(12) UK Patent Application (19) GB (11) 2 242 896 (13) A

(43) Date of A publication 16.10.1991

(21) Application No 9015340.4

(22) Date of filing 12.07.1990

(30) Priority data
(31) 498952 (32) 26.03.1990 (33) US

(71) Applicant
Intevep S.A.

(Incorporated in Venezuela)

Apartado 76343, Caracas 1070A, Venezuela

(72) Inventors
Domingo Rodriguez
Jose Carrazza

(74) Agent and/or Address for Service
Eric Potter & Clarkson
St Mary's Court, St Mary's Gate, Nottingham, NG1 1LE,
United Kingdom

(51) INT CL^5
B01D 53/34

(52) UK CL (Edition K)
C1A ASB AS22Y AS221 AS41Y AS415 AS418
AS419 AS453 AS454 AS46X AS491 AS493

(56) Documents cited
None

(58) Field of search
UK CL (Edition K) **C1A ASB**
INT CL^5 **B01D**
Online databases:WPI,CLAIMS

(54) Process for the in-situ production of a sorbent-oxide aerosol used for removing effluents from a gaseous combustion stream

(57) A process for the in-situ production of an effluent sorbent-oxide aerosol during the combustion of a hydrocarbon containing fuel whereby the efluents are removed from the resultant gaseous hydrocarbon stream comprises admixing an aqueous solution of the sorbent with the fuel, atomizing and combusting the mixture under controlled conditions so as to generate the effluent sorbent-oxide aerosol and cooling the combustion stream to allow absorption to take place.

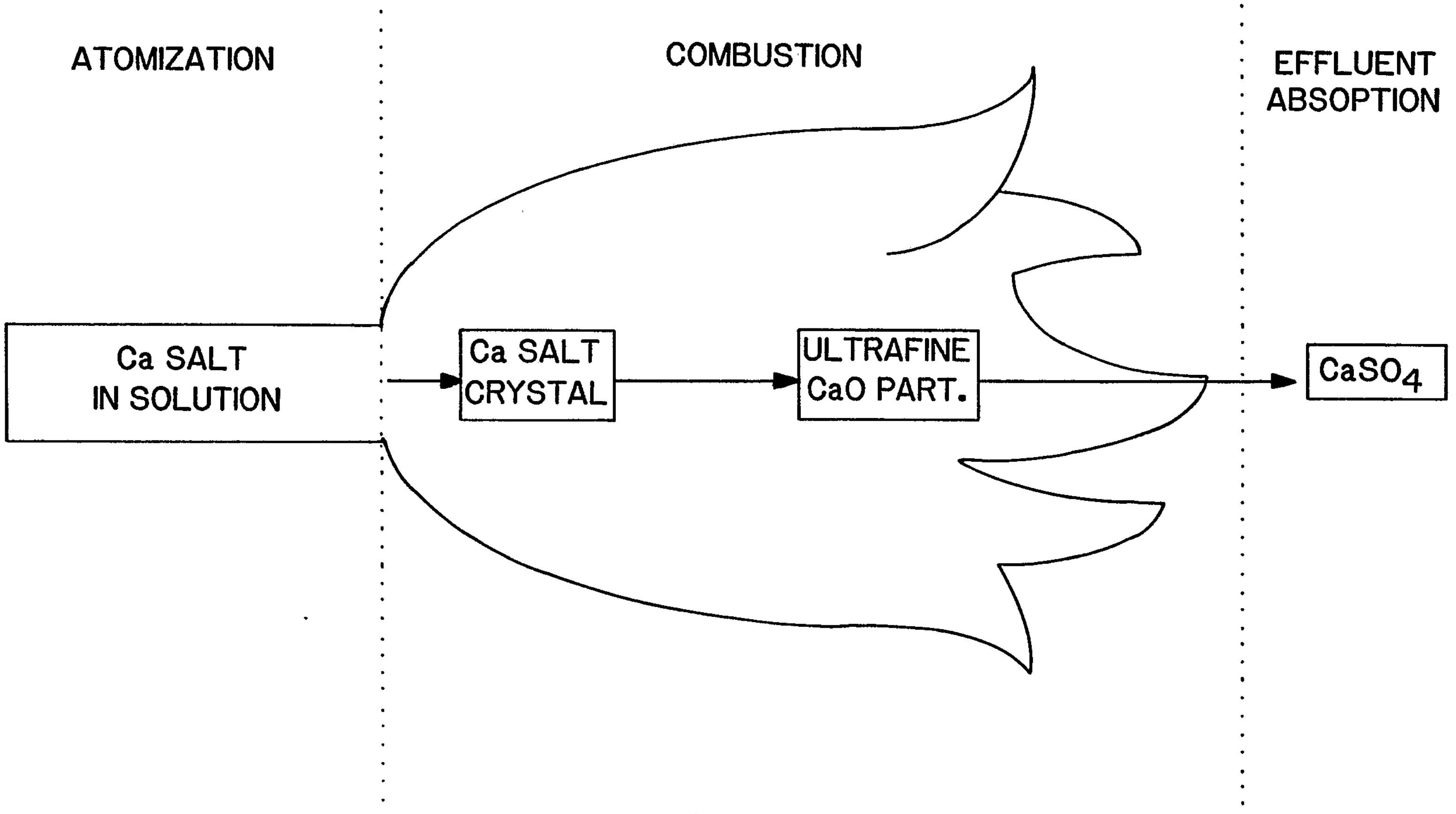
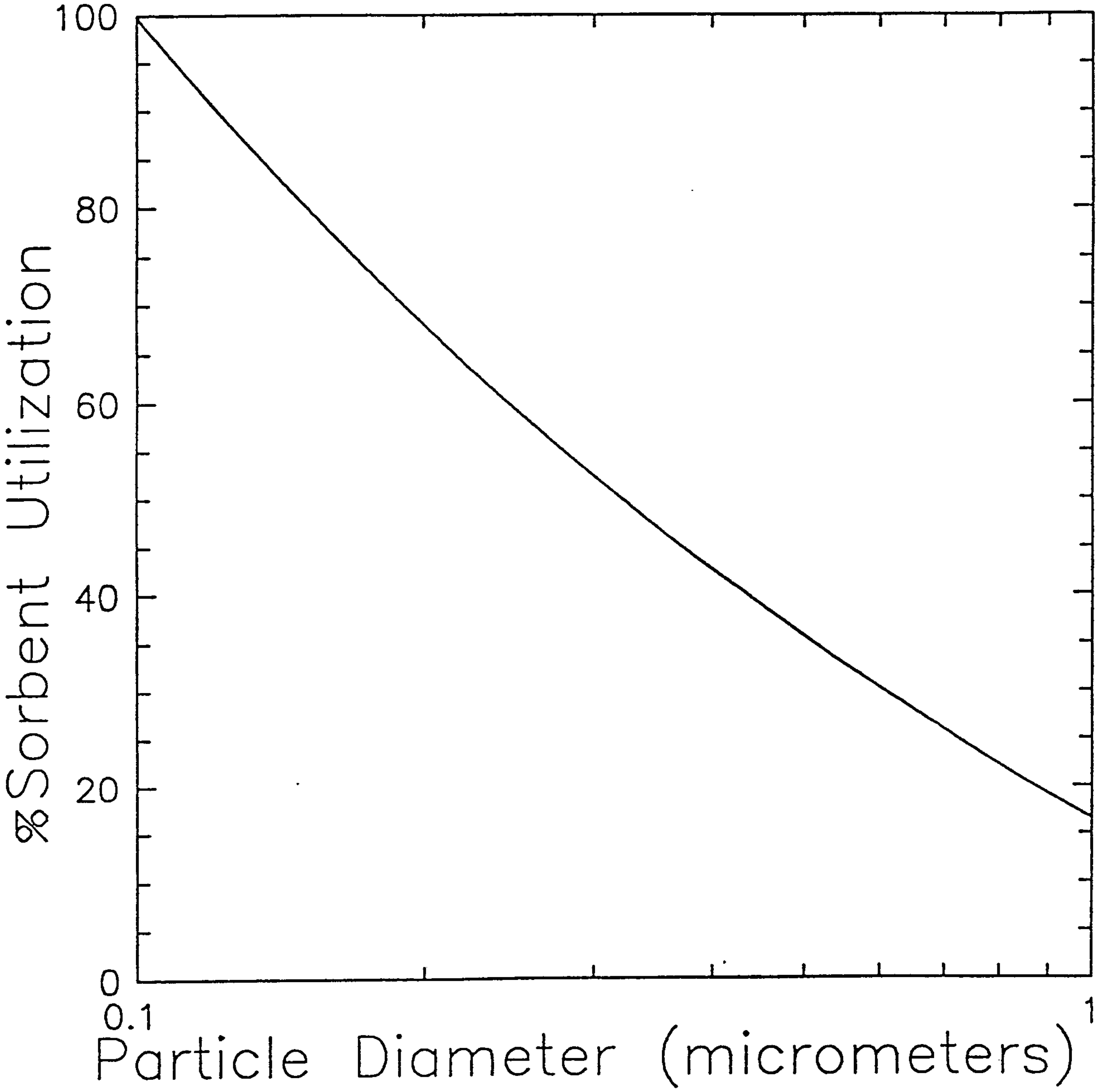

ATOMIZATION
COMBUSTION
EFFLUENT ABSOPTION
Ca SALT IN SOLUTION
Ca SALT CRYSTAL
ULTRAFINE CaO PART.
CaSO4

FIG. 1



100
80
60
40
20
0
%Sorbent Utilization
0.1
1
Particle Diameter (micrometers)

FIG. 2

GOOD ATOMIZATION CONDITIONS INCREASE THE DENSITY OF SMALL PARTICLES

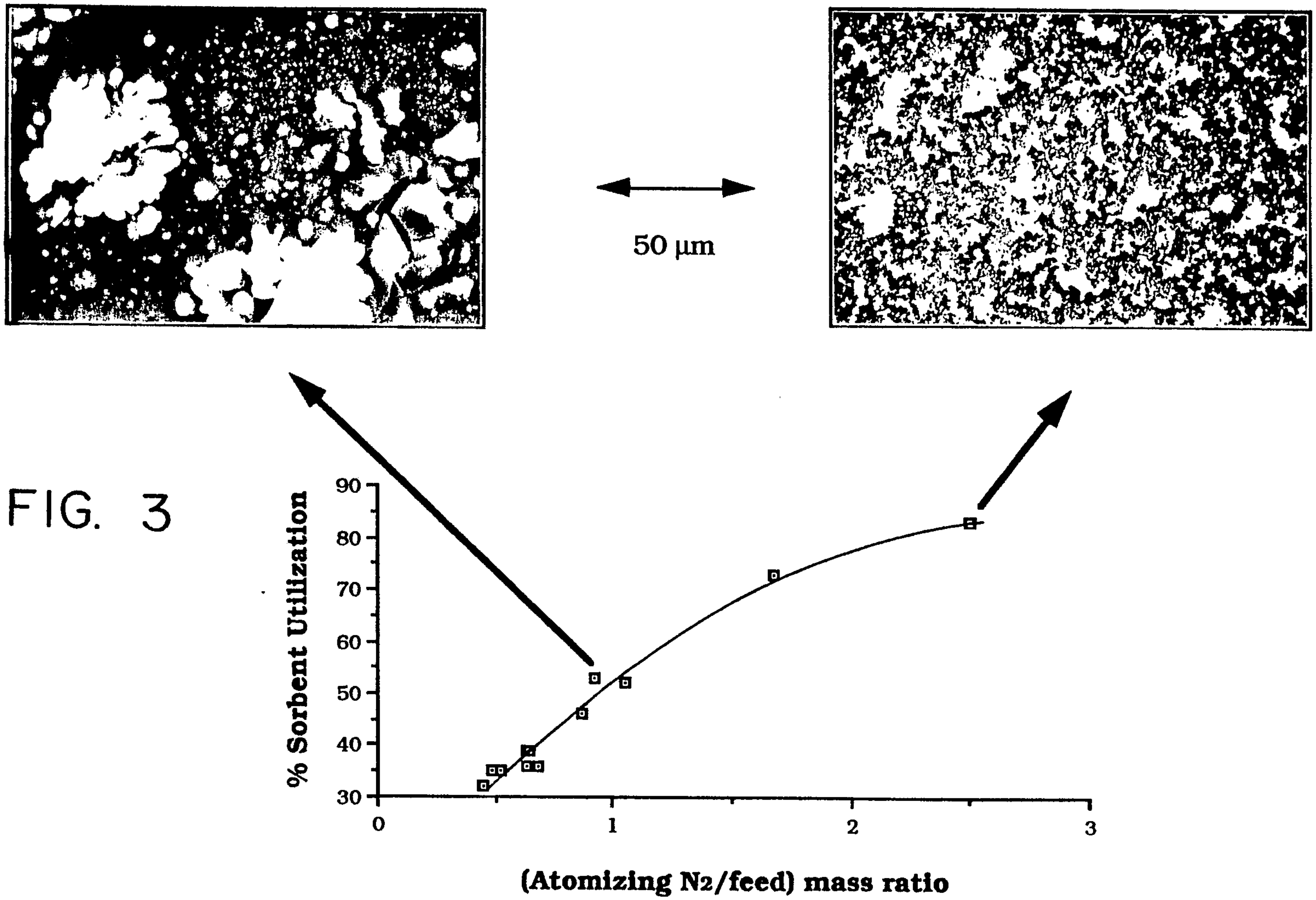


FIG. 3

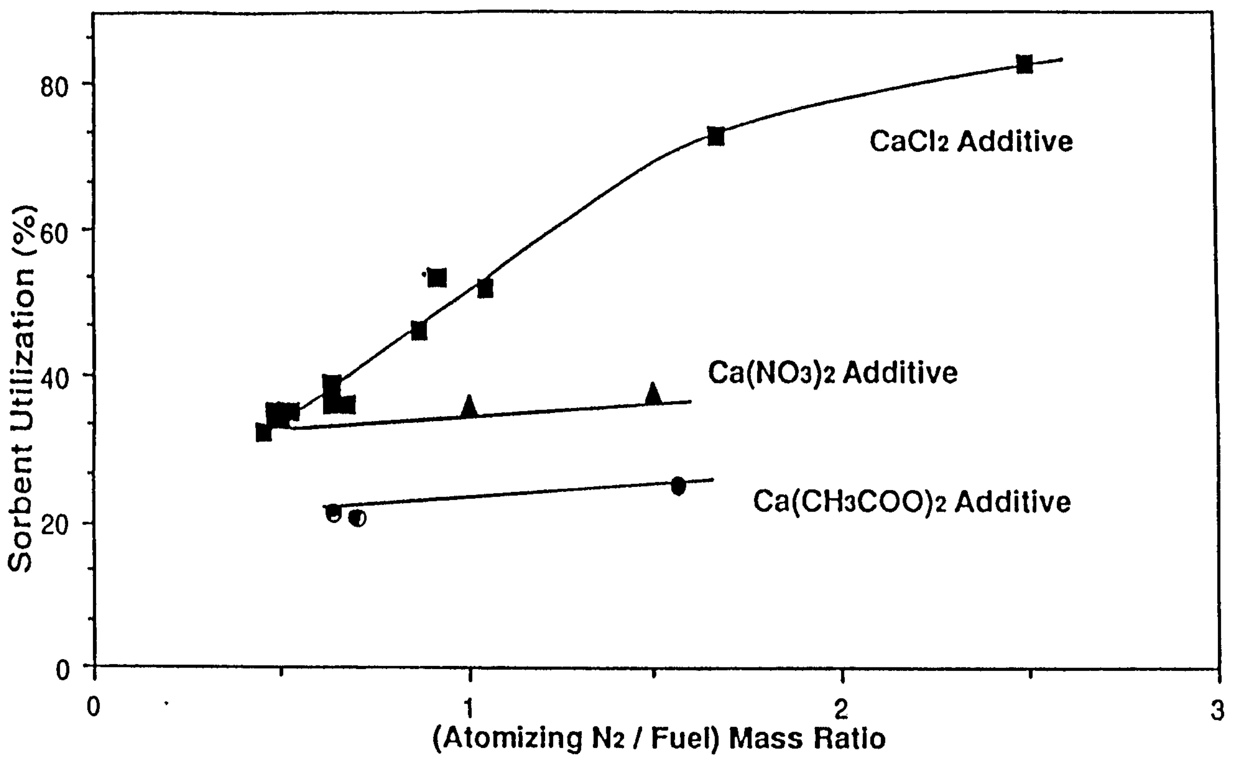
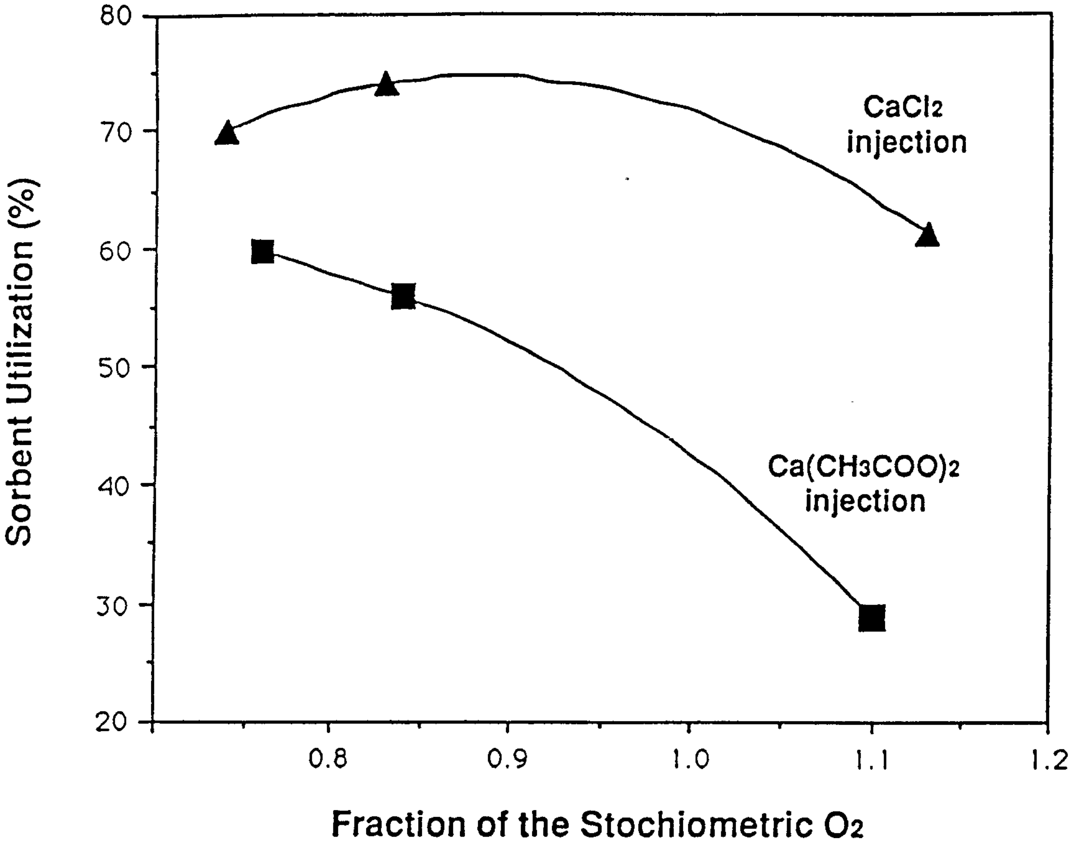

80
60
40
20
0
0
1
2
3
Sorbent Utilization (%)
(Atomizing N_2 / Fuel) Mass Ratio
$CaCl_2$ Additive
$Ca(NO_3)_2$ Additive
$Ca(CH_3COO)_2$ Additive

FIG. 4



Sorbent Utilization (%)
80
70
60
50
40
30
20
0.8
0.9
1.0
1.1
1.2
Fraction of the Stochiometric O2
CaCl2 injection
Ca(CH3COO)2 injection

FIG. 5

PROCESS FOR THE IN-SITU PRODUCTION OF A SORBENT-OXIDE AEROSOL USED FOR REMOVING EFFLUENTS FROM A GASEOUS COMBUSTION STREAM

The present invention relates to processes for the in-situ production of a sorbent-oxide aerosol used for removing effluents from a gaseous combustion stream and, more particularly, to processes for the production of a metal oxide sorbent which absorbs sulfur and other effluents from a hydrocarbon fuel combustion stream.

Gaseous combustion streams are the source of many undesirable effluents discharged into the environment which result in atmospheric pollution. The undesirable effluents include, for example, sulfur, nitrogen, fluorine and a host of other undesirable effluents. Particularly harmful to the environment are the undesirable effluents which result from the combustion of hydrocarbon containing fossil fuels.

Heretofore, many mechanisms have been proposed for removing effluents from combustion streams. In the case of sulfur, nitrogen and other like effluents it is common practice to scrub the gaseous streams. In addition, in-furnace limestone injection has been commonly employed. Neither of these processes tend to be cost effective on a commercial level.

Naturally, it would be highly desirable to provide a mechanism for removing effluents from industrial combustion streams in an economic manner.

It is an object of the invention to provide an improved process for the in-situ production of a sorbent-oxide aerosol used for removing effluents from a gaseous combustion stream.

According to one aspect of this invention there is provided a process for the in-situ production of an effluent sorbent-oxide aerosol during the combustion of a hydrocarbon containing fuel whereby effluents are removed from the resultant gaseous hydrocarbon combustion stream, said process comprising forming an aqueous solution comprising an effluent sorbent compound dissolved in water, admixing the aqueous solution of the effluent sorbent compound with a hydrocarbon containing fuel so as to form a combustible fuel mixture, atomizing said combustible fuel mixture and feeding said atomized fuel to a combustion zone, combusting said atomized fuel mixture in said combustion zone under controlled temperature conditions T_1 wherein T_1 is greater than or equal to 1400°K in the presence of an oxidant so as to obtain a sorbent-oxide aerosol comprising ultra-fine sorbent-oxide particles having a mean diameter of submicron size in said gaseous combustion stream, and cooling said gaseous combustion stream to a temperature

T_2 wherein T_2 is less than T_1 so that said sorbent-oxide particles absorb said effluents from said gaseous combustion stream.

According to another aspect of this invention there is provided a process for the in-situ production of an effluent sorbent-oxide aerosol during the combustion of a hdyrocarbon containing fuel whereby effluents are removed from the resultant gaseous hydrocarbon combustion stream, said process comprising providing a hydrocarbon containing fuel, forming an aqueous solution comprising an effluent sorbent compound dissolved in water, separately feeding said hydrocarbon fuel and aqueous solution to a combustion zone wherein said fuel and solution are admixed, combusting said atomized fuel mixture in said combustion zone under controlled temperature conditions T_1 wherein T_1 is greater than or equal to 1400°K in the presence of an oxidant so as to obtain a sorbent-oxide aerosol comprising ultra-fine sorbent-oxide particles having a mean diameter of submicron size in said gaseous combustion stream, and cooling said gaseous combustion stream to a temperature T_2 wherein T_2 is less than T_1 so that said sorbent-oxide particles absorb said effluents from said gaseous combustion stream.

Accordingly, it is an advantage of the present invention that it provides a process for removing environmental harmful effluents from a gaseous stream.

It is another advantage of the present invention that it provides a process for the production of a sorbent material suitable for removing effluents from a gaseous combustion stream.

It is a further advantage of the present invention that it provides a process for the in-situ production of a sorbent-oxide aerosol for removing effluents from a gaseous combustion stream which is effective and economical.

It is still a further advantage of the present invention that it provides a process for the production of a sorbent-oxide stream useful for removing sulfur and other effluents from a gaseous hydrocarbon fuel combustion stream.

The present invention is drawn to a process for the production of a sorbent-oxide aerosol used for removing effluents from a gaseous combustion stream. It is a particular feature of one embodiment of the present invention to produce a sulfur sorbent metal-oxide aerosol for removing sulfur from a gaseous hydrocarbon fuel combustion stream. The process of the present invention comprises forming an aerosol of an effluent sorbent in the form of ultra-fine sorbent-oxide particles having preferably a mean diameter of submicron size in-situ during the combustion of a hydrocarbon containing fuel which may be a fossil fuel and contacting the gaseous combustion stream containing the effluents with the aerosol so that the sorbent-oxide particles absorb the effluents from the gaseous stream. In a preferred process of the present invention, a hydrocarbon containing fuel is admixed with an aqueous solution consisting essentially of a dissolved effluent sorbent compound so as to form a combustible fuel mixture. The combustible fuel mixture may be atomized under controlled conditions and fed to a combustion zone in the presence of an oxidant. Alternatively, the hydrocarbon fuel and aqueous solution of effluent sorbent compound may be fed separately to the combustion zone and be admixed therein; however, admixing prior to feeding is preferred. The combustible fuel mixture and oxidant are combusted in the combustion zone under controlled temperature conditions T_1 so as to obtain an aerosol of the sorbent in the form of ultra-fine sorbent-oxide particles having preferably a mean diameter of submicron size in the gaseous combustion stream. The gaseous combustion stream is thereafter cooled to a temperature T_2, where T_2 is less than T_1, so as to allow the sorbent-oxide particles to absorb the effluents from the combustion stream. In accordance with various embodiments of the present invention, the oxidant can be introduced at flame level or a portion of the oxidant may be introduced into the gaseous combustion stream downstream of the combustion zone in a stepwise manner which results in improved effluent absorption. In accordance with the process of the present invention, the combustion flame temperature, oxidant introduction and atomizing conditions are controlled so as to insure the production of a submicron sized sorbent-oxide particle.

Reference is now made to the accompanying drawings in which:

Figure 1 is a schematic illustration of the process of the present invention employing a Ca salt as the water soluble effluent sorbent compound for the in-situ product of the effluent sorbent-oxide aerosol.

Figure 2 is a graph illustrating the effect of sorbent-oxide particle size on sulfur capture.

Figure 3 is a graph illustrating the effect of atomization on sorbent-oxide particle size and sorbent utilization.

Figure 4 is a further graph showing the effect of atomization on sorbent utilization and correspondingly effluent absorption.

Figure 5 is a graph illustrating the effect of stepwise oxidant introduction on sorbent utilization.

The present invention relates to a process for removing effluents from a gaseous combustion stream and, more particularly, a process for the in-situ production of a sorbent-oxide aerosol during the combustion of a hydrocarbon whereby effluents are removed from the resultant gaseous hydrocarbon combustion stream.

With reference to Figure 1, the mechanism of the process of the present invention will be discussed in detail. An aqueous solution of a dissolved effluent sorbent compound is admixed with a hydrocarbon containing fossil fuel to form a combustible fuel mixture. The amount of sorbent in the aqueous solution and the volume of aqueous solution mixed with the fossil fuel is dependent on the nature and amount of effluent bearing material which is present in the fuel. In the case of sulfur, for example, the molar ratio of sorbent to sulfur in the fuel mixture may be up to 2.5 and preferably is between about 0.6 to 1.2 depending on the particular sorbent used. In the case of nitrogen, the ratio would be substantially the same as for sulfur given above. In accordance with the present invention, the effluent sorbent compound is in the form of a metal salt selected from the group consisting of alkaline, alkaline earth or other metal salts wherein the metals have the same or higher valence than the alkaline earth metals. Preferred metals are Ca and Mg with Ca being the ideal. Particularly suitable calcium metal salt compounds are $CaCl_2$, $Ca(NO_3)_2$, $Ca(CH_3COO)_2$, $Ca(C_2H_5COO)_2$, $Ca(CHOO)_2$, $Ca(OH)_2$, CaO and mixtures thereof. Similar magnesium compounds may be employed. The addition of solubility enhancing compounds to the water that raise the solubility of the metal salt, such as sucrose, glycerol, alcohols, and the like improves the performance of the process. In the case of water insoluable metal salt compounds such as $CO(OH)_2$ and CaO solubility enhancing compounds are required to dissolve the salts in order to form the aqueous solution. The solubility enhancing compound is employed in an amount sufficient to take all of the metal salt into aqueous solution.

The fuel mixture as described above is fed to a nozzle where the fuel is atomized under controlled conditions with or without an atomizing gas, preferably with an atomizing gas. Suitable atomizing gases include air, steam, N_2, O_2, Ar, He, with air, steam, N_2 being preferred. Atomization, as will be demonstrated in the examples hereinbelow, tends to have a strong effect on the particle size of the resultant sorbent-oxide produced and, ultimately, the degree of effluent absorption. During fuel atomization, the fuel mixture is transformed into small droplets. By controlling atomizing conditions, droplet size is controlled which, it has been found, controls the particle size of the sorbent-oxide ultimately produced in the process of the present invention. As noted above, it is preferred to atomize the fuel mixture with an atomizing gas. The mass ratio of gas to fuel mixture should be greater than or equal to 0.05 preferably greater than or equal to 0.10 and ideally between about 0.15 and 3.00 in order to obtain the desired sorbent oxide particle size as set forth hereinbelow and demonstrated by the examples and experimental work.

The atomized fuel mixture is thereafter combusted in a combustion zone in the presence of an oxidant under controlled conditions. During combustion, it is believed that small solid crystals of the sorbent are formed after evaporation of the water. These crystals then decompose at the combustion flame temperature T_1 and ultra-fine particles of sorbent-oxide are generated in the gaseous combustion stream. The combustion temperature T_1, namely the adiabatic flame temperature may be controlled in order to achieve the desired combustion of the fuel and formation of the sorbent. At elevated flame temperatures there is a tendency for a coalescense effect which has an adverse effect on the sorbent-oxide particle size. At the same time, the temperature must be sufficiently high to obtain sufficient fuel utilization and sorbent generation. In order to effectively carry out the process of the present invention, the combustion temperature T_1 is between about 1400°K to 2450°K, preferably 1900°K to 2200°K.

In order to obtain effective combustion, the oxidant must be present in an amount at least equal to the stoichiometric amount with respect to the fuel oil and preferably in an amount greater than the stoichiometric amount and up to 1.1 times the stoichiometric amount. It has been found that the process of the present invention may be improved by feeding the oxidant in a stepwise manner, that is, a portion to the combustion zone, i.e. flame, and a portion downstream of the combustion zone at a desired temperature. The oxidant is fed to the combustion zone and downstream thereof, with respect to total oxidant employed, of between about 60% to 95% and 5% to 40%, respectively, preferably 80% to 90% and 10% to 20%, respectively. The oxidant introduced downstream of the combustion zone should be introduced at a temperature of between about 1400°K to 2200°K, preferably 1400°K to 1600°K in order to obtain best results with respect to complete combustion of the fuel and formation of the sorbent to obtain the desired sorbent-oxide particles.

The resultant aerosol from the combustion of the atomized fuel mixture, that is the sorbent-oxide particles carried in the gaseous hydrocarbon combustion stream, is characterized by an ultra-fine sorbent-oxide particle having preferably a mean diameter of submicron size and ideally less than or equal to 0.5 μm. The combustion stream is cooled in a controlled manner through a desired temperature range T_2 in order to allow the sorbent-oxide particles to react with and absorb the effluent from the combustion stream. The temperature range T_2 is between about 1350°K to 700°K, preferably 1350°K to 1000°K. The gaseous combustion stream should remain within the temperature range T_2

for a period of greater than 0.10 seconds and preferably greater than 0.50 seconds in order to insure effective sorbent utilization and effluent capture. It is preferred that sorbent utilization be greater than or equal to about 35%, ideally 50%. Sorbent utilization is defined as follows:

$$\%\ \text{sorbent utilized} = 100 \times \frac{\left(\dfrac{[\text{effluent}]\text{baseline} - [\text{effluent}]\text{sorbent}}{[\text{effluent}]\text{baseline}}\right)}{\dfrac{1}{\alpha}\left(\dfrac{\text{moles sorbent}}{\text{moles effluent}}\right)}$$

where α is the stoichiometric coefficient in the sorbent and effluent chemical reaction and [effluent]baseline is the concentration of effluent in the dry emission gases in the absence of a sorbent.

The following examples illustrate specific features of the process of the present invention but in no way are intended to be limiting.

EXAMPLE I

In order to demonstrate and quantify the existance of unwanted effluents, namely sulfur, in a hydrocarbon fuel combustion stream, a No. 6 fuel oil having a sulfur content of 2% by weight and a heating value of 17,000 BTU/lb. was combusted in a furnace. The fuel oil was fed to the furnace through a commercially available nozzle and was atomized with N_2 (nitrogen) in a mass ratio of N_2 to No. 6 fuel oil of 1.0. The fuel was combusted with air at a firing rate of 56,000 BTU/hr. until completely combusted. The concentration of SO_2 in the dry emission gases was then measured. By dry emission gases is meant all the gases produced during the combustion process, with the exception of H_2O, corrected to a zero percent oxygen. The concentration was found to be 2000 ppm.

In order to demonstrate what effect an aqueous mixture of the hydrocarbon would have on SO_2 emissions, the run described above was repeated with the No. 6 fuel oil mixed with water. The fuel oil was present in an amount of 86% by weight, balance water. The fuel oil and water were admixed with the aid of an in-line mixer and fed to the furnace, atomized with N_2 in the same manner as previously described and combusted with air at a firing rate of 56,000 BTU/hr. The concentration of SO_2 in the dry emission gases was again 2000 ppm thereby demonstrating that the addition of water per se to the fuel oil prior to combustion did not have any effect on the concentration of SO_2 emissions in the combustion gases.

EXAMPLE II

A further experiment was conducted to demonstrate the effectiveness of the process of the present invention on removing effluents from a gaseous hydrocarbon fuel combustion stream. The experiment was similar to those run in Example I above with the exception that the No. 6 fuel oil was admixed with a 34 weight percent aqueous solution of $CaCl_2$ so as to yield a mixture comprising 77% by weight No. 6 fuel oil. The molar ratio of Ca to S was equal to 1.0. This fuel mixture was atomized and combusted in the same manner as described above with reference to Example I.

The concentration of SO_2 in the dry emission gases was measured and was found to be 960 ppm which represents a 52% reduction in SO_2 emissions when compared to Example I above. Based on elemental analysis, the solids produced during this experiment contained a sulfur to calcium molar ratio of 0.52. This experiment indicates that the addition of the $CaCl_2$ aqueous solution prior to combustion caused a greater than 35% reduction in the concentration of SO_2 in the dry emission gases, that is, a 52% SO_2 reduction, which can be associated with the reaction with S of more than 35% of the Ca injected, i.e., a greater than 35% calcium utilization. This is derived from the equation set forth below in Example IV.

EXAMPLE III

In order to demonstrate the effect atomization of the fuel mixture has on effluent emissions, the experiment of Example II was repeated with the fuel mixture being atomized with N_2 in a mass ratio of N_2 to fuel mixture of 2.5, that is, 2.5 times greater than the mass ratio of Example II. The mixture was combusted in air at a firing rate of 56,000 BTU/hr. as was the case in Example II.

The SO_2 concentration in the dry emission gases was measured and was found to be 300 ppm. This value represents an 85% reduction in SO_2 emissions when compared with run 2 of Example I, where no Ca salt was dissolved in the water. This value also represents a further reduction in SO_2 emission when compared with Example II where the same amount of calcium was employed but where the fuel mixture was atomized at a lower N_2 to fuel oil mass ratio.

Scanning-electron micrographs of the solids collected from Examples II and III show that in the latter case, when the atomizing fluid to fuel ratio is higher and the SO_2 emissions are lower, the concentration of submicron sorbent particles produced was much higher than in the former case. In the former an important fraction of the sorbent particles (between

30 and 50%) have a mean diameter higher than 5 μm, while in the latter most of them (more than 80%) were submicron sized. This demonstrates that good atomization increases the density of small particles which, it is believed, effects effluent emission removal as shown above. The increase in density of small particles increases the surface area of the sorbent and, correspondingly, the ability to absorb effluents.

EXAMPLE IV

A further experiment was conducted employing 27.2% by weight calcium acetate aqueous solution added to the No. 6 fuel oil of the previous examples so that the fuel oil represented 83% by weight of the fuel mixture, and the calcium to sulfur molar ratio was equal to 0.56. The mixture was combusted with air in the same facility as in Example I. The mixture was atomized with N_2, at a N_2 to fuel mass ratio of 2.3. The SO_2 concentration in the dry emission gases were measured and found to be 1502 ppm, which corresponds to a percentage of calcium utilization equal to 44.5%, as given by the equation:

$$\%\ \mathrm{Ca\ util} = 100 \times \frac{\left(\dfrac{[SO_2]_{\mathrm{baseline}} - [SO_2]_{\mathrm{sorbent}}}{[SO_2]_{\mathrm{baseline}}}\right)}{\dfrac{1}{\alpha}\left(\dfrac{\mathrm{moles\ Ca}}{\mathrm{moles\ S}}\right)}$$

where $\alpha = 1$, $\frac{\text{moles Ca}}{\text{moles S}}$ is the calcium to sulfur molar ratio, which in this case is 0.56, the $[SO_2]_{baseline}$ is the concentration of SO_2 in the dry emission gases in the absence of a Ca salt dissolved in the water, which is equal to 2000 ppm, as indicated by experiment 2 in Example I, and $[SO_2]_{sorbent}$ is the concentration of SO_2 in the dry emission gases when a Ca salt dissolved in water is injected with the fuel, which in the particular case of this example is equal to 1502 ppm.

A scanning electron micrograph of the solids produced indicates that most of the sorbent particles produced were cubic crystals of submicron size. A particle size distribution of the solids shows that the volume mean diameter of the particles is between 0.3 and 0.4 µm.

This example again demonstrates the effectiveness of the process of the present invention.

EXAMPLE V

A further experiment was conducted employing a coal-water slurry as the hydrocarbon fuel. The coal-water slurry was combusted in a furnace under conditions similar to those described for the experiment 1 in Example I, and the SO_2 concentration in the dry gases was found to be 2000 ppm.

In a similar experiment an aqueous solution containing calcium acetate in a 27.2% by weight concentration was mixed with the coal-water slurry with the aid of an in-line mixer as described in the previous examples. The amount of calcium acetate solution added was such that the molar ratio of calcium in the solution to sulfur in the coal-water slurry was equal to 1.0. The mix was fired under the same conditions as described above in Example I and the SO_2 concentration in the dry gases was found to be 800 ppm which, according to the equation described in the previous example, represents a 60% calcium utilization.

As in the previous example, a scanning electron micrograph of the solids produced indicated that most of the sorbent particles produced were crystals of submicron size.

This example demonstrates that the process of the present invention is equally effective in the removal of sulfur effluents from combustion gases produced during combustion of either solid or liquid hydrocarbons.

EXAMPLE VI

A further pair of experiments were conducted to demonstrate the effect of oxidant introduction on effluent removal. In both experiments a fuel mixture of the No. 6 fuel oil and a 27.2% by weight calcium acetate was prepared such that the molar ratio of Ca to S was 1.0. The combustion conditions were identical to those described above with the exception that in experiment 1 all of the oxidant, in this case air, was introduced with the fuel/Ca-solution mixture at the top of the furnace, while in experiment 2, 75% of the air was injected with the aforesaid mixture, and the other 25% was injected downstream of the furnace, at a temperature of 1530°K.

In experiment 1, a 30% Ca utilization was obtained which, according to the equation described in the previous example, corresponds to a 30% reduction in SO_2 emission. In experiment 2, a 60% Ca utilization was obtained, corresponding to a 60% reduction in SO_2 emission.

This example clearly shows that with an adequate injection of oxidant into the furnace, the capabilities of the Ca salt to reduce the SO_2 emissions in the combustion process can be strongly enhanced in a two-stage process.

EXAMPLE VII

In a further experiment the same kind of fuel oil No. 6 used in Example I was mixed with a $Ca(OH)_2$

slurry, so that fuel oil represents 81% by weight of the mixture, $Ca(OH)_2$ 6% by weight with balance water. The molar ratio of $Ca(OH)_2$ to sulfur in the fuel oil in the mixture is equal to 1.0, and the weight ratio of fuel oil to water was the same as that of the mixture used in experiment 2 of Example I. This mixture was prepared and combusted under the same conditions as in Example I, and the SO_2 concentration in the dry emission gases was equal to 1680 ppm. Since the combustion of such mixture without the addition of $Ca(OH)_2$ generates an SO_2 concentation of 2000 ppm, the percentage of calcium utilization in this experiment is equal to 16%, according to the formula described in Example IV, above.

In a similar experiment, sucrose was added to the $Ca(OH)_2$ slurry prior to the mixing with the fuel oil. The sucrose enables the $Ca(OH)_2$ to be dissolved in water, and in this case, sucrose was used in an amount to insure all the $Ca(OH)_2$ dissolved and a homogeneous solution of $Ca(OH)_2$ and sucrose in water was produced. This solution was mixed with fuel oil No. 6 in proportions so that the molar ratio of calcium to sulfur was equal to 1.0 and the weight ratio of fuel oil to water is the same as in the previous experiment. This mixture was combusted under the same conditions as in the previous experiment, and the SO_2 concentration in the dry emission gases was found to be 1300 ppm, which represents a 35% calcium utilization.

In a third experiment, a solution of sucrose in water of the same concentration as in the previous experiment was mixed with fuel oil, so that the weight ratio of fuel oil to water was the same as above. The combustion of this mixture resulted in a 2000 ppm SO_2 concentration in the dry emission gases, indicating that the addition of sucrose by itself to the mixture does not cause any reduction of the SO_2 concentration in the effluent gases.

This example shows that the addition of a compound to the water that enhances the solubility of the calcium salt improves the effectiveness of the sorbent generated for removal of effluents from a gaseous combustion stream.

Based on the results of the foregoing examples and additional experimental work, the predicted effect of (1) sorbent-oxide particle size, (2) atomization, (3) flame temperature, and (4) two stage feeding of the oxidant was determined. The results are graphically illustrated in Figures 2 through 5.

Figure 2 demonstrates the effect of sorbent-oxide particle size on sulfur capture where the sorbent employed is calcium. From Figure 2, it is clear that as the particle size of the sorbent-oxide decreases the degree of sulfur capture increases. This is believed to be attributable to the increase in sorbent surface area achieved via small particle size.

Figure 3 illustrates the effect of atomization on sorbent-oxide particle size and sorbent utilization. As is clearly seen from the graph and photo-micrographs, as the mass ratio of atomizing gas to fuel mixture increases, the resultant sorbent-oxide particle size decreases and sorbent utilization increases and, therefore, effluent absorption.

Figure 4 further demonstrates the effect of atomization on sorbent utilization for various sorbent materials. Again, as was the case above, sorbent utilization increases with an increase in atomizing mass ratio; however, the degree of effect is shown to be sorbent dependent.

The effect of stepwise feeding of the oxidant is demonstrated illustratively in Figure 5. As the amount of oxidant delivered to the combustion zone decreases and correspondingly downstream feeding decreases, the sorbent utilization increases.

CLAIMS

1. A process for the in-situ production of an effluent sorbent-oxide aerosol during the combustion of a hydrocarbon containing fuel whereby effluents are removed from the resultant gaseous hydrocarbon combustion stream, said process comprising forming an aqueous solution comprising an effluent sorbent compound, admixing the aqueous solution of the effluent sorbent compound with a hydrocarbon containing fuel so as to form a combustible fuel mixture, atomizing said combustible fuel mixture and feeding said atomized fuel to a combustion zone, combusting said atomized fuel mixture in said combustion zone under controlled temperature conditions T_1 wherein T_1 is greater than or equal to 1400°K in the presence of an oxidant so as to obtain a sorbent-oxide aerosol comprising ultra-fine sorbent-oxide particles having a mean diameter of submicron size in said gaseous combustion stream, and cooling said gaseous combustion stream to a temperature T_2 wherein T_2 is less than T_1 so that said sorbent-oxide particles absorb said effluents from said gaseous combustion stream.

2. A process according to claim 1 wherein said effluent sorbent compound is selected from the group consisting of salts of Ca, salts of Mg and mixtures thereof.

3. A process according to claim 1 or 2 wherein said effluent sorbent compound is a salt of Ca.

4. A process according to claim 3 wherein said hydrocarbon fuel contains sulfur which upon combustion forms a sulfurous by-product effluent in the form of SO_x.

5. A process according to claim 4 wherein said fuel mixture has a Ca to S ratio of up to 2.5.

6. A process according to claim 4 or 5 wherein said fuel mixture has a Ca to S ratio of between about 0.6 to 1.2.

7. A process according to claim 4, 5 or 6 wherein at least 35% by weight of said sorbent is utilized in sulfur absorptions so as to obtain a sulfur reduction in the amount of at least 21% when compared to sorbent-free combustion processes.

8. A process according to claim 7 wherein said sorbent utilization is greater than 50%.

9. A process according to claim 1 wherein said effluent sorbent compound is selected from the group consisting of $CaCl_2$, $Ca(NO_3)_2$, $Ca(CH_3COO)_2$, $Ca(CHOO)_2$, $Ca(OH)_2$, CaO and mixtures thereof.

10. A process according to claim 1 including admixing a sorbent solubility enhancing compound in said aqueous solution forming step.

11. A process according to claim 10 wherein said effluent sorbent compound is selected from the group consisting of $Ca(OH)_2$, CaO and mixtures thereof.

12. A process according to claim 10 or 11 wherein said sorbent solubility enhancing compound is selected from the group consisting of sucrose, glycerol, alcohols and mixtures thereof.

13. A process according to any preceding claim wherein said temperature T_1 is between about 1400°K to about 2450°K.

14. A process according to any preceding claim wherein said temperature T_1 is between about 1900°K to about 2200°K.

15. A process according to any preceding claim wherein said temperature T_2 is between about 700°K to about 1350°K.

16. A process according to any preceding claim wherein said temperature T_2 is between about 1000°K to about 1350°K.

17. A process according to any preceding claim wherein said sorbent-oxide particles have a mean diameter of about ≤ 1.0 µm.

18. A process according to any preceding claim wherein said sorbent-oxide particles have a mean diameter of about ≤ 0.5 µm.

19. A process according to any preceding claim wherein said fuel mixture is atomized by an atomizing fluid.

20. A process according to any preceding claim wherein said oxidant is fed to said combustion zone in at least the stoichiometric ratio with respect to said hydrocarbon fuel.

21. A process according to any preceding claim including the step of feeding additional oxidant to said gaseous stream downstream of said combustion zone.

22. A process according to claim 21 wherein said oxidant is fed to said combustion zone and to said gaseous stream in a total amount greater than the stoichiometric ratio with said hydrocarbon fuel.

23. A process according to claim 21 or 22 wherein said combustion zone is fed with between about 60 to 95% of total oxidant and said gaseous stream downstream of said combustion zone is fed with between about 5 to 40% of total oxidant.

24. A process according to claim 21, 22 or 23 wherein said combustion zone is fed with between about 80 to 90% of total oxidant and said gaseous stream downstream of said combustion zone is fed with between about 10 to 20% of total oxidant.

25. A process for the in-situ production of an effluent sorbent-oxide aerosol during the combustion of a hydrocarbon containing fuel whereby effluents are removed from the resultant gaseous hydrocarbon combustion stream said process comprising providing a hydrocarbon containing fuel, forming an aqueous solution comprising an effluent sorbent compound dissolved in water, separately feeding said hydrocarbon fuel and aqueous solution to a combustion zone wherein said fuel and solution are admixed, combusting said atomized fuel mixture in said combustion zone under controlled temperature conditions T_1 wherein T_1 is greater than or equal to 1400°K in the presence of an oxidant so as to obtain a sorbent-oxide aerosol comprising ultra-fine sorbent-oxide particles having a mean diameter of submicron size in said gaseous combustion stream, and cooling said gaseous combustion stream to a temperature

T_2 wherein T_2 is less than T_1 so that said sorbent-oxide particles absorb said effluents from said gaseous combustion stream.

26. A process substantially as herein described with reference to and as shown in the accompanying drawings.

Published 1991 at The Patent Office. Concept House. Cardiff Road. Newport. Gwent NP9 1RH. Further copies may be obtained from
Sales Branch. Unit 6. Nine Mile Point. Cwmfelinfach. Cross Keys. Newport. NP1 7HZ. Printed by Multiplex techniques ltd. St Mary Cray. Kent.