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(54) Title: PROCESS FOR THE REMOVAL OF HEAVY METALS FROM FLUIDS

(57) Abstract: The present invention discloses a process for the removal of heavy metals and/or dioxins from a fluid comprising heavy metals, wherein the fluid is brought in contact with a mixture comprising between 30 %vol. and 60 %vol. of an activated carbon catalyst impregnated with sulfur, between 30 %vol. and 60 %vol. of an activated carbon catalyst impregnated with iron and between 5 %vol. and 40 %vol. of a filler material, the total of these three ingredients being 100%vol. The fluid is left in contact with the mixture, the heavy metals and/or dioxins are absorbed onto the mixture to obtain a fluid with a depleted level of heavy metals, which fluid is then evacuated from the mixture.

PROCESS FOR THE REMOVAL OF HEAVY METALS FROM FLUIDS

Technical field

[0001] The present invention generally relates to the removal of heavy metals from fluids and relates in particular to a process for the removal of heavy metals from liquids and/or gas in a fixed bed reactor.

Background Art

[0002] Activated carbon catalysts are widely used for different applications including heavy metal removals from gas and liquids. It has been found however that the performance of the activated carbon catalysts could still be enhanced.

[0003] US 7,722,843 discloses a process for the removal of mercury from a combustion exhaust gas stream in a combustion exhaust gas purification scheme that includes a combustion exhaust scrubber system that uses an aqueous liquid to remove acid gases from the combustion exhaust gas. The process comprises providing a powdered mercury sorbent, introducing the powdered mercury sorbent into the aqueous liquid in the scrubber system, and after introduction of the mercury sorbent into the aqueous liquid, separating at least some of the mercury sorbent from the aqueous liquid.

[0004] The so-called Kombisorbon® process (Chemosphere Vol. 37 Nos 9-12, pp2327-2334, 1998 Elsevier Science Ltd) is a fixed bed process designed for the removal of heavy metals, in particular mercury and cadmium, dioxins and furans, other ecotoxic organic components from waste gases.

[0005] Typical raw gas conditions:

Gas temperature	up to 90°C
Dust	2 - 10 mg/dscm (dry standard cubic meter)
Mercury	up to 10 mg/dscm
Dioxin/Furan (TE)	up to 300 ng/dscm

[0006] Clean gas criteria (new MACT emission standards for new FBIs (USEPA 2011, Federal Register : 40CFR Part 60): at 7% O2):

Mercury	< 1 µg/dscm
Dioxin/Furan (TE)	< 0.004 ng/dscm

[0007] The Kombisorbon® system generally uses a conditioner and a fixed-bed adsorber. The conditioner includes a coalescer, a droplet separator and a heat exchanger to condition the flue gas to reach optimal parameters before entering the adsorber.

[0008] The Kombisorbon® process offers the following key advantages:

- Removal of ionic mercury known as Hg^{2+} through adsorption as $HgCl_2$ on the activated carbon
- Elemental mercury known as Hg^0 by forming with the sulfur on the carbon mercuric sulfide known as HgS
- Removal of dioxins and furans through absorption.

[0009] Typical applications are sewage sludge or hazardous waste incineration plants. The first commercial-scale Kombisorbon® unit was installed in a sewage sludge incineration plant in 1994. Since that time more than 20 units have been put into operation worldwide.

Technical problem

[0010] It is an object of the present invention to provide an activated carbon catalyst composition having an improved activity as well as a more efficient process for the removal of heavy metals from a fluid.

[0011] This object is achieved by a process for the removal of heavy metals from a fluid comprising heavy metals as claimed in claim 1.

General Description of the Invention

[0012] The object of the invention is achieved by a process for the removal of heavy metals from a fluid comprising heavy metals, wherein the fluid is brought in contact with a mixture comprising between 30 %vol. and 60 %vol. of an activated carbon catalyst impregnated with sulfur, between 30 %vol. and 60 %vol. of an activated carbon catalyst impregnated with iron and between 5 %vol. and 40 %vol. of a filler material, the total of these three ingredients being 100%vol., leaving the fluid in contact with the mixture, absorption of the heavy metals onto the mixture to obtain a fluid with a depleted level of heavy metals, evacuation of the fluid with a depleted level of heavy metals from the mixture.

[0013] Surprisingly it has been found that the process for removal of heavy metals from a fluid is more efficient if a mixture of an activated carbon catalyst impregnated with sulfur and of an activated carbon catalyst impregnated with iron and of a filler material is used. It has also been found that the catalyst activity is more easily regenerated if between 5 and 40 %vol. of a filler material is used. As a demonstration example of this, a Kombisorbon® unit is regenerated periodically (2-4 times a year) on an industrial site. The drying time period after this regeneration period is reduced by more than 40 % (28 instead of 48 hours) in case of a reactor bed with an activated carbon (80 %) / filler material (20 %) mixture compared to activated carbon alone.

[0014] The term heavy metal refers to any metallic chemical element that has a relatively high density and is toxic or poisonous at low concentrations. Examples of heavy metals include mercury (Hg), cadmium (Cd), arsenic (As), chromium (Cr), thallium (Tl), and lead (Pb). A toxic heavy metal is any relatively dense metal or metalloid that is noted for its potential toxicity, especially in environmental contexts. The term has particular application to cadmium, mercury, lead and arsenic, all of which appear in the World Health Organisation's list of 10 chemicals of major public concern. Other examples include manganese (Mg), cobalt (Co), nickel (Ni), copper (Cu), zinc (Zn), selenium (Se), silver (Ag) and antimony (Sb).

[0015] Surprisingly it has been found that the process can be used for the removal of heavy metals from a gas – i.e. waste gas from incineration plant eliminating municipal solid waste, industrial solid wastes and sewage sludge or liquids from industrial waste water, from cement industry, from petroleum refining, from chemical manufacturing, from metal finishing, from printed circuit manufacturing, from oil and gas extraction and from hazardous waste.

[0016] According to various embodiments, the mixture comprises at least 30 %vol., 31%vol., 32%vol., 33%vol., 34%vol., 35%vol., 36%vol., 37%vol., 38%vol., 39%vol., 40%vol., 41%vol., 42%vol., 43%vol., 44%vol., 45%vol., 46%vol., 47%vol., 48%vol., 49%vol., 50%vol., 51%vol., 52%vol., 53%vol., 54%vol., 55%vol., 56%vol., 57%vol., 58%vol. or 59%vol. of an activated carbon catalyst impregnated with sulfur.

[0017] According to various embodiments, the mixture comprises at most 60%vol., 59%vol., 58%vol., 57%vol., 56%vol., 55%vol., 54%vol., 53%vol., 52%vol., 51%vol., 50%vol., 49%vol., 48%vol., 47%vol., 46%vol., 45%vol., 44%vol., 43%vol., 42%vol., 41%vol., 40%vol., 39%vol., 38%vol., 37%vol., 36%vol., 35%vol., 34%vol., 33%vol., 32%vol., or 31%vol., of an activated carbon catalyst impregnated with sulfur.

[0018] In a preferred embodiment, the mixture comprises between 40 %vol. and 50 %vol. of activated carbon catalyst impregnated with sulfur.

[0019] Preferably, the activated carbon catalyst impregnated with sulfur comprises between 5 %weight and 20 %weight of sulfur.

[0020] According to various embodiments, the mixture comprises at least 30%vol., 31%vol., 32%vol., 33%vol., 34%vol., 35%vol., 36%vol., 37%vol., 38%vol., 39%vol., 40%vol., 41%vol., 42%vol., 43%vol., 44%vol., 45%vol., 46%vol., 47%vol., 48%vol., 49%vol., 50%vol., 51%vol., 52%vol., 53%vol., 54%vol., 55%vol., 56 %vol., 57%vol., 58%vol. or 59%vol. of an activated carbon catalyst impregnated with iron.

[0021] According to various embodiments, the mixture comprises at most 60%vol., 59%vol., 58%vol., 57%vol., 56%vol., 55%vol., 54%vol., 53%vol., 52%vol., 51%vol., 50%vol., 49%vol., 48%vol., 47%vol., 46%vol., 45%vol., 44%vol., 43%vol., 42%vol., 41%vol., 40%vol., 39%vol., 38%vol., 37%vol., 36%vol., 35%vol., 34%vol., 33%vol., 32%vol., or 31%vol. of an activated carbon catalyst impregnated with iron.

[0022] In a preferred embodiment, the mixture comprises between 40 %vol. and 50 %vol. of activated carbon catalyst impregnated with iron.

[0023] Preferably, the activated carbon catalyst impregnated with iron comprises between 10 %weight and 30 %weight of iron.

[0024] The activated carbon catalyst is preferably extruded and has a grain size of 0.80 - 130 mm. The activated carbon catalyst is preferably granulated and has a grain size: 0.30 to 4.75mm. The activated carbon catalyst is thus not under powder form.

[0025] In an embodiment the activated carbon catalyst is preferably a mixture of granulated and extruded catalyst.

[0026] The carbon catalyst may be produced from brown and bituminous coals, fruit pits, coconut shells, lignite, peat, wood, sawdust / saw chip, petroleum coke, bone and paper mill waste (lignin), synthetic polymers like PVC, rayon, viscose, polyacrylonitrile or phenols.

[0027] The carbon catalyst may be activated by :

- a physical treatment: heat, steam, oxygen, CO_2, air
- a chemical treatment: impregnation with acid, strong base or salts (e.g. sulfuric, chlorhydric or phosphoric acid, potassium or sodium hydroxide, calcium or zinc chloride)
- a combination of both a physical and a chemical treatment.

[0028] The activated carbon catalyst may have a specific surface area (BET) from 400 to 1800 m^2/g and an acid or alkaline pH.

[0029] According to various embodiments, the mixture comprises at least 5%vol., 6%vol., 7%vol., 8%vol., 9%vol., 10%vol., 11%vol., 12%vol., 13%vol., 14%vol., 15%vol., 16%vol., 17%vol., 18%vol., 19%vol., 20%vol., 21%vol., 22%vol., 23%vol., 24%vol., 25%vol., 26%vol., 27%vol., 28%vol., 29%vol., 30 %vol., 31%vol., 32%vol., 33%vol., 34%vol., 35%vol., 36%vol., 37%vol., 38%vol. or 39%vol., of filler material.

[0030] According to various embodiments, the mixture comprises at most 40%vol., 39%vol., 38%vol., 37%vol., 36%vol., 35%vol., 34%vol., 33%vol., 32%vol., 31%vol., 30%vol., 29%vol., 28%vol., 27%vol., 26%vol., 25%vol., 24%vol., 23%vol., 22%vol., 21%vol., 20%vol., 19%vol., 18%vol., 17%vol., 16%vol., 15%vol., 14%vol., 13%vol., 12%vol., 11%vol., 10%vol., 9%vol., 8%vol., 7%vol. or 6%vol. of filler material.

[0031] In a preferred embodiment, the filler materials are present in an amount from 5 to 15 %vol.

[0032] Preferably, the filler material comprises plastic, metals, alumina, ceramic materials or mixture thereof.

[0033] According to various embodiments, the filler material is a shape chosen among saddle shaped, ring shaped, ball shaped, torus shaped, prism shaped or irregular shaped.

[0034] In particular, filler materials made of ceramic material, having a free volume of 50-79% may be used:

i. Novalox® Saddle : 12.7-76.2 mm
ii. Berl saddle : 4-50 mm
iii. Cylindrical ring : 5-200 mm
iv. Pall® ring : 25-100 mm
v. Transitional grid lining
vi. Cylindrical ring with 1 bar or 1 cross : 80-200 mm
vii. Grid block : 215*145*90 mm

[0035] In particular, filler materials made of metal, having a free volume of 95-98% may be used:

i. Cylindrical ring . 15-50 mm
ii. Pall® ring : 15-90 mm
iii. VSP® : 25-50 mm
iv. Top-Pak® : 15 mm
v. Novalox®-M : 15-70 mm
vi. Twin-Pak® : 10-15 mm
vii. Interpak® : 10-20 mm

[0036] In particular, filler materials made of plastic, having a free volume of 87-97% may be used:

i. Novalox® saddle : 12.7 – 50.8 mm
ii. Pall® ring : 15-90 mm
iii. VSP® : 25-90 mm
iv. Igel® : 40 mm
v. Netball® : 45-90 mm

[0037] The filler material is thus made up of distinct, individual particles that are added to the activated carbon catalyst to improve, to enhance some properties of the mixtured material. The filler material particles generally have a mean particle size (based on the average largest dimension (by number) of the particle) of more than 4 mm. Usually their mean particle size (based on the average largest dimension (by number) of the particle) is less than 200 mm.

[0038] In an embodiment, the mixture of activated carbon catalyst impregnated with sulfur, activated carbon catalyst impregnated with iron and a filler material contains no other solid ingredients than the activated carbon catalysts and the filler material. The total of these three ingredients makes thus 100%vol. of the mixture. It goes without saying that the mixture is a heterogeneous mixture since the components have a different particles sizes, different densities etc. The mixture comprises preferably a mixture of separate, distinct particles of filler and separate, distinct particles of activated carbon catalyst. This makes it easy to separate the activated carbon catalyst from the filler when the activated carbon catalyst needs to be replaced.

[0039] According to various embodiments, the process can be used where the fluid is a gas, preferably a waste gas from sewage incineration plants, sludge incineration plants or hazardous waste incineration plants.

[0040] In a preferred embodiment, the gas comprises at least 50 mg/dscm, preferably at least 45 mg/dscm, more preferably at least 40 mg/dscm of heavy metals.

[0041] In a preferred embodiment, the gas comprises at least 1000 ng/dscm, preferably at least 500 ng/dscm, more preferably at least 200 ng/dscm of dioxins. The term "dioxins" as used herein refers to dioxins and dioxin-like substances, including PCBs, as defined in the Stockholm Convention on Persistent Organic Pollutants.

[0042] According to various embodiments, the fluid used in the above process can be a liquid.

[0043] Preferably, the liquid is left in contact with the catalyst composition for at least 1h, 2h, 3h or 10h.

[0044] According to various embodiments, the liquid comprises at least 50 mg/l of heavy metals, preferably at least 45 mg/l, more preferably at least 40 mg/l of heavy metals.

[0045] In a preferred embodiment, the liquid comprises at least 20 µg/l, preferably at least 2 µg/l, more preferably at least 0,02 µg/l of dioxins.

Description of Preferred Embodiments

[0046] Further details and advantages of the present invention will be apparent from the following detailed description of several not limiting embodiments.

[0047] Test 1 – Removal from Gas - Plant Scale

[0048] Emission sampling during two days was performed at the outlet of the Kombisorbon® process reactor, filled with a specific activated carbon mixture: 45 % of activated carbon impregnated with sulfur supplied from Jacobi Carbons, 45 % of activated carbon impregnated with iron supplied from Watch-Water, and 10 % of a plastic filler material.

[0049] The removal rate of cadmium was 99.9 %, for mercury more than 99,9 % and more than 99,9 % removal rate for dioxins. The initial levels were 5 mg/dscm for cadmium, 1 mg/dscm for mercury and 350 ng/dscm for dioxins.

[0050] The presence of activated carbon mixture and filler material allowed a better gas flow distribution and subsequently the cleaning of a higher concentrated inlet gas due to an increased removal rate of contaminants.

[0051] The presence of filler allowed a more efficient washing of the activated carbon with sulfates removal coming from the reaction between SOx and NOx with water vapors from inlet flue gas.

[0052] The presence of filler allowed a quicker drying step after regeneration with water flow.

[0053] Test 1-b Comparative example – Removal from Gas - Plant Scale

[0054] Emission sampling during two days was performed at the outlet of the Kombisorbon® process reactor, filled with a 100 % of activated carbon impregnated with sulfur supplied from Jacobi Carbons.

[0055] The removal rate of cadmium was 99 %, for Mercury, more than 99 % and more than 99 % removal rate for dioxins. The initial levels were 5 mg/dscm for cadmium, 1 mg/dscm for mercury and 350 ng/dscm for dioxins.

[0056] Test 2 – Removal from Liquid - Laboratory scale – single pass

[0057] 500 cm^3 of a mixture: 30 % of activated carbon catalyst impregnated with sulfur supplied from Jacobi Carbons, 30 % of activated carbon impregnated with iron supplied from Watch-Water, 40 % of a plastic filler material was used during this test.

[0058] The level of heavy metals in a phosphoric acid solution was reduced significantly. 20 % removal rate for cadmium and mercury and 35 % removal rate for arsenic.

[0059] Test 3 – Removal from Liquid - Laboratory scale – single pass

[0060] 500 cm^3 of a mixture of 45 % of activated carbon impregnated with sulfur, 45 % of activated carbon impregnated with iron supplied from Watch-Water, and 10 % of a plastic filler material was used during this test.

[0061] The level of heavy metals in a phosphoric acid solution was reduced significantly. 75 % removal for cadmium and mercury and 65 % removal for arsenic. The initial concentrations were 39 ppm for cadmium, 0.1 ppm for mercury and 23 ppm for arsenic.

[0062] The presence of filler material allowed less clogging from silica coming from the phosphoric acid media inside the activated carbon bed.

[0063] The presence of filler material allowed a more efficient washing of the activated carbon with easier silica removal.

[0064] Test 3-b – Comparative example - Removal from Liquid - Laboratory scale – single pass

[0065] 500 cm^3 of 100 % of activated carbon impregnated with sulfur supplied from Jacobi Carbons was used during this test.

[0066] The level of heavy metals in a phosphoric acid solution (As: 23 ppm, Hg: 0.1 ppm and Cd: 39 ppm) was reduced. Only a 20 % removal rate for mercury and only 35 % removal rate for arsenic were achieved.

[0067] Test 3-c – Comparative example - Removal from Liquid - Laboratory scale – single pass

[0068] 500 cm^3 of 100 % of activated carbon catalyst impregnated with iron supplied from Watch-Water was used during this test.

[0069] The level of heavy metals in a phosphoric acid solution (As: 23 ppm, Hg: 0.1 ppm and Cd: 39 ppm) was reduced. Only a 50 % removal rate for cadmium and mercury and only a 15 % removal rate for arsenic were achieved.

[0070] The activated carbon used in the tests above had a specific high catalytic surface area (BET at least 700 m^2/g) with impregnation (like Br, Cu, Fe, S, OH …).

[0071] The activated carbon was mixed with various types of filler materials of different shapes (cylinder, balls, “Sattelkörper”, …) and different material (plastic, alumina, ceramic, ..) in various ratios (1/5; 1/3; 1/10; …). Different suppliers of activated carbon catalysts for companies like Jacobi, Cabot Carbon, Chemviron, Desotec, Carbotech and ATEC were tested.

[0072] It must be noted that the active carbon catalysts do not contain:

a. any iodine, bromine or a compound thereof,

b. any water repellent,

c. any catalytically active metals such as Platinum, Palladium, Rhodium etc. or,

d. any organic/ catalytically active metal complexes based on metals such as Platinum, Palladium, Rhodium etc.

[0073] The active carbon catalyst is not hydrophobized by means of hydrophobic polymer compounds such as polytetrafluoroethylene, polyisobutylene, polyethylene, polypropylene or polytrichlorfluorethylen.

[0074] Although the present invention has been described in considerable detail with reference to certain preferred versions thereof, other versions are possible. Therefore, the spirit and scope of the appended claims should not be limited to the description of the preferred versions contained herein.

[0075] All the features disclosed in this specification (including any accompanying claims, abstract, and drawings) may be replaced by alternative features serving the same, equivalent or similar purpose, unless expressly stated otherwise. Thus, unless expressly stated otherwise, each feature disclosed is one example only of a generic series of equivalent or similar features.

Claims

1. A process for the removal of heavy metals and/or dioxins from a fluid comprising heavy metals, wherein the fluid is brought in contact in a fixed-bed adsorber with a mixture comprising between 30 %vol. and 60 %vol. of an activated carbon catalyst impregnated with sulfur, between 30 %vol. and 60 %vol. of an activated carbon catalyst impregnated with iron and between 5 %vol. and 40 %vol. of a filler material, leaving the fluid in contact with the mixture, absorption of the heavy metals and/or dioxins onto the mixture to obtain a fluid with a depleted level of heavy metals and/or dioxins, evacuation of the fluid with a depleted level of heavy metals and/or dioxins from the mixture.
2. The process as claimed in claim 1, wherein the fluid is a gas.
3. The process as claimed in claim 2, wherein the gas is a waste gas from sewage, sludge or hazardous waste incineration plants.
4. The process as claimed in claim 2 or 3, wherein the gas comprises at least 50 mg/dscm %weight of heavy metals and/or at least 200 ng/dscm of dioxins.
5. The process as claimed in claim 1, wherein the fluid is a liquid.
6. The process as claimed in claim 5, wherein the liquid comprises at least 40 mg/l of heavy metals and/or at least 0,02 µg/l of dioxins.
7. The process as claimed in any one of the preceding claims, wherein the mixture comprises between 40 %vol. and 50 %vol. of activated carbon catalyst impregnated with sulfur.
8. The process as claimed in any one of the preceding claims, wherein the activated carbon catalyst impregnated with sulfur comprises between 5 %weight and 20 %weight of sulfur
9. The process as claimed in any one of the preceding claims, wherein the mixture comprises between 40 %vol. and 50 %vol. of activated carbon catalyst impregnated with iron.
10. The process as claimed in any one of the preceding claims, wherein the activated carbon catalyst impregnated with iron comprises between 10 %weight and 30 %weight of iron

11. The process as claimed in any one of the preceding claims, wherein the filler material comprises plastic, alumina or ceramic materials or mixtures thereof.
12. The process as claimed in any one of the preceding claims, wherein the filler material comprises a free volume of 50% vol and 97 % vol.
13. The process as claimed in any one of the preceding claims, wherein the filler materials are present in an amount from 5 to 15 %vol.
14. The process as claimed in any one of the preceding claims, wherein the filler material is a shape chosen among saddle shaped, ring shaped, ball shaped, torus shaped, prism shaped or irregular shaped.
15. The process as claimed in any one of the preceding claims, wherein the gas is conditioned in a coalescer, a droplet separator and/or a heat exchanger before it is put in contact with the mixture.

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/056902

A. CLASSIFICATION OF SUBJECT MATTER
INV. B01D53/64 B01D53/81 B01D53/72 C02F1/28
ADD. C02F101/20

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)
B01D C02F

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 practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	FELL, H.J.; TUCZEK, M.: "Removal of Dioxins and Furans from Flue Gases by Non-Flammable Adsorbents in a Fixed Bed", CHEMOSPHERE, vol. 37, no. 9-12, 1998, pages 2327-2334, XP002769699, the whole document -----	1-15
A	US 7 722 843 B1 (SRINIVASACHAR SRIVATS [US]) 25 May 2010 (2010-05-25) column 5, line 66 - column 6, line 7 column 9, lines 35-37; claims 8-11 abstract -----	1-15

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family 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 application or patent but published on or after the international filing date

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
28 April 2017	12/05/2017

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Gruber, Marco

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Form PCT/ISA/210 (second sheet) (April 2005)

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2008/207443 A1 (GADKAREE KISHOR PURUSHOTTAM [US] ET AL) 28 August 2008 (2008-08-28) paragraphs [0003], [0163]; claims 1,20 abstract	1-15
A	US 2010/239479 A1 (GADKAREE KISHOR PURUSHOTTAM [US] ET AL) 23 September 2010 (2010-09-23) paragraphs [0002], [0190], [0191]; claims 1,54	1-15
A	US 2009/111690 A1 (GADKAREE KISHOR PURUSHOTTAM [US] ET AL) 30 April 2009 (2009-04-30) abstract; claims 1,10,13,14	1-15
A	US 4 911 825 A (ROUSSEL MICHEL [FR] ET AL) 27 March 1990 (1990-03-27) claims 1-4 abstract	1-15

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2017/056902

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