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Ceramic foam as a potential molten salt oxidation catalyst support in the removal of soot from diesel exhaust gas

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Abstract

An exploratory study has been carried out to determine the potential of open-pore ceramic foam as support for molten-salt diesel soot oxidation catalysts. These catalysts are based on eutectic mixtures of Cs_2O, V_2O_5, MoO_3, and Cs_2SO_4. Open-pore ceramic foams are very interesting, since they can act as supports and as soot filters. 50 ppi α-alumina foam has been tested as support substance. Attractive methods have been developed for depositing the molten salt on the external surface of the pore walls of the foam. The combustion of 'loose-contact' synthetic soot has been analysed with a micro-flow reactor. The oxidation rate is a function of the amount of molten salt deposited on the foam. Stable rates in the range from 5 to 25 $\mu g_{soot}/g_{soot,initial}/s$ at 650 K have been observed. These rates are in the same order of magnitude as measured for the best catalytic fuel additives; and, therefore, catalytic foams are very promising. The initially minor 'deactivation' that occurs after the thermal treatment up to 100 h at 725 K probably has a physical explanation. During the treatment, the molten salt redistributes to a configuration that has less catalyst available for accelerating the soot oxidation. ©1999 Elsevier Science B.V. All rights reserved.

Keywords: Diesel; Soot; Oxidation; Combustion; Molten salt; Eutectic; Catalyst; Foam; Preparation

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1. Introduction

The tightening of future exhaust emission limits for diesel engines requires the reduction of emissions by improved fuel combustion processes and needs probably advanced exhaust after-treatment systems [1]. A satisfactory solution is urgently needed, it is particularly in urban areas that diesel engines do not show good environmental performance.

It is, therefore, not surprising that diesel-exhaust control devices are currently being developed. A filter in combination with a heat-regeneration control strategy can, in principle, reduce particulate emissions up to 90% [2]. The problem with this technology is the reliability of the regeneration. Severe temperature extremes can be encountered during regeneration, resulting in thermal shock cracking of the filter. This technology will also give a high fuel penalty. Catalytic filtering is a more elegant solution: the energy required for regeneration is less, the recycle frequency is lowered, there is a smaller chance of filter failure and a more simple regeneration strategy can be called-for [2].

Recently, we demonstrated that molten salts, based on eutectic mixtures of Cs_2O, V_2O_5, MoO_3, and Cs_2SO_4, are good candidate catalysts for soot oxidation, since close contact between the catalyst and soot components can be established under simulated, practical conditions [3,4]. It is in the catalyst's liquid state that contact is promoted with the soot. The

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current molten salt formulations have their melting points in the range from 600 to 635 K, at which temperature they start to oxidise soot. These onset temperatures are well below the temperatures at which the single metal-oxides, from which the molten salts were composed, have their onset temperatures [3]. We concluded from research on ceramic model supports of simple geometry, i.e. grains and bricks, that ceramics are promising candidate supports for the molten salt soot oxidation catalyst [5]. High-strength, high-temperature, low-porous ceramics are very promising supports, since soot filters can be produced from these types of ceramics.

Under practical conditions, diesel soot lays deposits on the channel walls of the soot filter. The catalyst should also be deposited at this location to create a large contact area with the soot. In the case of a molten salt catalyst, the catalyst fills the pores near the external surface [5]. This would result in an unreasonably high pressure drop when a surface filter type, like the wall-flow monolith, is used. Deep-bed filters seem to be better candidates for molten salt, since the catalyst does not obstruct the exhaust gas stream when deposited on such a type of filter. Ceramic foam deep-bed filters are often mentioned as soot filters in literature [6–10].

In this paper, the preparation and the catalytic performance of molten-salt based catalytic foams are investigated. Different ways of depositing the molten salt catalyst on ceramic foam are investigated. The performance of the prepared catalytic foams is tested with a laboratory micro-flow reactor.

2. Experimental

2.1. Catalyst preparation

In this study, 50 ppi (poresper inch) α-alumina foam of Porvair Advanced Materials was used as catalyst support for kinetic experiments with micro-flow equipment. The foam was sawed into cylinders with diameters of 7 mm and lengths of 25 mm. (These foam cylinders are suitable for kinetic experiments with our micro-flow equipment.)

$Cs_2SO_4 \cdot V_2O_5$ (0.55 : 0.45 mol, melting point 623 K) and $CsVO_3 \cdot MoO_3$ (0.75 : 0.25 mol, melting point 635 K) eutectic mixtures were synthesised by fusion as described elsewhere [3]. The solidified mixtures were crushed with a mortar into fine powder and sieved. The <106-μm sieve fraction from both the catalysts was collected.

It was observed, in our research performed on ceramic model supports (i.e. grains and bricks), that the molten salt catalyst is very active when located on the external surface of the support [5]. The eutectic mixtures can be deposited on the external surface in high concentrations by distributing a homogeneous layer of powder over the surface, and by subsequently melting it [5]. This method has some advantages when compared to more classical deposition procedures like aqueous pore volume impregnation. By fusion, the catalyst can be prepared in advance and the right eutectic composition can be established, while with the more classical impregnation methods the eutectic mixture is prepared on the support by depositing dissolved precursor materials. The precursor materials have, in this case, very different solubilities, a fact that gives rise to problems when preparing the right eutectic composition at a high loading. Furthermore, with direct deposition it can be very easy to deposit the catalytic phase at the external surface of the support (i.e. foam channel walls). With the more classical impregnation methods, a more homogenous distribution would be obtained which is disadvantageous in this case, since catalyst deposited in the interior of the pore walls cannot combust soot. The direct deposition methods used to deposit the catalyst on the external surface of the ceramic model supports [5] are unsuitable for ceramic foam. Ceramic foam has a more complex and brittle structure and would not survive the deposition procedure. Alternative deposition methods were evaluated to prepare catalytic foam:

- A ceramic foam cylinder was dipped into 40 ml molten salt at 725 K and removed after 5 min. The excess salt was removed from the saturated foam by blowing 10 $l_n\ min^{-1}$ air through the pore structure at 725 K for 5 h. The removal of the excess molten salt by means of gravity was also included. The saturated foam was kept at 725 K on top of a bed of γ-alumina absorbent particles for 4–48 h until the molten salt stopped trickling out of the foam cylinder.
- Oxalic acid powder (<250 μm) was mixed with salt powder. Twenty-five millilitres of the powder mixture and a foam cylinder were placed into a 30-ml

sample bottle. The closed sample bottle was treated in a Retsch US1 ultrasonic transducer tank at 35 kHz and 160 W for 1 h to enable the powder mixture to penetrate the pores of the foam. The foam was removed from the powder mixture and treated at 725 K for 4 h to burn the oxalic acid and to melt the salt. A series of foams with different catalyst loadings was produced.

- Salt particles were deposited on foam by using a procedure slightly similar to the method used by Hartwig [11]. Thereafter, 1.5 g salt powder was vigorously mixed with 30 ml heptane and forced through a ceramic foam at different superficial velocities: 0.1 to 2 cm/s. The foam filtered the salt particles from the suspension. After the filtration, the foam was dried in air at 400 K to evaporate the heptane and then heated to 725 K to melt the salt. This method was applied on ceramic foams with diameters of 25 mm and lengths of 40 mm. These foams were to be used in a later investigation for catalytic experiments in a diesel exhaust gas side-stream.

2.2. Soot deposition

Synthetic flame soot (Printex U of Degussa) was used to determine the soot oxidation rate of the synthesised supported catalysts. Two different methods were evaluated for the depositing of soot on the catalytic foams. These methods are slightly similar to the methods used by Inui et al. [12].

- Soot was deposited on the foams by filtering it from a soot aerosol (Fig. 1). The aerosol was produced by fluidising a mixture of silicon carbide particles (127 μm) and synthetic soot (mass ratio 65 : 1). The soot separated from the silicon carbide particles because of its lower density, and was forced under ambient conditions through the catalytic foam at a realistic superficial gas velocity of 3 m/s [6].
- The soot was deposited on the catalytic foam by impregnation with a dispersion of soot in heptane. 1.5 mg soot was mixed with 50 ml heptane for 24 h. Ceramic foam was immersed in the dispersion for 1 min and dried for 1 h at 350 K.

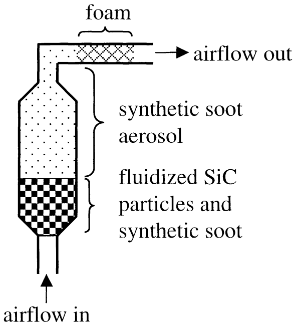

Fig. 1. Experimental setup for the production of a soot aerosol that can be forced through ceramic foam at a realistic superficial gas velocity.

2.3. Catalytic testing

A series of catalytic foams that were kept at 725 K for 3–720 h, and a series of foams with varying catalyst loading (0–80 $\text{mg}_{\text{catalyst}}/\text{ml}_{\text{foam}}$) were tested. The performance of the catalytic foams was investigated with a micro-flow reactor system described elsewhere [13]. The reactor tubes were loaded with the catalytic foams, on which soot was deposited in advance. The temperature was raised in argon to the desired reaction temperature of 650 K, and then 10 vol% oxygen was introduced at this temperature. The soot oxidation rates were determined by measuring with NDIR analysis (Hartman and Braun Uras 10E) the amounts of CO and CO_2 released during the reaction. The rates were normalised to the amount of soot initially present in the reactor tubes. The influence the soot deposition method had on the performance of the catalytic foam was also investigated with the micro-flow equipment.

3. Results

3.1. Catalyst preparation

The foams that were impregnated by means of dipping into molten salt were completely saturated. It took hours-to-days at high temperatures to remove a part of the excess amount of salt from the saturated foam. Neither were attempts to blow the excess amount of molten salt from the foam successful. The dipped foams emitted a lot of salt during kinetic experiments, thereby contaminating the flow equipment. The method was abandoned in further research.

The catalytic foams prepared by impregnation of a powder mixture of salt and oxalic acid and, subsequently, calcination were very useful for kinetic experiments with the micro-flow equipment. Homogeneous catalytic foams with a wide range of salt loadings and high reproducibility could easily be prepared. Attempts to impregnate cylindrical foams with diameters larger than 10 mm were not successful: the powder mixture penetrated only the 5-mm outer layer of the foams.

Catalytic foams with diameters of 25 mm and lengths of 40 mm could be prepared by filtering salt particles from a liquid heptane stream and, subsequently, calcining it. These foams had a molten salt distribution similar to that of the catalytic foams that were prepared by powder impregnation.

3.2. Catalyst-soot contact

Synthetic soot was deposited on the catalytic foams by impregnating soot dispersed in heptane, or by filtering soot derived from an aerosol. In both cases, the soot loading can be controlled by varying the soot concentration of the dispersion or by varying the time needed for the soot aerosol to pass through the foam structure. A typical soot loading was 10 mg_{soot}/ml_{foam}. At this loading level, the pore walls of the foam were covered in soot. Fig. 2 shows the activity at 650 K as a function of the conversion of soot that had been deposited on catalytic foams by both deposition techniques. It is clear that the soot deposition technique does not influence the observed soot oxidation rate.

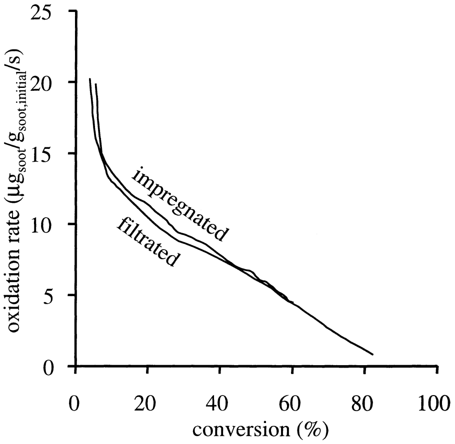

Fig. 2. Soot oxidation rate as a function of conversion at 650 K of $Cs_2SO_4 \cdot V_2O_5$-foams on which synthetic soot has been deposited either by aerosol filtration or by impregnation with a dispersion in heptane.

3.3. Catalyst performance

The catalytic foams were tested in the micro-flow equipment by oxidating a set amount of soot at controlled conditions without feeding in additional soot. The reaction is a batch reaction and the catalytic activity is, therefore, a function of the amount of soot converted. The shape of the activity graph in Fig. 2 is typical for the experiments that were performed. Firstly, the soot is oxidised at a high, but rapidly declining rate up to ≈6%. This rate is higher due to the conversion of hydrocarbons absorbed on Printex U (≈6 wt% [14]). Secondly, from 6% onwards the carbon core was combusted, the oxidation rate decreased slowly with the ongoing combustion reaction, because of the decreasing amount of soot. The soot oxidation rate at a conversion of 30% was used to compare different catalytic foams to each other. This 30% was chosen arbitrarily. It should be noted that the comparison of rates, at for instance 20% or 50% conversion, gave similar comparison results.

$Cs_2SO_4 \cdot V_2O_5$-foams were pre-treated at 725 K for different time periods. Fig. 3 shows the oxidation rates of these foams as a function of the pre-treatment

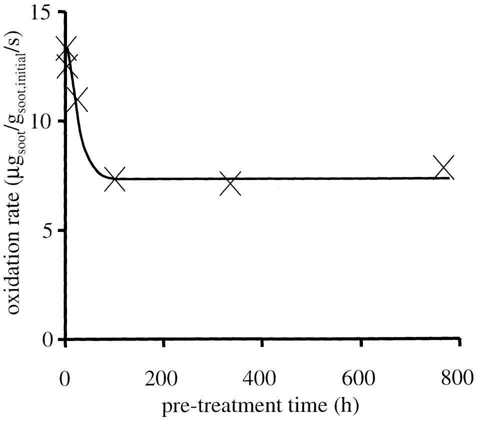

Fig. 3. Soot oxidation rate at 30% conversion at 650 K of $Cs_2SO_4 \cdot V_2O_5$-foams with a loading of 40 $mg_{catalyst}/ml_{foam}$ that were pre-treated at high temperature for different time periods, viz. 3, 4, 24, 100, 336 and 768 h.

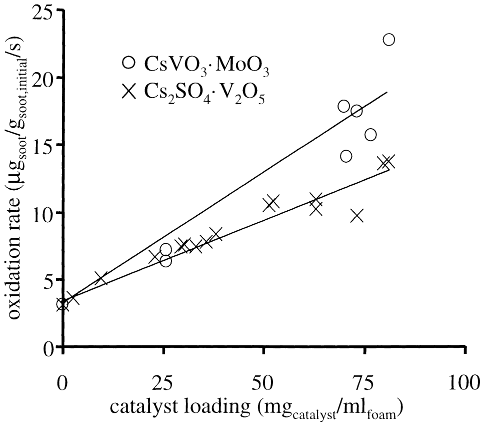

Fig. 4. Soot oxidation rate at 30% conversion at 650 K of $Cs_2SO_4 \cdot V_2O_5$-foams and $CsVO_3 \cdot MoO_3$-foams as a function of catalyst loading.

time. For a $Cs_2SO_4 \cdot V_2O_5$-foam that was kept for 3 h at 725 K a rate of 13 $\mu g_{soot}/g_{soot,initial}/s$ was observed. The rate decreased to a stable value of 7.5 $\mu g_{soot}/g_{soot,initial}/s$ by increasing the treatment time to 100 h at 725 K.

Fig. 4 shows the stabilised soot oxidation rate as a function of the catalyst loading of $Cs_2SO_4 \cdot V_2O_5$-foams and $CsVO_3 \cdot MoO_3$-foams that were both stabilised for a period longer than 100 h. For $Cs_2SO_4 \cdot V_2O_5$ a soot oxidation rate of 5 $\mu g_{soot}/g_{soot,initial}/s$ was observed at a loading of 9.5 $mg_{catalyst}/ml_{foam}$. The rate increased linearly when the salt loading was increased. The rate was 14 $\mu g_{soot}/g_{soot,initial}/s$ at a loading of 80 $mg_{catalyst}/ml_{foam}$. To reduce the research effort, all systematic experiments were only conducted on the $Cs_2SO_4 \cdot V_2O_5$-foams. Some reference experiments were conducted with $CsVO_3 \cdot MoO_3$ to see if this catalyst formulation behaves similarly to $Cs_2SO_4 \cdot V_2O_5$. (At a later stage of the research program stability testing will establish what is the best catalyst and support.) The reference experiments with $CsVO_3 \cdot MoO_3$-foams showed the same effect of pre-treatment time on the activity of the catalytic foam as for the $Cs_2SO_4 \cdot V_2O_5$-foams. The $CsVO_3 \cdot MoO_3$ loading had, like the $Cs_2SO_4 \cdot V_2O_5$loading, a positive effect on the oxidation rate, but there are not enough points in the scattergraph to determine whether the dependence is linear or not. In the graph, the $CsVO_3 \cdot MoO_3$-foams with higher loading were roughly 60% more active than the $Cs_2SO_4 \cdot V_2O_5$-foams. One should keep in mind that catalytic foams with equal mass loading are compared. If the catalytic foams with high loading are compared on basis of the molar catalyst loading in $mol_{catalyst}/ml_{foam}$, similar oxidation rates can be found.

4. Discussion

4.1. Catalyst preparation

In a previous work, molten salt had been successfully deposited directly onto the external surface of ceramic model supports (i.e. grains and bricks). This direct deposition technique has been adapted for the impregnation of ceramic foams. Different procedures for depositing the catalyst onto ceramic foam have been examined.

Impregnation by dipping the foam in molten salt failed. With that method, the channels in the foam are completely filled with molten salt. The excess molten salt is hard to remove. Catalytic foams that are prepared accordingly emit much molten salt during the kinetic experiments. This impregnation method seemed impractical when it came to scaling up and so further investigations were abandoned.

Preparing catalytic foam by forcing a powdered mixture of salt and oxalic acid particles into the foam channels and, subsequently, calcination is a method well suited for the process of preparing catalytic foams for laboratory-scale kinetic experiments. The method is easy to perform and produces homogeneous catalytic foams with adjustable, reproducible catalyst loading. The disadvantage of the method is that only small foam structures can be impregnated. The ultrasonic sound waves that are used to force the powdered mixture into the pores of the foam are muffled by the foam structure. More mechanical energy will be required if the powdered mixture is to be transported over a longer distance. It is thought that the mechanical energy needed for forcing the powder mixture into a foam filter of, for instance, 2 l is too high for the foam to absorb without damage. Therefore, no attempts were made for optimisation and scaling up.

The most promising method for scaling up the production of catalytic foams of larger dimensions is the process of direct deposition by filtration of salt powder in a heptane stream and calcination. When compared to powder impregnation, this method still is more laborious and probably needs additional developmental steps. The parameters that can be optimised are: the type of liquid, particle-size distribution, flow rate, etc.

4.2. *Catalyst-soot contact*

Soot oxidation rates determined under laboratory conditions with synthetic soot can only be representative when the soot is distributed on the catalyst in a realistic manner. In an earlier work, this realistic distribution was defined as a ‘loose contact’ [15]. Closer contact, defined as a ‘tight contact’ is also encountered in literature and can be created by exerting physical force by means of a mortar-or-ball mill during the preparation of the catalyst soot mixture [16–18]. Tight contact gives no representative soot oxidation rates, since it is in general believed that such contact will not be established under practical, realistic conditions. For unsupported catalysts, mixing soot and catalyst powder with a spatula will create ‘loose contact’ [19]. Soot can be deposited in ‘loose contact’ on grain supports by mixing for a period of time, and on flat ceramic surfaces by rubbing. These methods are not applicable for ceramic foam supports. Ceramic foams have a complex structure, which means that the available area for depositing soot is difficult to access.

Soot was deposited on catalytic foams by filtering synthetic soot from an aerosol at a realistic superficial gas velocity. The contact that is created with this method will be approximately similar to the contact that would be encountered under realistic, practical conditions with diesel exhaust gas. This deposition method proved to be useful when it came to verifying the type of contact that is created, but it is laborious. A more simple soot deposition method was desired. Therefore, the deposition by impregnation of soot dispersed in heptane was examined. This method proved to be fast, easy to perform and reproducible. The oxidation rates observed for soot that was deposited by the two different methods are similar. Therefore, the type of contact that is created by the impregnation of soot is similar to the contact that will be created by filtration at realistic gas velocities, and so it can be considered realistic.

4.3. *Catalyst performance*

The molten salt catalysts, supported by ceramic foam, were initially very active. The activity stabilises to a constant level when the catalytic foam is heated for several hours above the melting point of the molten salt. A constant soot oxidation rate has been observed for catalytic foams that were thermally pre-treated for longer than 100 h. The oxidation rate was stable even after a 720 h treatment period. The effect of heat treatment was also observed in our previous work with molten salt deposited on ceramic model supports, such as bricks and grains [5]. In that study it was observed with scanning electron microscopy analysis that during the heat pre-treatment phase, the molten salt re-distributes itself. The configuration formed probably has less molten salt available on the external surface of the pore walls, and this causes lower oxidation rates. It is not argued that a chemical interaction between ceramic foam and the molten salt does not occur, but the lower and stable activity after thermal pre-treatment probably has a physical and not a chemical explanation. The notion that chemical reactions between the molten salt and the support might occur is not excluded. Previous work had shown, for instance, the oxidation of SiC by a molten salt catalyst [3]. According to Dario et al. [20] oxidation of SiC will negatively influence the properties of SiC supports. Furthermore, SiO_2 will not give a stably supported catalyst, since the molten salt catalyst does not anchor very well to it [5]. A stability study, has to be performed to establish the chemical compatibility between the molten salt catalyst and ceramic foam. The stability of the molten salt catalytic phase itself is considered to be promising: in the presence of high-temperature steam (900 K, 40 vol% steam in air, 5 m/s, one week) no evaporation of molten salt was observed [21]. More detailed studies will be published shortly.

The activity of the catalytic foams with stabilised molten salt distribution increases with an increasing catalyst loading. The pores near to the external surface get saturated with the molten salt, where it is inaccessible to soot. At higher loadings, the additional molten salt cannot enter the filled pores and remain at the external surface of the foam pore walls where it is available for accelerating the oxidation of soot. This effect corresponds with our results with ceramic model supports [5]. The positive effect on the activity will end when the external surface of the foam channels is completely filled and the foam can start to emit molten salt into the gas flow.

The oxidation rates that were observed for the catalytic foams are in the same order of magnitude as the oxidation rates that were observed for molten salt catalyst by model supports (i.e. grains and bricks) [1]. The geometry of the support, apparently, has no influence on the activity of the catalyst. In our previous work with ceramic model supports, it also was determined that catalyst-support interactions of a chemical nature are not important for this type of supported catalyst and that texture differences between different supports have a little influence on the activity of the supported catalysts [5]. Therefore, developing the support comes down to combining the criteria that should be fulfilled for stable catalyst performance with a reliable filter structure. The support should retain the molten salt in a stable distribution, and keep it accessible to the deposited soot. The support should not react with the molten salt.

The activity of molten-salt based ceramic foam is considered to be very promising. Soot oxidation rates in the range of 5 to 25 $\mu g_{soot}/g_{soot,initial}/s$ at 650 K were measured. In our earlier work with supported molten salts, we stated that rates in the range of 10 to 20 $\mu g_{soot}/g_{soot,initial}/s$ at 650 K are needed for filter regeneration [5]. These rates are similar to the rates of the most active catalytic fuel additives (a combination of Pt and Ce) [13]. These fuel additives show very satisfactory activities and they can continuously regenerate a soot filter in a side stream of a diesel engine exhaust (at temperatures as low as 585–605 K). The activity of these additive catalysts was tested by combusting the additives with diesel fuel in an engine and, subsequently, sampling soot from the exhaust gas. The sampled soot with incorporated additive was then tested with the same flow equipment as that used for the catalytic foams [13]. For a complete comparison with the performance of fuel additives, the minimum operational temperature of supported molten-salt based catalytic foams at realistic conditions downstream of a diesel engine has to be determined.

The minimum operation temperature in real exhaust gas should also be known to determine the applicability of the discussed catalytic trap. It is also important where the trap is going to be located. The placement of the trap ahead of the turbocharger has from the catalyst developer's point of view the advantage of the availability of higher temperatures. This concept has previously been extensively investigated and introduced on the Californian market by Daimler-Benz [22], but failed because ceramic elements of the filter destroyed the radial turbine of the turbocharger. This catastrophic failure and uncontrolled risk deterred car manufacturers from using pre-turbine traps. In view of this, it is very likely that the currently discussed catalytic trap is going to be placed downstream of the turbocharger. In the case of a modern diesel-powered passenger car, the trap will not be able to regenerate itself. The average exhaust temperature after the turbocharger of a modern diesel passenger car is $\approx$425 K during the European ECE driving cycle. Temperatures in that range are too low for the discussed catalytic trap. A severe optimisation in the formulation of the molten salt catalyst is needed to apply the discussed catalytic trap. However, it is expected that diesel engine manufacturers will meet the proposed EURO IV emission standards for passenger cars and light trucks solely by engine modifications, so that a trap will not be needed to meet these regulations. For diesel powered vehicles of more than 1800 kg, it is not certain if engine manufacturers will meet the EURO IV regulations of 2005 only with engine modifications. These vehicles probably will need some kind of trap technology to meet the EURO IV regulations. The exhaust-gas temperatures downstream the turbocharger are higher than for passenger cars, but the discussed catalytic trap is probably not yet advanced enough to regenerate itself during all driving conditions. A possible regeneration strategy will be a combination of two options: passive regeneration during driving conditions at high temperatures, and periodically active regeneration by exhaust throttling during driving conditions at low temperatures. For such a regeneration strategy, the working temperature of the catalyst should probably be lowered with another 75 K to become interesting. The placement of the trap upstream of the turbocharger remains an option from a catalyst developer's point of view. In order to accomplish this, the following will be needed: a guaranteed robustness of the trap to avoid damaging of the turbocharger; a lot of convincing of car manufacturers; and a new configuration of the turbocharger, since the trap introduces extra thermal inertia before the turbocharger which will make the turbocharger respond differently.

The catalyst, discussed here, is from the beginning being developed in co-operation with a manufacturer of large heavy-duty diesel engines (rated power in MW-range) used for powering ships and electricity regenerators. These engines have much higher exhaust temperatures than diesel engines used for powering cars and trucks. This will make the temperature problem surmountable for the discussed catalytic trap. However, these engines produce large amounts of inorganic ash, and it should be investigated how this ash affects the performance and stability of the catalytic trap.

5. Conclusions

- Two attractive methods for the deposition of molten salt on ceramic foams have been developed. Reproducible catalytic foams for laboratory-scale kinetic experiments can be produced if a powdered mixture of salt and a solid dilutent is impregnated and, subsequently, calcined. For the preparation of catalytic foams of larger dimensions, the deposition by filtration of a suspension of catalyst particles forced through foam is more suitable. This impregnation method needs to be further developed and optimised for scaling up.
- Mixtures of Cs_2O, MoO_3, V_2O_5, and Cs_2SO_4 with eutectic composition deposited on a ceramic foam, have a promising activity at 650 K (5–25 $\mu g_{soot}/g_{soot,initial}/s$). At this temperature, the 'loose contact' activity is comparable to the activity of the most active catalytic fuel additives (a combination of cerium and platinum). The working temperature of the catalyst is still on the high side and should be lowered by another 75 K to become commercially interesting.
- Catalytic foams have a stable activity after being exposed to a temperature of 725 K. The initial minor deactivation that occurs during the temperature treatment is probably caused by the slow occupancy of the less accessible mesopores of the support, which means that less catalyst is available for soot oxidation.
- The activity of the catalytic foams is a function of the amount of molten salt deposited on the foam. At a very high catalyst loading, the foam will be saturated with the molten salt and the surplus molten salt will be emitted.
- The texture and the geometry of the support have so far a negligible influence on the oxidation activity of the catalyst.
- To determine the real potential of the catalytic foams, the stability of the molten salt catalyst in combination with the support and the performance in real diesel exhaust gas should be investigated. SiO_2 and SiC have already proved to be inapplicable supports. The molten salt catalyst does not anchor to SiO_2. SiC can be oxidised by this type of catalyst to SiO_2.

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