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Inventeur(s):

STRICKROTH ALAIN –
4251 ESCH/ALZETTE (Luxembourg)

43

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Mandataire(s):

OFFICE FREYLINGER S.A. –
8001 STRASSEN (Luxembourg)

47

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Titulaire(s):

CPPE CARBON PROCESS & PLANT ENGINEERING S.A.
(EN ABRÉGÉ CPPE S.A.) – 1337 LUXEMBOURG-
DOMMELDANGE (Luxembourg)

54

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. 93013

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.

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] The so-called Kombisorbon® process is designed for the removal of heavy metals, in particular mercury and cadmium, dioxins and furans, other ecotoxic organic components from waste gases.

[0004] 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

[0005] 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

[0006] 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.

[0007] CPPE's Kombisorbon® process offers the following key advantages:

- Removal of ionic mercury known as Hg²⁺ through adsorption as HgCl₂ 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.

[0008] 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

[0009] 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.

[0010] 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

[0011] 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.

[0012] 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.

[0013] 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).

[0014] 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.

[0015] 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.

[0016] 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.

[0017] In a preferred embodiment, the mixture comprises between 40 %vol. and 50 %vol. of activated carbon catalyst impregnated with sulfur.

[0018] Preferably, the activated carbon catalyst impregnated with sulfur comprises between 5 %weight and 20 %weight of sulfur.

[0019] 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.

[0020] 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.

[0021] In a preferred embodiment, the mixture comprises between 40 %vol. and 50 %vol. of activated carbon catalyst impregnated with iron.

[0022] Preferably, the activated carbon catalyst impregnated with iron comprises between 10 %weight and 30 %weight of iron.

[0023] 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.

[0024] In an embodiment the activated carbon catalyst is preferably a mixture of granulated and extruded catalyst.

[0025] 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.

[0026] The carbon catalyst may be activated by :

a physical treatment: heat, steam, oxygen, CO₂, 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.

[0027] The activated carbon catalyst may have a specific surface area (BET) from 400 to 1800 m²/g and an acid or alkaline pH.

[0028] 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.

[0029] 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.

[0030] In a preferred embodiment, the filler materials are present in an amount from 5 to 15 %vol.

[0031] Preferably, the filler material comprises plastic, alumina, ceramic materials or mixture thereof.

[0032] According to various embodiments, the filler materials are shaped as balls, saddles, rings or tubes.

[0033] 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

[0034] 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

[0035] 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

[0036] 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.

[0037] 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.

[0038] 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.

[0039] 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.

[0040] According to various embodiments, the fluid used in the above process can be a liquid.

[0041] Preferably, the liquid is left in contact with the catalyst composition for at least 1h, 2h, 3h or 10h.

[0042] 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.

[0043] 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

[0044] Further details and advantages of the present invention will be apparent from the following detailed description of several not limiting embodiments.

[0045] Test 1 – Removal from Gas - Plant Scale

[0046] Emission sampling during two days was performed at the outlet of our CPPE 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.

[0047] 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.

[0048] 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.

[0049] The presence of filler allowed a more efficient washing of the activated carbon with sulfates removal coming from the reaction between SO_x and NO_x with water vapors from inlet flue gas.

[0050] The presence of filler allowed a quicker drying step after regeneration with water flow.

[0051] Test 1-b Comparative example – Removal from Gas - Plant Scale

[0052] Emission sampling during two days was performed at the outlet of our CPPE Kombisorbon® process reactor, filled with a 100 % of activated carbon impregnated with sulfur supplied from Jacobi Carbons.

[0053] 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.

[0054] Test 2 – Removal from Liquid - Laboratory scale – single pass

[0055] 500 cm³ 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.

[0056] 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.

[0057] Test 3 – Removal from Liquid - Laboratory scale – single pass

[0058] 500 cm³ 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.

[0059] 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.

[0060] The presence of filler material allowed less clogging from silica coming from the phosphoric acid media inside the activated carbon bed.

[0061] The presence of filler material allowed a more efficient washing of the activated carbon with easier silica removal.

[0062] Test 3-b – Comparative example - Removal from Liquid - Laboratory scale – single pass

[0063] 500 cm³ of 100 % of activated carbon impregnated with sulfur supplied from Jacobi Carbons was used during this test.

[0064] The level of heavy metals in a phosphoric acid solution (As: 23 ppm, Hg: 0.1 ppm and Cd: 39 ppm) was reduced. 20 % removal rate for mercury and 35 % removal rate for arsenic

[0065] Test 3-c – Comparative example - Removal from Liquid - Laboratory scale – single pass

[0066] 500 cm³ of 100 % of activated carbon catalyst impregnated with iron supplied from Watch-Water was used during this test.

[0067] The level of heavy metals in a phosphoric acid solution (As: 23 ppm, Hg: 0.1 ppm and Cd: 39 ppm) was reduced. 50 % removal rate for cadmium and mercury and 15 % removal rate for arsenic

[0068] The activated carbon used in the tests above had a specific high catalytic surface area (BET at least 700 m²/g) with impregnation (like Br, Cu, Fe, S, OH ...).

[0069] 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.

[0070] 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.

[0071] 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

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otherwise. Thus, unless expressly stated otherwise, each feature disclosed is one example only of a generic series of equivalent or similar features.

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REVENDICATIONS

1. Procédé pour l'élimination de métaux lourds et/ou de dioxines à partir d'un fluide comprenant des métaux lourds, qui comprend la mise en contact du fluide dans un réacteur à lit-fixe avec un mélange comprenant entre 30 % en volume et 60 % en volume d'un catalyseur à base de charbon activé, imprégné avec du soufre, entre 30 % en volume et 60 % en volume d'un catalyseur à base de charbon activé, imprégné avec du fer, et entre 5 % en volume et 40 % en volume d'une matière de charge, le maintien du fluide en contact avec le mélange, l'absorption des métaux lourds et/ou des dioxines sur le mélange pour obtenir un fluide possédant une teneur appauvrie en métaux lourds et/ou en dioxines, l'évacuation du fluide possédant une teneur appauvrie en métaux lourds et/ou en dioxines du mélange.
2. Procédé selon la revendication 1, dans lequel le fluide est un gaz.
3. Procédé selon la revendication 2, dans lequel le gaz est un gaz résiduaire provenant d'installations d'incinération de déchets dangereux, ou de boues d'eaux usées.
4. Procédé selon la revendication 2 ou 3, dans lequel le gaz comprend au moins 50 mg/dscm de métaux lourds et/ou 200 ng/dscm de dioxines.
5. Procédé selon la revendication 1, dans lequel le fluide est un liquide.
6. Procédé selon la revendication 5, dans lequel le liquide comprend au moins 40 mg/l de métaux lourds et/ou au moins 0,02 µg/l de dioxines.

7. Procédé selon l'une quelconque des revendications précédentes, dans lequel le mélange comprend entre 40 % en volume et 50 % en volume d'un catalyseur à base de charbon activé, imprégné avec du soufre.
- 5 8. Procédé selon l'une quelconque des revendications précédentes, dans lequel le catalyseur à base de charbon activé, imprégné avec du soufre comprend entre 5 % en poids du 20 % en poids de soufre.
- 10 9. Procédé selon l'une quelconque des revendications précédentes, dans lequel le mélange comprend entre 40 % en volume et 50 % en volume d'un catalyseur à base de charbon activé, imprégné avec du fer.
- 15 10. Procédé selon l'une quelconque des revendications précédentes, dans lequel le catalyseur à base de charbon activé, imprégné avec du fer comprend entre 10 % en poids et 30 % en poids de fer.
- 20 11. Procédé selon l'une quelconque des revendications précédentes, dans lequel la matière de charge comprend une matière plastique, une matière à base d'alumine ou une matière céramique ou encore leurs mélanges.
- 25 12. Procédé selon l'une quelconque des revendications précédentes, dans lequel la matière de charge comprend un volume libre de 50 % en volume et de 97 % en volume.
- 30 13. Procédé selon l'une quelconque des revendications précédentes, dans lequel les matières de charge sont présentes en une quantité de 5 à 15 % en volume.
14. Procédé selon l'une quelconque des revendications précédentes, dans lequel le gaz est conditionné dans un coalesceur, un séparateur de

gouttes et/ou un échangeur de chaleur avant sa mise en contact avec le mélange.

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



SEARCH REPORT

in accordance with Article 35.1 a)
of the Luxembourg law on patents
dated 20 July 1992

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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	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	INV. B01D53/64 B01D53/81 B01D53/72
X	----- 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	
X	----- 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	
X	----- US 2009/111690 A1 (GADKAREE KISHOR PURUSHOTTAM [US] ET AL) 30 April 2009 (2009-04-30) * abstract; claims 1,10,13,14 *	1-15	TECHNICAL FIELDS SEARCHED (IPC)
A	----- US 4 911 825 A (ROUSSEL MICHEL [FR] ET AL) 27 March 1990 (1990-03-27) * claims 1-4 * * abstract *	1-15	B01D C02F
The present search report has been drawn up for all claims			
Date of completion of the search		Examiner	
13 December 2016		Gruber, Marco	
CATEGORY OF CITED DOCUMENTS			
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document			
T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

**ANNEX TO THE SEARCH REPORT
ON LUXEMBOURG PATENT APPLICATION NO.**

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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

13-12-2016

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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		JP H01231920 A 18-09-1989	
		NO 890993 A 11-09-1989	
		US 4911825 A 27-03-1990	



WRITTEN OPINION

File No. LO1318	Filing date (day/month/year) 04.04.2016	Priority date (day/month/year)	Application No. LU93013
International Patent Classification (IPC) INV. B01D53/64 B01D53/81 B01D53/72			
Applicant CPPE Carbon Process & Plant Engineering S.A.			

This report contains indications relating to the following items:

- ☒ Box No. I Basis of the opinion
- ☐ Box No. II Priority
- ☐ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- ☐ Box No. IV Lack of unity of invention
- ☒ Box No. V Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- ☐ Box No. VI Certain documents cited
- ☐ Box No. VII Certain defects in the application
- ☐ Box No. VIII Certain observations on the application

Form LU237A (Cover Sheet) (January 2007)	Examiner Gruber, Marco
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WRITTEN OPINION

Application No.

LU93013

Box No. I Basis of the opinion

1. This opinion has been established on the basis of the latest set of claims filed before the start of the search.
2. With regard to any **nucleotide and/or amino acid sequence** disclosed in the application and necessary to the claimed invention, this opinion has been established on the basis of:
 - a. type of material:
 - ☐ a sequence listing
 - ☐ table(s) related to the sequence listing
 - b. format of material:
 - ☐ on paper
 - ☐ in electronic form
 - c. time of filing/furnishing:
 - ☐ contained in the application as filed.
 - ☐ filed together with the application in electronic form.
 - ☐ furnished subsequently.
3. ☐ In addition, in the case that more than one version or copy of a sequence listing and/or table relating thereto has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that in the application as filed or does not go beyond the application as filed, as appropriate, were furnished.
4. Additional comments:

Box No. V Reasoned statement with regard to novelty, inventive step and industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty	Yes: Claims	1-15
	No: Claims	
Inventive step	Yes: Claims	
	No: Claims	1-15
Industrial applicability	Yes: Claims	1-15
	No: Claims	

2. Citations and explanations

see separate sheet

Re Item V

Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1 Reference is made to the following documents:

- D1 US 7 722 843 B1 (SRINIVASACHAR SRIVATS [US]) 25 May 2010 (2010-05-25)
- D2 US 2008/207443 A1 (GADKAREE KISHOR PURUSHOTTAM [US] ET AL) 28 August 2008 (2008-08-28)
- D4 US 2010/239479 A1 (GADKAREE KISHOR PURUSHOTTAM [US] ET AL) 23 September 2010 (2010-09-23)
- D5 US 2009/111690 A1 (GADKAREE KISHOR PURUSHOTTAM [US] ET AL) 30 April 2009 (2009-04-30)

2 The present application does not meet the criteria of patentability, because the subject-matter of claims 1 to 15 does not involve an inventive step.

2.1 Document D1 discloses a method for removal of mercury from a scrubber liquid which is used for capturing acid components in a flue gas (ref. abstract). The spent scrubber liquid is contacted with mercury sorbents and afterwards, the sorbents are separated from the liquid.

According to col. 5, l. 66 to col. 6, l. 7, the sorbent used is powdered activated carbon which is enhanced with sulfur and/or with iron. The common presence of sulfur and iron is further suggested in claims 8 to 11 and the affinity for mercury of all components, i.e. carbon, sulfur and iron is mentioned in col. 9, l. 35 to 37.

Hence, the the subject matter of the claim 1 of the present application differs from D1 is that

- (i) sulfur and iron are impregnated on different activated carbon particles,
- (ii) both particle types are present in a mixture with an amount of 30 to 60 % vol.
- (iii) a filler material is present with an amount of 5 to 40% vol..

For none of the differences (i) to (iii), taken individually or together, a technical effect has been demonstrated on the basis of a comparison between an (inventive) example and a comparative example (representative for D1 as closest prior art).

In the absence of such effect, the problem to be solved can therefore only be regarded as to provide an alternative material for the capture of mercury. At the moment, there is no evidence to suggest that the solution to the problem which is offered in claim 1 is not obvious to the skilled person.

Claim 1 is not considered to involve an inventive step over D1.

- 2.2 Document D2 which can also be considered as closest prior art discloses a sorbent material for removal of mercury from a flue gas (ref. §[0003]).

Acc. to claim 1 of D2, the sorbent body comprises

- (a) an activated carbon matrix defining a plurality of pores;
- (b) sulfur; and
- (c) an additive adapted for promoting the removal of at least one of As, Cd, Hg and Se from a fluid stream, and
- (d) less than 10% by weight of inorganic materials (a "filler") other than carbon, sulfur-containing inorganic material and the additive (see also claim 20 referring to an optional filler material).

Acc. to §[0163], the additive can be present as metallic iron (valency: 0).

Hence, the the subject matter of the claim 1 of the present application differs from D1 is that

- (i) sulfur and iron are impregnated on different activated carbon particles,
- (ii) both particle types are present in a mixture with an amount of 30 to 60 % vol.

As argued for D1, for none of the differences (i) and (ii), taken individually or together, a technical effect has been demonstrated on the basis of a comparison between an (inventive) example and a comparative example (representative for D2 as closest prior art).

In the absence of such effect, the problem to be solved can therefore only be regarded as to provide an alternative material for the capture of mercury. At the moment, there is no evidence to suggest that the solution to the problem which is offered in claim 1 is not obvious to the skilled person.

- 2.3 Documents D3 and D4 are similar in content to document D2 and are considered to take away the inventive step of claim 1 (ref. cited passages in the search report).

- 2.4 The subject matter of claims 2 to 4, 13 and 15 is disclosed in documents D2 to D4.

It is, at present, not clear to which extent the subject matter of claims 5, to 12 and 14 causes unexpected or surprising effects with respect to what is disclosed in the above mentioned prior art. Therefore, no inventive activity can be acknowledged for the time being.