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(54) **REDUCED-EMISSIONS COMBUSTION
UTILIZING MULTIPLE-COMPONENT
METALLIC COMBUSTION CATALYST AND
LIGHTLY CATALYZED DIESEL OXIDATION
CATALYST**

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(57) **ABSTRACT**

An improved diesel operation system employs a lightly diesel oxidation catalyst (DOC), preferably with a platinum containing fuel borne catalyst (FBC) in the fuel. The DOC is at least partially lightly catalyzed with precious metal catalyst, e.g., platinum group metal, having a metal loading of from about 3 to 15 grams per cubic foot to minimize formation of NO₂ in the exhaust gas. Preferred fuel borne catalyst levels will be low, e.g., from 0.05 to 0.5 ppm for platinum and 3 to 8 ppm for cerium and/or iron, thereby providing effective engine out emissions reductions without discharging excessive amounts of metal catalysts or NO₂ to the atmosphere.

**REDUCED-EMISSIONS COMBUSTION UTILIZING
MULTIPLE-COMPONENT METALLIC
COMBUSTION CATALYST AND LIGHTLY
CATALYZED DIESEL OXIDATION CATALYST**

RELATED APPLICATIONS AND PRIORITY

[0001] This is a continuation in part of and claims priority to pending U.S. patent application Ser. No. 10/306,954 filed 29 Nov. 2002, which claims priority to U.S. Provisional Patent Application No. 60/354,435 filed Feb. 04, 2002 (hereinafter, both referred to as priority applications).

BACKGROUND OF THE INVENTION

[0002] The invention concerns a new process for to reduce emission of pollutants of the type generated by incomplete combustion, e.g., particulates, unburned hydrocarbons and carbon monoxide, while avoiding increasing the production of NO₂.

[0003] Diesel engines have a number of important advantages over engines of the Otto type. Among them are fuel economy, ease of repair and long life. From the standpoint of emissions, however, they present problems more severe than their spark-ignition counterparts. Emission problems relate to particulate matter (PM), nitrogen oxides (NO_x), unburned hydrocarbons (HC) and carbon monoxide (CO). NO_x is a term used to describe various chemical species of nitrogen oxides, including nitrogen monoxide (NO) and nitrogen dioxide (NO₂), among others. NO is of concern because it is believed to undergo a process known as photo-chemical smog formation, through a series of reactions in the presence of sunlight and hydrocarbons, and is significant contributor to acid rain. NO₂ on the other hand has a high potential as an oxidant and is a strong lung irritant. Particulates (PM) are also connected to respiratory problems. As engine operation modifications are made to reduce particulates and unburned hydrocarbons on diesel engines, the NO_x emissions tend to increase.

[0004] After treatment devices, such as diesel particulate filters (DPFs) and diesel oxidation catalysts (DOCs), have been proposed to reduce the emission of particulates and gaseous hydrocarbons and carbon monoxide from diesel engines. These devices are greatly stressed in older engines and are in need of efficiency improvements in newer engines. In all cases, they are expensive due in significant part to the cost of precious metals used required to be effective. It would be desirable to reduce the cost of DOC devices and/or improve their efficiency.

[0005] NO₂, being a strong oxidant, has been recognized by the art for playing a useful role in burning diesel particulates. Cooper, et al., U.S. Pat. No. 4,902,487, implements this reaction through the use of a heavily catalyzed DOC upstream of an uncatalyzed DPF. The heavily catalyzed DOC converts NO present in the exhaust to NO₂, which oxidizes carbon particulates to help regenerate the filter. As a first element in Example 2 of that patent, a conventional ceramic monolith supported catalyst was employed containing approximately 80 gm/ft³ Pt. Typical loadings of platinum are reportedly 30 to 90 gm/ft³ of DOC volume. More recently a manufacturer of such devices has introduced a system which utilizes a heavily catalyzed DPF to help with low temperature regeneration. Total precious metal loadings are now reportedly 90 to 120 gm/ft³. A result

of this approach is large quantities of excess NO₂ escaping the system. NO₂ is a strong lung irritant and concentrations have been limited in exhaust gas by MSHA and are proposed to be capped at 20% of exhaust nitrogen oxides by CARB. However, in this type of system, the art finds it necessary to utilize high platinum loadings to achieve satisfactory regeneration despite the high cost of the platinum and the associated problems of NO₂ emission.

[0006] Another commercial effort has been made to improve regeneration of the soot filter of the Cooper type, and generate high NO₂ emissions and aid DPF regeneration through the use of cerium or iron fuel additives. See U.S. Pat. No. 6,767,526 to Blanchard, et al., which employs a DOC with a DPF or a DPF alone with fixed platinum loadings of unspecified concentrations sufficient to oxidize NO to NO₂. It does not address the high cost of platinum related to the Cooper system or the adverse effect of NO₂ emissions.

[0007] Another commercially tested system uses a DOC upstream of a new wire mesh filter but needs the heavily catalyzed DOC which forms high NO₂ in the exhaust to regenerate the uncatalyzed wire mesh filter. See, for example, EP 1 350 933.

[0008] In U.S. Pat. No. 6,023,928, Peter-Hoblyn and Valentine describe a platinum FBC with a DOC or DPF and or Pt/Ce with a catalyzed or uncatalyzed DPF but does not describe minimizing platinum loadings or reduction in NO₂. Conventional DOC's with high platinum loadings can convert sulfur into sulfate species increasing particulates and also increasing NO₂. Catalyzed DOCs have not been considered effective, only able to provide PM reductions of 20 to 25%.

[0009] What is needed is a system that provides good PM reduction while minimizing the generation and escape of NO₂.

BRIEF DESCRIPTION OF THE INVENTION

[0010] It is an object of the invention to provide a system that provides good PM reduction through a catalytic exhaust treatment while minimizing the escape of NO₂.

[0011] It is another object of the invention to provide a system that can reduce system costs by lowering the requirements for platinum catalyst while maintaining the apparent benefit of NO₂ as an aid to soot oxidation in a DOC.

[0012] These and other objects are accomplished by the invention, which provides an improved diesel exhaust treatment system. In a principal aspect, the invention provides a method for reducing particulate emissions from a diesel engine while also controlling emissions of NO₂ as a percent of exhaust total nitrogen oxides, comprising: adding a fuel borne catalyst comprising platinum and cerium and/or iron at a total metal concentration of from 2 to 15 ppm in the fuel to a diesel fuel; and passing exhaust produced by the combustion through a diesel oxidation catalyst having substrate with a precious metal catalyst thereon, the catalyst be present on the substrate in an amount of less than 15 grams per cubic foot of substrate.

**DETAILED DESCRIPTION OF THE
INVENTION**

[0013] As noted, the invention provides improved systems for diesel operation and preferably employs an FBC and an

emissions after treatment device comprising a lightly catalyzed diesel oxidation catalyst, DOC, e.g., of conventional or alternative construction. The term FBC refers to fuel borne catalyst, which is typically a fuel soluble or suspended composition having a metal component that is released to the combustion chamber in active form during the combustion of the fuel in the diesel engine. The terms DOC and FBC will all be explained in greater detail below and are also known to the art as evidenced by the above citations.

[0014] The invention employs an emissions after treatment device treatment comprising a catalyst substrate that can be a DOC alone or with a DPF, the catalyst substrate being lightly catalyzed with precious metal, e.g., a platinum group metal. The catalyst loading will be less than the art has seen the need for to convert NO to NO₂ for use as a soot oxidant, preferably having a metal loading of less than 15 gm/ft³ platinum group metal loading, desirably less than 10 gm/ft³, and most preferably 3 to 5 gm/ft³. These low catalyst loadings aid in burning soot, without creating so much NO₂ that excessive emission of the NO₂ becomes an environmental problem. Among the suitable precious metals for catalyzing the DOC are those identified in the Cooper, et al., patent identified above, and particularly comprises platinum group metal.

[0015] In one embodiment of the invention, a lightly catalyzed DOC contains less than 15 grams per cubic foot (gm/ft³) platinum group metal loading, desirably less than 10 gm/ft³, and preferably 3 to 5 gm/ft³, used with a platinum and cerium FBC at 0.015-0.5 ppm Pt and 0.5-8 ppm Ce and/or iron. Higher and lower levels of additives may be employed for portions of a treatment or operation cycle. A further discussion of FBC compositions is provided below.

[0016] The improved systems of the invention significantly reduce PM, e.g., by 30 to 50% in preferred embodiments, e.g., when used with ultra low sulfur diesel fuel and does not increase NO₂ above baseline and has demonstrated the ability to maintain low NO₂ emissions, e.g., to below 20% of total nitrogen oxide species while also minimizing the use of platinum group metals.

[0017] Among the diesel fuels suitable for use in the invention are those which typically comprise a fossil fuel, such as any of the typical petroleum-derived fuels including distillate fuels. The diesel fuel can be of any of those formulations disclosed in the above priority patent applications, which are incorporated by reference herein in their entireties. A fuel can be one or a blend of fuels selected from the group consisting of distillate fuels, including diesel fuel, e.g., No. 2 Diesel fuel, No. 1 Diesel fuel, jet fuel, e.g., Jet A, or the like which is similar in boiling point and viscosity to No. 1 Diesel fuel, ultra low sulfur diesel fuel (ULSD) and biologically-derived fuels, such as those comprising a "mono-alkyl ester-based oxygenated fuel", i.e., fatty acid esters, preferably methyl esters of fatty acids derived from triglycerides, e.g., soybean oil, Canola oil and/or tallow.

[0018] Jet A and Diesel No. 1 are deemed equivalent for applications of the invention, but are covered by different American Society For Testing and Materials (ASTM) specifications. The diesel fuels are covered by ASTM D 975, "Standard Specification for Diesel Fuel Oils". Jet A has the designation of ASTM D 1655, "Standard Specification for Aviation Turbine Fuels". The term ultra low sulfur diesel fuel (ULSD) means No. 1 or No. 2 diesel fuels with a sulfur

level no higher than 0.0015 percent by weight (15 ppm) and some jurisdictions require a low aromatic hydrocarbon content e.g., less than ten percent by volume.

[0019] The process of the invention employs a fuel-soluble, multi-metal catalyst, i.e., an FBC, preferably comprising fuel-soluble platinum and either cerium or iron or both cerium and iron. The cerium and/or iron are typically employed at concentrations of from 0.5 to 20 ppm and the platinum from 0.0005 to 2 ppm, with preferred levels of cerium and/or iron being from 5 to 10 ppm, e.g., 7.5 ppm, and the platinum being employed at a level of from 0.0005 to 0.5 ppm, e.g., less than 0.15 ppm. In some embodiments, the treatment regimen can call for the utilizing higher catalyst concentrations initially or at defined intervals or as needed—but not for the whole treatment as has been necessary in the past. The cerium and/or iron are preferred at levels of cerium and/or iron being from 2 to 10 ppm, e.g., 3-8 ppm, and the platinum being employed at a level of from 0.05 to 0.5 ppm, e.g., from 0.1 to 0.5 ppm, e.g., 0.15 ppm, for typical operations. The tests below run at these levels show surprising results in terms emissions utilizing a lightly catalyzed DOC.

[0020] The cerium and/or iron FBC is preferred at concentrations of 1 to 15 ppm cerium and/or iron w/v of fuel, e.g., 4 to 15 ppm. A preferred ratio of cerium and/or iron to platinum for the FBC is from 100:1 to 3:1, e.g., more typically will be from 75:1 to 10:1. A formulation using 0.15 ppm platinum with 7.5 ppm cerium and/or iron is exemplary.

[0021] An advantage of low levels of catalyst (about 3 to 15 ppm total), preferably below 12 ppm and more preferably below 8 ppm, is the reduction in ultra fine particles resulting from metal oxide emissions. Data published under the European VERT program show that at high FBC dose rates of 20 ppm, or 100 ppm, cerium the number of ultra fine particles increases dramatically above baseline. However, for a bimetallic used at 0.5/7.5 or 0.25/4 ppm there is no significant increase in the ultra fine particle number. It has been found that at low levels of FBC there is not a separate ultrafine oxide particle peak and metal oxides are contained in the soot over the entire particle size distribution. A further advantage of the low dose rates prescribed by the current invention is a reduction in the contribution of metal ash to overall engine emissions. For an engine meeting 1998 US emission standards, particulate emissions are limited to 100,000 µg/hp-hr (0.1 gram/hp-hr). A cerium FBC used at 30 ppm in fuel represents a metal catalyst input loading to the engine of 6000 µg/hp-hr of metal or roughly 6% of untreated engine emissions. Therefore, low levels of catalyst used in the present invention of less than 8 ppm and preferably 4 ppm as a bimetallic or trimetallic FBC will, for example, contribute only 800-1600 µg/hp-hr of catalyst loading to the engine or 0.8-1.6% of baseline soot emissions. This has the advantage of reduced metal ash emissions and reduces the contribution of the FBC to overall particulate mass emissions or loading of metal ash to downstream emission control devices.

[0022] The fuel can contain detergent (e.g., 50-300 ppm), lubricity additive (e.g., 25 to about 500 ppm), other additives, and suitable fuel-soluble catalyst metal compositions, e.g., 0.1-2 ppm fuel soluble platinum group metal composition, e.g., platinum COD or platinum acetylacetonate and/or 2-20 ppm fuel soluble cerium and/or iron composition,

e.g., cerium as a soluble compound or suspension, cerium octoate, ferrocene, iron oleate, iron octoate and the like. The fuel as defined, is combusted without the specific need for other treatment devices although they can be used especially for higher levels of control on diesels.

[0023] Among the specific cerium compounds are: cerium III acetylacetonate, cerium III naphthenate, and cerium octoate, cerium oleate and other soaps such as stearate, neodecanoate, and other C₆ to C₂₄ alkanolic acids, and the like. Many of the cerium compounds are trivalent compounds meeting the formula: Ce (OOCR)₃ wherein R=hydrocarbon, preferably C₂ to C₂₂, and including aliphatic, alicyclic, aryl and alkylaryl. Preferably, the cerium is supplied as cerium hydroxy oleate propionate complex (40% cerium by weight) or a cerium octoate (12% cerium by weight). Preferred levels are toward the lower end of this range.

[0024] Among the specific iron compounds are: ferrocene, ferric and ferrous acetyl-acetonates, iron soaps like octoate and stearate (commercially available as Fe(III) compounds, usually), iron naphthenate, iron tallate and other C₆ to C₂₄ alkanolic acids, iron penta carbonyl Fe(CO)₅ and the like.

[0025] Any of the platinum group metal compositions, e.g., 1,5-cyclooctadiene platinum diphenyl (platinum COD), described in U.S. Pat. No. 4,891,050 to Bowers, et al., U.S. Pat. No. 5,034,020 to Epperly, et al., and U.S. Pat. No. 5,266,083 to Peter-Hoblyn, et al., can be employed as the platinum source. Other suitable platinum group metal catalyst compositions include commercially-available or easily-synthesized platinum group metal acetylacetonates, including substituted (e.g., alkyl, aryl, alkylaryl substituted) and unsubstituted acetylacetonates, platinum group metal dibenzylidene acetonates, and fatty acid soaps of tetramine platinum metal complexes, e.g., tetramine platinum oleate.

[0026] The invention can employ a DOC alone or it can be used with other devices including DPFs, particulate reactors, partial filters or NO_x adsorbers can also be used and benefit from reduced engine out emissions of the current invention. See the examples below, for the engine out results and the benefits of the FBC with catalyzed DOC devices to reduce NO₂ and particulate emissions. While not wishing to be bound by any theory, the unexpectedly good results with after treatment devices as well as for engine out emissions, this may be because the platinum is not present in amounts sufficient to produce excessive amounts of NO₂ and yet produces some NO₂ which is sufficient to foster oxidation of the carbon in the particulates in the presence of low levels of cerium and/or iron. NO₂ is a strong lung irritant and can be generated in large quantities by traditional use of heavily catalyzed aftertreatment devices such as DOCs, DPFs or combinations. The net result of the limited NO₂ production due to low platinum concentrations and the cerium and/or iron being present in low but sufficient amounts is to produce greater than expected reductions in particulates (as well as other species resulting from incomplete oxidation) and at the same time control the amount of NO₂ generated and released. Unlike the prior art, then, the invention has found that high NO₂ production rates are not necessary and, indeed, has found a way to provide emissions less irritating to humans.

[0027] The following examples are presented to further explain and illustrate the invention and are not to be taken

as limiting in any regard. Unless otherwise indicated, all parts and percentages are by weight.

EXAMPLE 1

[0028] This example reports testing on a 1990 International DT 466 7.6 liter diesel engine operated over replicate hot transient test cycles on an engine dynamometer. Emissions results are the average of triplicate tests and are measured in units of grams/hp-hr. Testing on untreated No. 2 diesel fuel with >300 ppm sulfur produced baseline particulate emissions of 0.253 gr/hr-hr and NO₂ of 1.1 g/hp-hr or 18% of total nitrogen oxides in the exhaust. Use of a bimetallic FBC in the No. 2D fuel at a dose rate of 0.15 ppm Pt and 7.5 ppm Ce reduced PM by 15% to 0.215 gr/hp-hr with NO₂ reduced to 12% of total nitrogen oxide emissions.

[0029] Installation of a lightly catalyzed ceramic DOC with 3 grams/cu ft of precious metal loading operated on untreated No. 2D fuel produced PM emissions of 0.196 gr/hp-hr or a 23% reduction from baseline. No measurement of NO₂ was made due to unavailability of test equipment. Use of FBC treated No. 2D with the lightly catalyzed DOC reduced PM emissions to 0.178 gr/hp-hr for a 30% reduction while further reducing NO₂ emission to 8% of total nitrogen oxide emissions.

[0030] Use of the same DOC with the engine operated on FBC treated ULSD (<15 ppm S) reduced PM by 34% to 0.168 gr/hp-hr with NO₂ emissions at 8% of total NO_x. These results demonstrate the ability of the FBC to enhance the overall PM reduction efficiency of a lightly catalyzed DOC even on No. 2D fuel where the use of traditional heavily catalyzed devices can cause conversion of sulfur species to sulfate particulate emissions and increase NO₂ emissions.

[0031] Another unexpected benefit of the FBC used with a lightly catalyzed DOC is the reduction in NO₂ emissions versus baseline. NO₂ emissions are generally increased with traditional heavily catalyzed devices, but are decreased by over 50% with the FBC/DOC combination described in the invention.

Emissions Results for 1990 International DT 466 7.6 Liter Engine
(g/hp-hr)

Fuel/Device	HC	CO	NO _x	NO	NO ₂	PM
Baseline No. 2D	0.3	1.4	6.1	5.0	1.1	0.253
Baseline No. 2D + FBC (0.15/7.5)	0.3	1.3	6.0	5.3	0.7	0.215
Baseline No. 2D + DOC (no FBC)	0.2	0.7	6.0	ND	ND	0.196
Baseline No. 2D + DOC + FBC (0.15/7.5)	0.2	0.7	6.0	5.5	0.5	0.178
ULSD + FBC + DOC (0.15/7.5)	0.2	0.5	5.3*	4.9	0.4**	0.168

*Duplicate Measurements

**Single Measurement

EXAMPLE 2

[0032] This example presents the results of testing over a single cold and triple hot FTP transient test cycles for the FBC/DOC combination on a 1990 Cummins 8.3 liter 6 CTA, 275 hp medium heavy-duty engine certified to meet 1991

emission standards for NO_x and PM. The engine was initially run on untreated No. 2D fuel (>300 ppm Sulfur) with no exhaust aftertreatment DOC installed. Particulate emissions were determined from the average composite at 0.190 gr/hp-hr.

[0033] Fuel was switched to FBC treated commercial ULSD (<15 ppm) and a degreened DOC-1 was installed in the engine exhaust. The engine was run for 16 hours and tested for emissions. Average particulate emissions were reduced by over 53% to 0.089 gr/hp-hr. Total NO₂ was also reduced by more than 50% from 0.9 gr/hp-hr to 0.4 gr/hp-hr.

[0034] The DOC was a 9.5" dia.×6" L 400 cpsi ceramic substrate made by Corning, Inc. and catalyzed with 3 gr/cu ft. of precious metal by Clean Air Systems, Inc. of New Mexico. It was installed in a stainless steel can with conventional inlet and outlet cones. The FBC was a platinum/cerium bimetallic used at a dose rate of 0.5 ppm/7.5 ppm.

[0035] An identical field aged DOC-2 which had been operated in commercial field service for 1000 hours on FBC treated ULSD was also tested using FBC treated ULSD. Average particulate emissions were reduced by 48% to 0.098 gr/hp-hr and NO₂ emissions were held to 13% of overall nitrogen oxide representing a level of 0.6 gr/hp-hr.

[0036] In another test, an identical DOC-3 that had been operated in commercial service for 1100 hours on FBC treated No. 2D at a 0.15/7.5 ppm dose rate was tested on FBC treated No. 2D at 0.15/7.5 ppm. Overall PM reduction was to a level of 0.113 gr/hp-hr while total NO₂ was reduced from 0.9 gr/hp-hr to 0.5 gr/hp-hr representing 10% of total nitrogen oxide emissions versus 19% for the baseline NO₂ emissions on No. 2D fuel.

[0037] These data support the unexpected high level of particulate reduction achieved by low levels of FBC with a lightly catalyzed DOC and confirm that PM performance can be maintained at high levels even after commercial service with the use of FBC treated fuel. There is also an unexpected reduction in NO₂ from the combination of FBC and DOC, which is an advantage over heavily catalyzed devices which tend to increase NO₂ emissions.

Emissions from a 1990 (1991 Certified) Cummins 8.3 Liter Engine (Average Composite Emissions gr/hp-hr)						
Fuel/Device	HC	CO	NO _x	NO ₂	% NO ₂	PM
Baseline No. 2D	0.39	0.78	4.8	0.9	19%	0.190
DOC-1 (degreened) + FBC + ULSD	0.16	0.28	4.5	0.4	9%	0.089
DOC-2 (aged) + FBC + ULSD	0.24	0.36	4.7	0.6	13%	0.098
DOC-3 (aged) + FBC + No. 2D	0.29	0.66	4.8	0.5	10%	0.113

EXAMPLE 3

[0038] This example reports testing that further confirms the benefits of low levels of FBC in ULSD combined with a lightly catalyzed DOC. In this Example testing was conducted on a 1995 Navistar DT466, 7.6 liter engine over a single cold and three hot test cycles. The average of three

composite emissions results was calculated and reported in grams/bhp-hr. Baseline emission results on untreated No. 2D fuel (>300 ppm S) show average PM emissions of 0.106 gr/hp-hr with NO₂ emissions at 1.1 gr/hp-hr representing 23% of total NO_x emissions.

[0039] Use of ULSD (<15 ppm S) treated with a bimetallic FBC at 0.15/7.5 ppm reduced PM by 31% to 0.073 gr/hp-hr with NO₂ reduced to 0.8 gr/hp-hr or 19% of total NO_x emissions. Reductions in HC, CO and NO_x were also observed for the FBC/ULSD combination.

[0040] In a further test, a degreened lightly catalyzed DOC-1 from Example 2 was installed in the exhaust and the engine was run on FBC treated ULSD. Overall PM emissions were reduced by 45% to 0.058 gr/hp-hr while NO₂ was reduced to 0.6 gr/hp-hr representing 14% of overall NO_x emissions. Further reductions in HC, CO and NO_x were also noted.

Emissions from a 1995 Navistar DT 466 7.6 liter Engine (g/hp-hr)						
Fuel/Device	HC	CO	NO _x	NO ₂	% NO ₂	PM
Baseline No. 2D	0.3	1.3	4.8	1.1	23%	0.106
ULSD + FBC	0.2	1.0	4.3	0.8	19%	0.073
ULSD + FBC + DOC	0.1	0.5	4.2	0.6	14%	0.058

[0041] The above description is intended to enable the person skilled in the art to practice the invention. It is not intended to detail all of the possible modifications and variations which will become apparent to the skilled worker upon reading the description. It is intended, however, that all such modifications and variations be included within the scope of the invention which is seen in the above description and otherwise defined by the following claims. The claims are meant to cover the indicated elements and steps in any arrangement or sequence which is effective to meet the objectives intended for the invention, unless the context specifically indicates the contrary.

1. A method for reducing particulate emissions from a diesel engine while also controlling emissions of NO₂ as a percent of exhaust total nitrogen oxides, comprising: adding a fuel borne catalyst comprising platinum and cerium and/or iron at a total metal concentration of from 2 to 15 ppm in the fuel to a diesel fuel; and passing exhaust produced by the combustion through a diesel oxidation catalyst having substrate with a precious metal catalyst thereon, the catalyst be present on the substrate in an amount of less than 15 grams per cubic foot of substrate.

2. A diesel emissions control system according to claim 1, wherein the diesel oxidation catalyst has a catalyst metal loading of less than about 10 grams per cubic foot.

3. A diesel emissions control system according to claim 1, wherein the fuel comprises a fuel soluble platinum compound providing from about 0.05 to about 0.5 ppm of platinum in the fuel.

4. A diesel emissions control system according to claim 1, wherein the diesel oxidation catalyst has a catalyst metal loading of from about 3 to 5 grams per cubic foot.

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