosely bonded re-precipitated aluminium structures. These cobalt on loosely bonded re-precipitated aluminium structures can, dislodge during extended Fischer-Tropsch synthesis runs, possibly aggravated by the hydrothermal nature of a realistic synthesis environment, and contaminate the wax product (hydrocarbon product that is a liquid at the applied Fischer-Tropsch synthesis conditions and withdrawn as such from the reactor) with cobalt rich ultra fines of a sub-micron nature. These cobalt rich ultra fine particulates, of submicron nature, exit the reactor in the wax product. Due to the high cost of cobalt, this is a highly undesirable problem which has thus been solved, or at least alleviated, with this invention. Said alumina support should thus be protected during aqueous slurry impregnation by improving the inertness of the alumina surface, to prevent formation of cobalt ultra fines during Fischer-Tropsch synthesis. This is achieved in the present invention.

[0036] The invention will now be described in more detail with reference to the following non-limiting examples and with reference to the accompanying drawings.

[0037] In the drawings

FIGURE 1 shows dissolution profiles for an untreated alumina support, and a silicon modified alumina support according to the Example 1;

FIGURE 2 shows dissolution profiles for an untreated titania support, and a silicon modified titania support according

to Example 2;

FIGURE 3 shows dissolution profiles for an untreated alumina support, and a zirconium modified alumina support according to Example 3;

FIGURE 4 shows dissolution profiles for an untreated alumina support, and a titanium modified alumina support according to Example 4; and

FIGURE 5 shows the cobalt contamination level of secondary filtered wax product as a function of Fischer-Tropsch slurry phase synthesis time on stream as observed on Pilot Plant scale. Supported cobalt Fischer-Tropsch synthesis catalysts were compared, as obtained from an untreated particulate alumina support known by the trademark Puralox SCCa 2/150 (Catalyst B) and from a silicon modified alumina support (Catalyst A) in accordance with the invention.

EXAMPLE 1

Modification of alumina support with silicon

[0038] A spray-dried Puralox SCCa 2/150 (trademark) alumina support, in the form of spherical particles, obtainable from SASOL Germany GmbH of Überseering 40, 22297, Hamburg, Germany, was used. The support was thus an untreated support. The surfaces of the support particles were modified with silicon. An impregnation method was used to achieve the modification. Thus, silicon, in the form of TEOS (tetra ethoxy silane) as precursor, was added to ethanol at 60°C. Ethanol was thus used as the impregnation solvent. The particulate alumina support was added to this solution, which was then kept at 50°C-75°C for 1 hour. Subsequently, the solvent was removed under vacuum at 0.03-0.2bar (a), with a jacket temperature of the drier equipment of 95°C. No calcination was employed after the drying. A protected silicon modified alumina support was thus obtained. The aimed for silicon content was 2.5 Si atoms/nm² untreated support.

EXAMPLE 2

Modification of titania support with silicon

[0039] An untreated or fresh particulate titanium dioxide (Degussa P25 (trademark)) support was calcined at 650°C for 16 hours, spray dried and classified to 75-150 micron. The support had a rutile content of 80% and a surface area of 27m²/g.

[0040] This support was modified in the same fashion as described in Example 1 by addition of TEOS and drying at 95°C, to obtain a protected silicon modifier titania support. No calcination was employed after the drying. The aimed for silicon content was 4.5 Si atoms/nm² untreated resh support.

EXAMPLE 3

Modification of alumina support with zirconium

[0041] Zirconium, in the form of zirconium isopropoxide as precursor, was added under an inert atmosphere to isopropanol. Isopropanol was thus used as the impregnation solvent. A particulate alumina support (which was the same as that used in Example 1) was added to this solution, and the mixture stirred at 60°C for 1 hour. The solvent was then removed under a vacuum of 0.03-0.2bar(a) with a jacket temperature of the drier equipment at 95°C. No calcination was employed after the drying. A protected zirconium modified alumina support was thus obtained. The aimed for amount of modifying component was 0.1 Zr atoms per square nanometer untreated support.

EXAMPLE 4

Modification of alumina support with titanium

[0042] A particulate alumina support, the same support as used in Example 1, was modified in the same fashion as described in Example 1, using TEOT (tetra ethyl ortho titanate) as the precursor rather than TEOS, with drying at 95°C. No calcination was employed after the drying. A protected titanium modified alumina support was thus obtained. The aimed for titanium content was 2.5 Ti atoms/nm² untreated support.

EXAMPLE 5Conductivity measurements

[0043] Alumina and titania dissolve in an aqueous medium at low pH. The dissolution of alumina or titania results in the formation of aluminium ions or titanium ions respectively. As more and more alumina or titania dissolves, the concentration of aluminium or titanium ions increases with time. The increase of aluminium or titanium ions with time was followed by monitoring the conductivity at a constant pH of 2. The pH was kept constant by automated addition of a 10% nitric acid solution.

[0044] In Figure 1, the cumulative mg Al dissolved per m² untreated support for an untreated alumina as well as for the protected silicon modified alumina of Example 1 was plotted against time. It can be seen that the untreated pure alumina dissolved faster than the protected silicon modified alumina.

[0045] In Figure 2, the dissolution profiles of untreated titania as well as of the protected silicon modified titania of Example 2 are plotted. This Figure indicates that modification of the untreated titania brought about an increase in resistance to dissolution.

[0046] In Figure 3, the dissolution profile of the untreated Puralox SCCa 2/150 (trademark) alumina support is plotted against the dissolution profile of the protected zirconium modified alumina support of Example 3. Figure 3 shows that the addition of zirconium to the untreated support improved the resistance of the untreated support to dissolution and aqueous/acid attack.

[0047] In Figure 4, the cumulative mg Al dissolved per m² untreated support for an unmodified alumina as well as for the protected titanium modified alumina of Example 4 was plotted against time. It can be seen that the untreated pure alumina dissolved faster than the protected titanium modified alumina.

EXAMPLE 61. Catalyst preparationCatalyst A

[0048] A supported cobalt catalyst precursor was prepared on a protected silicon modified alumina support as prepared in Example 1. In a first impregnation / drying / calcination step, a solution of 17.4kg of Co(NO₃)₂·6H₂O, 9.6g of (NH₃)₄Pt(NO₃)₂, and 11kg of distilled water was mixed with 20.0kg of a silicon modified alumina support, by adding the support to the solution. The slurry was added to a conical vacuum drier and continuously mixed. The temperature of this slurry was increased to 60°C after which a pressure of 20kPa(a) was applied. During the first 3 hours of the drying step which commenced with the application of the pressure of 20kPa(a), the temperature was increased slowly and reached 95°C after the 3 hours. After the 3 hours, the pressure was decreased to 3-15kPa(a), and a drying rate of 2.5m%/h at the point of incipient wetness was used. The impregnation and drying took 9 hours to complete, after which the impregnated and dried catalyst support was immediately and directly loaded into a fluidized bed calciner. The temperature of the dried impregnated catalyst support was about 75°C at the time of loading into the calciner. The loading took about 1 to 2 minutes, and the temperature inside the calciner remained at its set point of about 75°C. The catalyst was heated from 75°C to 250°C, using a heating rate of 0.5°C/min and an air space velocity of 1.0 m³_n/kg Co(NO₃)₂·6H₂O/h, and kept at 250°C for 6 hours. To obtain a catalyst with a cobalt loading of 30gCo/100gAl₂O₃, a second impregnation/drying/calcination step was performed. A solution of 9.4kg of Co(NO₃)₂·6H₂O, 15.7g of (NH₃)₄Pt(NO₃)₂, and 15.1 kg of distilled water was mixed with 20.0kg of the ex first impregnated and calcined intermediate, by adding this material to the solution. The slurry was added to a conical vacuum drier and continuously mixed. The temperature of this slurry was increased to 60°C after which a pressure of 20kPa(a) was applied. During the first 3 hours of the drying step which commenced with the application of the pressure of 20kPa(a), the temperature was increased slowly and reached 95°C after the 3 hours. After the 3 hours, the pressure was decreased to 3-15kPa(a), and a drying rate of 2.5m%/h at the point of incipient wetness was used. The impregnation and drying took 9 hours to complete, after which the catalyst support was immediately and directly loaded into the fluidized bed calciner. The temperature of the dried impregnated intermediate material was about 75°C at the time of loading into the calciner. The loading took about 1 to 2 minutes, and the temperature inside the calciner remained at its set point of about 75°C. The impregnated and dried material was heated from 75°C to 250°C, using a heating rate of 0.5°C/min and an air space velocity of 1.0 m³_n/kg Co(NO₃)₂·6H₂O/h, and kept at 250°C for 6 hours.

Catalyst B

[0049] A supported cobalt catalyst precursor was prepared in a similar manner to that described hereinbefore for

Catalyst A, except that the catalyst precursor was prepared on an untreated alumina support.

2. Pilot Plant slurry phase Fischer-Tropsch Synthesis Test

[0050] During a confidential Pilot Plant slurry phase Fischer-Tropsch synthesis test run, using 5kg of catalyst prepared on unmodified alumina, ie catalyst B, in a 11m high bubble column reactor with an external recycle, the secondary filtered wax product turned grey after about 10 days on stream and the cobalt content increased to 350ppm after 25 days on stream, as shown in Figure 5. The test runs were completed under realistic Fischer-Tropsch synthesis conditions: ,

Reactor temperature:	230 °C
Reactor pressure:	20 Bar
%(H ₂ + CO) conversion:	50-70%
Feed gas composition:	
H ₂ :	about ('ca') 50 vol%
CO:	ca 25 vol%
Balance:	Ar, N ₂ , CH ₄ and or CO ₂

[0051] The wax product produced in the Fischer-Tropsch synthesis test run was thus subjected to a primary solids separation step, and thereafter to secondary ex-situ filtration through Whatmans 42 (trademark) filter paper, to obtain the secondary filtered wax product.

[0052] The presence of a high cobalt content in the secondary filtered wax product is believed to be due to the dislodgment of cobalt crystallites that were deposited on top of the physically bonded re-precipitated aluminium structures (eg hydrotalcites, boehmite), present in the catalyst after aqueous slurry phase impregnation of cobalt, when the catalyst is prepared from an untreated catalyst support.

[0053] Pilot Plant slurry phase Fischer-Tropsch synthesis tests runs performed on catalyst A, prepared on the modified alumina support with a silicon loading of 2.5 Si atoms/nm² untreated support, showed a substantial improvement with respect to, the submicron cobalt particulate contamination in the secondary filtered wax product, as is evident from Figure 5. After 22 days on stream the catalyst with 2.5 Si atoms/nm² untreated support did not show any cobalt in these secondary filtered wax product.

[0054] From the Pilot Plant synthesis tests, it can be seen that the improvement of the inertness of the untreated alumina support' by modifying it with silica, as shown by conductivity measurements, also prevented the dislodging of ultra fine cobalt rich particulates.

3. Laboratory Slurry Phase Fischer-Tropsch Synthesis

[0055] Cobalt catalyst precursors were reduced prior to Fischer-Tropsch synthesis in a tubular reactor at a hydrogen space velocity of 200ml_n hydrogen/g catalyst/h and atmospheric pressure. The temperature was increased to 425 °C at 1°C/min, after which isothermal conditions were maintained for 16 hours.

[0056] Between 10g and 30g of the resultant reduced catalyst, ranging between 38 μm to 150 μm, was suspended in 300 ml molten wax and loaded in a CSTR with an internal volume of 500 ml. The feed gas consisted of hydrogen and carbon monoxide in a H₂/CO molar ratio from 1.5/l to 2.3/l. This reactor was electrically heated and sufficiently high stirrer speeds were employed so as to eliminate any gas-liquid mass transfer limitations. The feed flow was controlled by means of Brooks mass flow controllers, and space velocities ranging from 2 and 4m³_n/kg_{cat}hr were used. GC analyses of the permanent gases as well as the volatile overhead hydrocarbons were used in order to characterize the product spectra.

[0057] ' The laboratory test runs were completed under realistic Fischer-Tropsch synthesis conditions:

Reactor temperature:	220 ° C
Reactor pressure:	20 bar
%(H ₂ + CO) conversion:	50-70%
Feed gas composition:	
H ₂ :	ca 50 vol%
CO:	ca 25 vol%
Balance:	Ar, N ₂ , CH ₄ and/or CO ₂

[0058] Having applied a reported cobalt based Fischer-Tropsch kinetic equation, such as:

$$r_{FT} = (k_{FT} P_{H_2} P_{CO}) / (1 + K P_{CO})^2$$

the Arrhenius derived pre-exponential factor of k_{FT} was estimated for each of the reported runs. By defining the relative intrinsic Fischer-Tropsch activity as (pre-exponential factor of catalyst X after reduction test)/(pre-exponential factor of catalyst B), where X is catalyst A or B, the intrinsic Fischer-Tropsch activities of the cobalt catalysts could be compared. The initial relative intrinsic Fischer-Tropsch activity is determined after 15 hours on line, as given in Table 1. It is clear that support modification did not influence the intrinsic Fischer-Tropsch characteristics when compared to the untreated alumina supported cobalt catalyst, Catalyst B.

Table 1: Laboratory CSTR Fischer-Tropsch synthesis performance comparison between catalysts prepared on untreated (catalyst B) and silicon modified alumina supports (catalyst A).

	Catalyst A	Catalyst B
<u>Run number</u>	363F	233\$
Synthesis conditions:		
Calcined catalyst mass (g)	22.2	20.6
Reactor temp (°C)	220.0	221.0
Reactor pressure(bar)	20.0	20.0
Time on stream (h)	16.0	15.0
Feed gas composition:		
H ₂ (vol%)	52.6	52.2
CO(vol%)	27.9	26.4
(Balance = Ar, CH ₄ + CO ₂)		
Syngas (H ₂ + CO) space velocity (m ³ _n /(kg cat.h)	3.6	3.0
Reactor partial pressures (bar)		
H ₂	5.5	4.5
CO	2.9	2.5
H ₂ O	4.5	4.8
CO ₂	0.3	0.3
Synthesis performance		
Conversion: %syngas	61.7	68.3
Initial relative intrinsic FT activity	1.0	1.0
%CO of total amount of CO converted to CO ₂	1.3	3.3
%C-atom CH ₄ selectivity	5.3	4.3

[0059] The catalyst of the present invention, obtained by impregnating a protected modified catalyst support according to the invention, was found to have excellent Fischer-Tropsch synthesis behaviour, resulting in high activity and selectivity. It was surprisingly found that the modified support material does not have to be calcined, after impregnation with the modifying component precursor and subsequent drying, to have the required inertness in aqueous media. These protected modified supports thus have an increased inertness towards an aqueous attack during subsequent slurry phase impregnation. Using catalysts prepared on these protected modified supports has resulted in a dramatic decrease in, the formation of active phase-containing ultrafine particulates during slurry phase Fischer-Tropsch synthesis. A slurry phase Fischer-Tropsch process, using the modified supported catalyst, produced a secondary filtered wax product containing less than 50ppm active phase ultra fines throughout extended slurry phase Fischer-Tropsch synthesis runs, thus reducing the cost for the catalyst used in the slurry phase Fischer-Tropsch process substantially. Due to the extreme difficulty with which separation of submicron particulates from wax product is achieved, the problem of removing solids from this wax product has thus been alleviated considerably.

Claims

1. A method of treating an untreated catalyst support and suppressing its solubility in neutral and/or acid aqueous solutions, which method includes contacting an untreated catalyst support which is partially soluble in an aqueous acid solution and/or in a neutral aqueous solution with a modifying component precursor of the formula Me(OR)_x , where Me is a modifying component selected from Si, Zr, Ti, Cu, Zn, Mn, Ba, Co, Ni, Na, K, Ca, Sn, Cr, Fe, Li, Tl, Mg, Sr, Ga, Sb, V, Hf, Th, Ce, Ge, U, Nb, Ta, and W, R is an alkyl or acyl group, and x is an integer having a value of from 1 to 5, thereby to introduce the modifying component onto and/or into the catalyst support and to form a protected modified catalyst support which is less soluble or more inert in the aqueous acid solution and/or the neutral aqueous solution, than the untreated catalyst support, with no calcination of the catalyst support, after treatment thereof with the modifying component precursor, being effected.
2. A method according to Claim 1, wherein the untreated catalyst support is in particulate form, with the modifying component being present, in the protected modified catalyst support particles, on the particle surfaces by being chemically bonded to the particle surfaces.
3. A method according to Claim 2, wherein the modifying component is chemically bonded to hydroxyl groups on the support particle surfaces.
4. A method according to any one of Claims 1 to 3 inclusive, wherein the contacting of the untreated catalyst support with the modifying component precursor is by means of impregnation.
5. A method according to Claim 4, wherein the modifying component precursor is an organic silicon compound, so that the modifying component is silicon.
6. A method according to Claim 5, wherein the organic silicon compound is tetra ethoxy silane or tetra methoxy silane.
7. A method according to Claim 5 or Claim 6, wherein the untreated catalyst support is an alumina catalyst support, with the silicon-based modifying component precursor being used in a quantity such that the silicon level in the resultant protected modified catalyst support is at least 0.06 Si atoms/nm² of the untreated catalyst support.
8. A method according to any one of Claims 5 to 7 inclusive, wherein the organic silicon compound is dissolved in an impregnation solvent having a boiling point, at atmospheric pressure, of less than 100°C, with the catalyst support being admixed with the resultant solution to form a treatment mixture, and the treatment mixture maintained at an elevated temperature at or near the boiling point of the impregnation solvent for a period of time to impregnate the modifying agent into and/or onto the catalyst support.
9. A method according to Claim 8, wherein the impregnation is effected at atmospheric pressure, and the period of time for which the impregnation is effected is from 1 minute to 20 hours.
10. A method according to Claim 8 or Claim 9, wherein the impregnated support is dried to obtain the protected modified catalyst support, with the drying being effected under a drying pressure or vacuum of 0.01 to 1 bar(a), and at a temperature equal to the boiling point of the solvent at the drying pressure.
11. A method according to Claim 4, wherein the modifying component precursor is a zirconium alkoxide so that the modifying component is zirconium.
12. A method according to Claim 11, wherein the zirconium alkoxide is dissolved in an impregnation solvent having a boiling point, at atmospheric pressure, of less than 100°C, with the catalyst support being admixed with the resultant solution to form a treatment mixture, and the treatment mixture maintained at an elevated temperature at or near the boiling point of the impregnation solvent for a period of time to impregnate the modifying agent into and/or onto the catalyst support.
13. A method according to Claim 12, wherein the impregnation is effected at atmospheric pressure, and the period of time for which the impregnation is effected is from 1 minute to 20 hours.
14. A method according to Claim 12 or Claim 13, wherein the impregnated support is dried to obtain the protected

modified catalyst support, with the drying being effected under a drying pressure or vacuum of 0.01 to 1 bar(a), and at a temperature equal to the boiling point of the solvent at the drying pressure.

- 5 15. A method of forming a catalyst precursor, which method comprises mixing a protected modified catalyst support obtained by the method of any one of Claims 1 to 15 inclusive, with an aqueous solution of an active catalyst component or its precursor, to form a slurry, and impregnating the protected modified catalyst support with the active catalyst component or its precursor, to form the catalyst precursor.
- 10 16. A method according to Claim 15, wherein the mixing of the protected modified catalyst support and the active catalyst component or its precursor aqueous solution, and the impregnating thereof, comprises subjecting a slurry of the protected modified catalyst support or carrier, water and the active catalyst component or its precursor to a sub-atmospheric pressure environment, drying the resultant impregnated carrier under a sub-atmospheric pressure environment, and calcining the dried impregnated carrier and, optionally, repeating the impregnation drying and calcination if a higher active catalyst component loading is required, thereby to obtain the catalyst precursor.
- 15 17. A method according to Claim 15 or Claim 16, wherein, during the impregnation, a water soluble precursor salt of platinum or palladium is added, as a dopant capable of enhancing the reducibility of the active component, with the mass proportion of dopant to active catalyst component being between 0.01:100 and 0.3:100.
- 20 18. A method of forming a catalyst, which includes reducing or activating a catalyst precursor obtained by the method of any one of Claims 15 to 17.
- 25 19. A method according to Claim 18, wherein the reduction or activation is effected by subjecting the precursor to heat treatment under the influence of a reducing gas to obtain the catalyst.
- 30 20. A process for producing hydrocarbons, which includes contacting a synthesis gas comprising hydrogen (H₂) and carbon monoxide (CO) at an elevated temperature between 180°C and 250°C and an elevated pressure between 10 and 40 bar with a catalyst obtained by the method of Claim 18 or Claim 19 to obtain hydrocarbons, by means of a slurry phase Fischer-Tropsch reaction of the hydrogen with the carbon monoxide.

Patentansprüche

- 35 1. Eine Methode zur Behandlung eines unbehandelten Katalysatorträgers und zur Verminderung dessen Löslichkeit in neutraler und/oder saurer, wässriger Lösung, wobei die Methode die Kontaktierung eines unbehandelten Katalysatorträgers, der teilweise in einer wässrigen, sauren Lösung und/oder in einer neutralen, wässrigen Lösung löslich ist, mit einer modifizierenden Vorstufenkomponente der Formel Me(OR)_x beinhaltet, wobei Me eine modifizierende Komponente ausgewählt aus Si, Zr, Ti, Cu, Zn, Mn, Ba, Co, Ni, Na, K, Ca, Sn, Cr, Fe, Li, Tl, Mg, Sr, Ga, Sb, V, Hf, Th, Ce, Ge, U, Nb, Ta und W ist, R eine Alkyl- oder Acylgruppe ist, und x eine ganze Zahl im Bereich von 1 bis 5 ist, um **dadurch** die modifizierende Komponente auf und/oder in den Katalysatorträger einzubringen und um einen geschützt modifizierten Katalysatorträger herzustellen, der weniger löslich oder mehr inert in der wässrigen, sauren Lösung und/oder der neutralen, wässrigen Lösung ist, als der unbehandelte Katalysatorträger, wobei keinerlei Kalzinierung des Katalysatorträgers, nach Behandlung davon mit der modifizierenden Vorstufenkomponente, erfolgt.
- 40 2. Eine Methode gemäß Anspruch 1, wobei der unbehandelte Katalysatorträger in Form eines Feststoffes vorliegt, und die modifizierende Komponente, in den Partikeln des geschützt modifizierten Katalysatorträgers, auf den Oberflächen der Partikel, chemisch an die Partikeloberflächen gebunden, vorhanden ist.
- 45 3. Eine Methode gemäß Anspruch 2, wobei die modifizierende Komponente chemisch an die Hydroxylgruppen auf den Partikeloberflächen des Trägers gebunden ist.
- 50 4. Eine Methode gemäß jedwedem Anspruch von Anspruch 1 bis einschließlich 3, wobei das Kontaktieren des unbehandelten Katalysatorträgers mit der modifizierenden Vorstufenkomponente durch Imprägnierung erfolgt.
- 55 5. Eine Methode gemäß Anspruch 4, wobei die modifizierende Vorstufenkomponente eine organische Silikonverbindung ist, so dass die modifizierende Komponente Silikon ist.
6. Eine Methode gemäß Anspruch 5, wobei die organische Silikonkomponente Tetraethoxysilan oder Tetramethoxy-

silan ist.

- 5 7. Eine Methode gemäß Anspruch 5 oder Anspruch 6, wobei der unbehandelte Katalysatorträger ein Aluminiumoxid-Katalysatorträger ist, während die auf Silikon basierende, modifizierende Vorstufenkomponente in einer Menge verwendet wird, dass der Silikongehalt in dem resultierenden, geschützt modifizierten Katalysatorträger mindestens 0,06 Si Atome/nm² des unbehandelten Katalysatorträgers ist.
- 10 8. Eine Methode gemäß jedwedem Anspruch von Anspruch 5 bis einschließlich 7, wobei die organische Silikonverbindung in einer Imprägnierungslösung mit einem Siedepunkt von weniger als 100°C bei Atmosphärendruck gelöst ist, und der Katalysatorträger mit der resultierenden Lösung vermischt wird, um ein Behandlungsgemisch herzustellen, und das Behandlungsgemisch bei einer erhöhten Temperatur beim oder in der Nähe des Siedepunktes des Imprägnierungslösungsmittels für einen Zeitraum gehalten wird, um das modifizierende Agens in und/oder auf den Katalysatorträger zu imprägnieren.
- 15 9. Eine Methode gemäß Anspruch 8, wobei die Imprägnierung bei Atmosphärendruck erfolgt, und der Zeitraum, während dem die Imprägnierung erfolgt, von 1 Minute bis 20 Stunden dauert.
- 20 10. Eine Methode gemäß Anspruch 8 oder 9, wobei der imprägnierte Träger getrocknet wird, um den geschützt modifizierten Katalysatorträger zu erhalten, und das Trocknen unter einem Trocknungsdruck oder Vakuum von 0,01 bis 1 bar (a) und bei einer Temperatur gleich dem Siedepunkt des Lösungsmittels beim Trocknungsdruck erfolgt.
- 25 11. Eine Methode gemäß Anspruch 4, wobei die modifizierende Vorstufenkomponente ein Zirkoniumalkoxid ist, so dass die modifizierende Komponente Zirkonium ist.
- 30 12. Eine Methode gemäß Anspruch 11, wobei das Zirkoniumalkoxid in einem Imprägnierungslösungsmittel mit einem Siedepunkt von weniger als 100°C bei Atmosphärendruck gelöst ist, und der Katalysatorträger mit der resultierenden Lösung vermischt wird, um ein Behandlungsgemisch herzustellen, und das Behandlungsgemisch bei einer erhöhten Temperatur beim oder in der Nähe des Siedepunktes des Imprägnierungslösungsmittels für einen Zeitraum gehalten wird, um das modifizierende Agens in und/oder auf den Katalysatorträger zu imprägnieren.
- 35 13. Eine Methode gemäß Anspruch 12, wobei die Imprägnierung bei Atmosphärendruck erfolgt, und der Zeitraum, während dem die Imprägnierung erfolgt, von 1 Minute bis 20 Stunden dauert.
- 40 14. Eine Methode gemäß Anspruch 12 oder 13, wobei der imprägnierte Träger getrocknet wird, um den geschützt modifizierten Katalysatorträger zu erhalten, und das Trocknen unter einem Trocknungsdruck oder Vakuum von 0,01 bis 1 bar (a) und bei einer Temperatur gleich dem Siedepunkt des Lösungsmittels beim Trocknungsdruck erfolgt.
- 45 15. Eine Methode zur Herstellung einer Katalysatorvorstufe, wobei die Methode das Mischen eines geschützt modifizierten Katalysatorträgers, der nach einer Methode aus jedwedem Anspruch von Anspruch 1 bis einschließlich 15 hergestellt wurde, mit einer wässrigen Lösung einer aktiven Katalysatorkomponente oder deren Vorstufe umfasst, um einen Brei zu formen, und die Imprägnierung des geschützt modifizierten Katalysatorträgers mit der aktiven Katalysatorkomponente oder dessen Vorstufe, um die Katalysatorvorstufe zu bilden.
- 50 16. Eine Methode gemäß Anspruch 15, wobei das Mischen des geschützt modifizierten Katalysatorträgers und der aktiven Katalysatorkomponente oder dessen Vorstufe, einer wässrigen Lösung, und die Imprägnierung davon einschließen, dass ein Brei des geschützt modifizierten Katalysatorträgers oder eines Trägers, Wasser und die aktive Katalysatorkomponente oder deren Vorstufe einer Umgebung mit einem Druck unter dem Atmosphärendruck ausgesetzt werden, der resultierende, imprägnierte Träger in einer Umgebung mit einem Druck unterhalb des Atmosphärendrucks getrocknet wird, und der getrocknete, imprägnierte Träger kalziniert wird, und wahlweise die Imprägnierungstrocknung und Kalzination wiederholt wird, falls eine höhere aktive Hauptkatalysatorkomponente benötigt wird, um dabei die Katalysatorvorstufe zu erhalten.
- 55 17. Eine Methode gemäß Anspruch 15 oder Anspruch 16, wobei während der Imprägnierung ein wasserlösliches Vorstufensalz aus Platin oder Palladium als Dotiersubstanz zugefügt wird, welche das Reduziervermögen der aktiven Komponente verstärken kann, mit einem Massenanteil der Dotiersubstanz zur aktiven Katalysatorkomponente zwischen 0,01:100 und 0,3:100.
18. Eine Methode zur Herstellung eines Katalysators, die das Reduzieren oder die Aktivierung einer Katalysatorvorstufe

durch eine Methode aus jedwedem Anspruch von Anspruch 15 bis 17 beinhaltet.

19. Eine Methode gemäß Anspruch 18, wobei die Reduzierung oder Aktivierung **dadurch** erreicht wird, dass die Vorstufe einer Hitzebehandlung unter dem Einfluss eines reduzierenden Gases unterzogen wird, um den Katalysator zu erhalten.
20. Ein Prozess zur Herstellung von Kohlenwasserstoffen, der die Kontaktierung eines Synthesegases, einschließlich Wasserstoff (H₂) und Kohlenstoffmonoxid (CO), bei einer erhöhten Temperatur zwischen 180°C und 250°C und einem erhöhten Druck zwischen 10 und 40 bar mit einem Katalysator beinhaltet, der durch die Methode aus Anspruch 18 oder Anspruch 19 hergestellt wurde, um Kohlenwasserstoffe, mit Hilfe einer Brei-Phase Fischer-Tropsch-Reaktion des Wasserstoffs mit dem Kohlenstoffmonoxid, zu erhalten.

Revendications

1. Procédé de traitement d'un support catalytique non traité et de suppression de sa solubilité en solution aqueuse neutre et/ou acide, ledit procédé comprenant la mise en contact d'un support catalytique non traité, qui est partiellement soluble en solution aqueuse acide et/ou en solution aqueuse neutre, avec un précurseur d'un composant modificateur de formule Me(OR)_x, où Me est un composant modificateur choisi parmi Si, Zr, Ti, Cu, Zn, Mn, Ba, Co, Ni, Na, K, Ca, Sn, Cr, Fe, Li, Tl, Mg, Sr, Ga, Sb, V, Hf, Th, Ce, Ge, U, Nb, Ta, et W, R est un groupe alkyle ou acyle, et x est un entier ayant une valeur allant de 1 à 5, ce qui permet d'introduire le composant modificateur sur et/ou dans le support catalytique et de former un support catalytique modifié protégé qui est moins soluble ou plus inerte en solution aqueuse acide et/ou en solution aqueuse neutre que le support catalytique non traité, aucune calcination du support catalytique n'étant effectuée après son traitement avec le précurseur du composant modificateur.
2. Procédé selon la revendication 1, dans lequel le support catalytique non traité est sous forme particulaire, le composant modificateur étant présent dans les particules du support catalytique modifié protégé, sur les surfaces des particules en étant chimiquement lié aux surfaces des particules.
3. Procédé selon la revendication 2, dans lequel le composant modificateur est chimiquement lié aux groupes hydroxyles sur les surfaces des particules supports.
4. Procédé selon l'une quelconque des revendications 1 à 3 comprise, dans lequel la mise en contact du support catalytique non traité avec le précurseur du composant modificateur est faite par le biais de l'imprégnation.
5. Procédé selon la revendication 4, dans lequel le précurseur du composant modificateur est un composé d'organosilicium, si bien que le composant modificateur est le silicium.
6. Procédé selon la revendication 5, dans lequel le composé d'organosilicium est le tétraéthoxysilane ou le tétraméthoxysilane.
7. Procédé selon la revendication 5 ou la revendication 6, dans lequel le support catalytique non traité est un support catalytique d'alumine, le précurseur du composant modificateur à base de silicium étant utilisé en une quantité telle que le taux de silicium dans le support catalytique modifié protégé résultant est au moins de 0,06 atomes/nm² du support catalytique non traité.
8. Procédé selon l'une quelconque des revendications 5 à 7 comprise, dans lequel le composé d'organosilicium est dissous dans un solvant d'imprégnation ayant un point d'ébullition, à pression atmosphérique, de moins de 100°C, le support catalytique étant ajouté à la solution résultante pour former un mélange de traitement, et le mélange de traitement maintenu à une température élevée au point d'ébullition ou près du point d'ébullition du solvant d'imprégnation pendant une durée permettant d'imprégner l'agent modificateur dans et/ou sur le support catalytique.
9. Procédé selon la revendication 8, dans lequel l'imprégnation est effectuée à pression atmosphérique, et la durée pendant laquelle l'imprégnation est effectuée est de 1 minute à 20 heures.
10. Procédé selon la revendication 8 ou la revendication 9, dans lequel le support imprégné est séché pour obtenir le support catalytique modifié protégé, le séchage étant effectué sous une pression de séchage ou un vide de 0,01 à 1 bar (a), et à une température égale au point d'ébullition du solvant à la pression de séchage.

11. Procédé selon la revendication 4, dans lequel le précurseur du composant modificateur est un alcoxyde de zirconium, si bien que le composant modificateur est le zirconium.
12. Procédé selon la revendication 11, dans lequel l'alcoxyde de zirconium est dissous dans un solvant d'imprégnation ayant un point d'ébullition, à pression atmosphérique, de moins de 100°C, le support catalytique étant ajouté à la solution résultante pour former un mélange de traitement, et le mélange de traitement maintenu à une température élevée au point d'ébullition ou près du point d'ébullition du solvant d'imprégnation pendant une durée permettant d'imprégner l'agent modificateur dans et/ou sur le support catalytique.
13. Procédé selon la revendication 12, dans lequel l'imprégnation est effectuée à pression atmosphérique, et la durée pendant laquelle l'imprégnation est effectuée est de 1 minute à 20 heures.
14. Procédé selon la revendication 12 ou la revendication 13, dans lequel le support imprégné est séché pour obtenir le support catalytique modifié protégé, le séchage étant effectué sous une pression de séchage ou un vide de 0,01 à 1 bar (a), et à une température égale au point d'ébullition du solvant à la pression de séchage.
15. Procédé de formation d'un précurseur catalytique, ledit procédé comprenant le mélange d'un support catalytique modifié protégé obtenu par le procédé de l'une quelconque des revendications 1 à 15 comprise, avec une solution aqueuse d'un composant catalytique actif ou son précurseur, pour former une suspension, et l'imprégnation du support catalytique modifié protégé avec le composant catalytique actif ou son précurseur, pour former le précurseur catalytique.
16. Procédé selon la revendication 15, dans lequel le mélange du support catalytique modifié protégé et du composant catalytique actif ou de sa solution aqueuse précurseur et son imprégnation comprennent la soumission d'une suspension du support ou véhicule catalytique modifié protégé, d'eau et du composant catalytique actif ou de son précurseur à un environnement de pression sous-atmosphérique, le séchage du véhicule imprégné résultant dans un environnement de pression sous-atmosphérique et la calcination du véhicule imprégné séché et, le cas échéant, la répétition du séchage de l'imprégnation et de la calcination si un composant catalytique plus actif conducteur est requis, ce qui permet d'obtenir le précurseur catalytique.
17. Procédé selon la revendication 15 ou la revendication 16, dans lequel, au cours de l'imprégnation, un sel de platine ou de palladium précurseur hydrosoluble est ajouté, en tant que dopant capable de renforcer la réductibilité du composant actif, la proportion en poids de dopant par rapport au composant catalytique actif étant située entre 0,01/100 et 0,3/100.
18. Procédé de formation d'un catalyseur qui comprend la réduction ou l'activation d'un précurseur catalytique obtenu par le procédé de l'une quelconque des revendications 15 à 17.
19. Procédé selon la revendication 18, dans lequel la réduction ou l'activation est effectuée en soumettant le précurseur à un traitement thermique sous l'influence d'un gaz réducteur pour obtenir le catalyseur.
20. Procédé de production d'hydrocarbures, qui comprend la mise en contact d'un gaz de synthèse comprenant de l'hydrogène (H₂) et du monoxyde de carbone (CO) à une température élevée entre 180°C et 250°C et une pression élevée entre 10 et 40 bars avec un catalyseur obtenu par le procédé de la revendication 18 ou de la revendication 19, pour obtenir des hydrocarbures, au moyen d'une réaction de Fischer - Tropsch de l'hydrogène avec le monoxyde de carbone en phase de suspension.

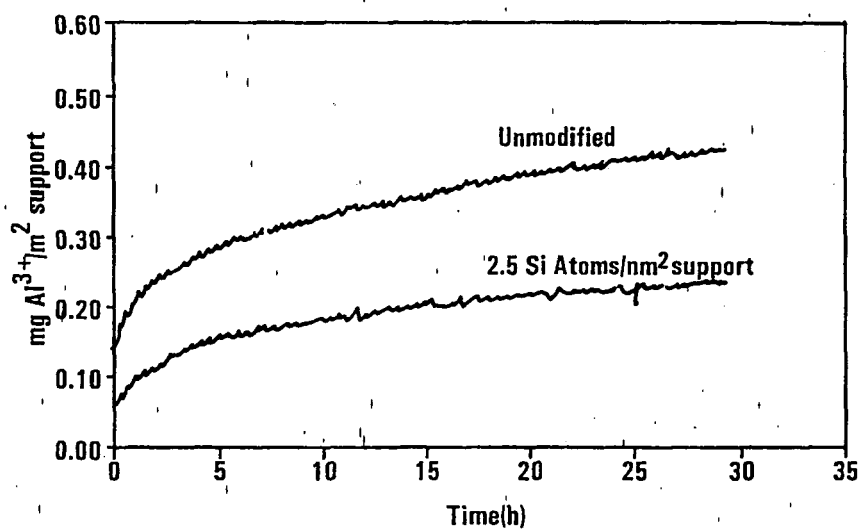


FIG 1

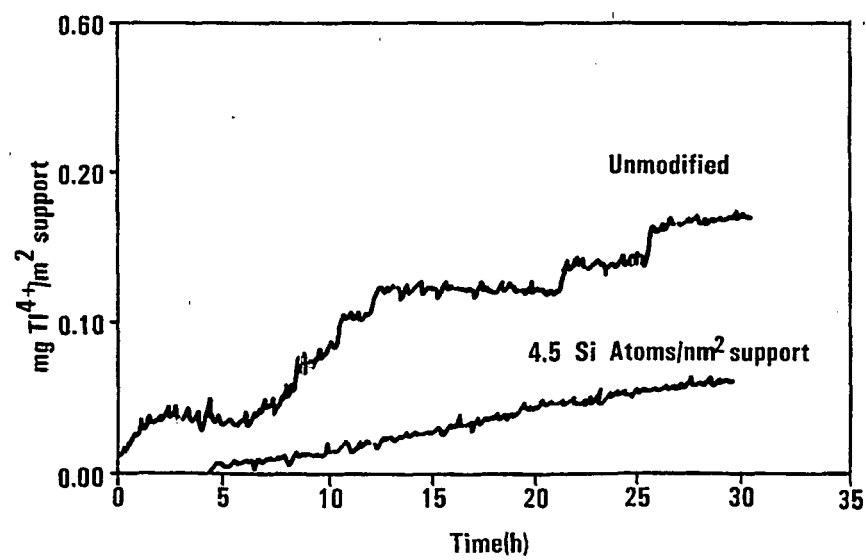


FIG 2

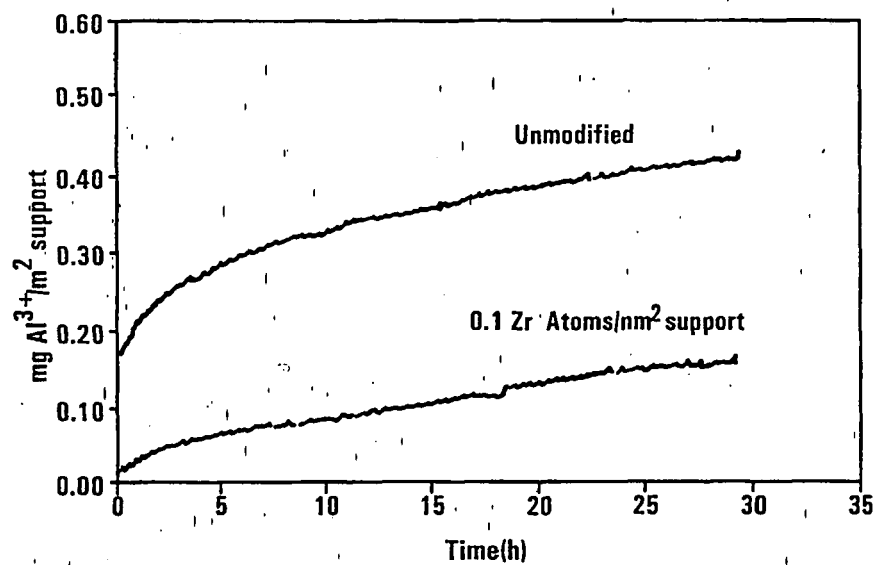


FIG 3

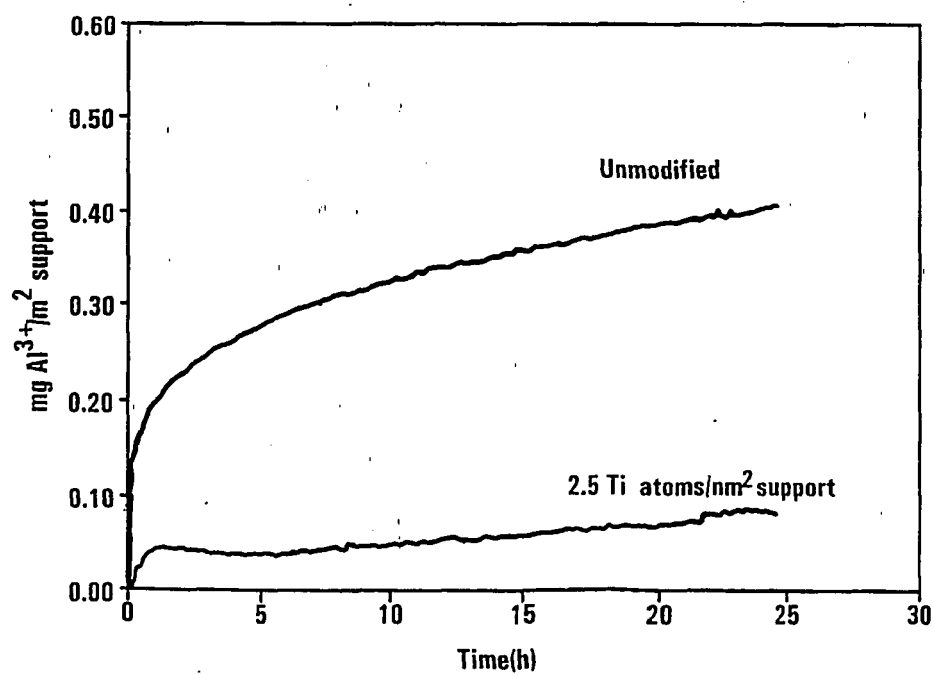


FIG 4

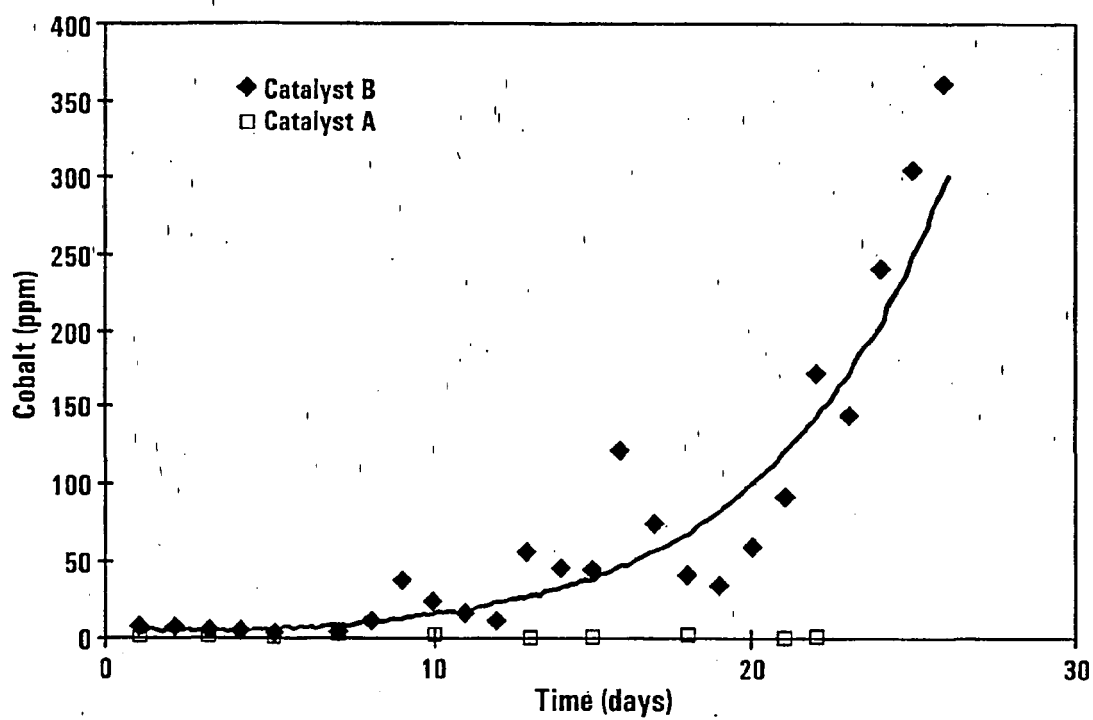


FIG 5