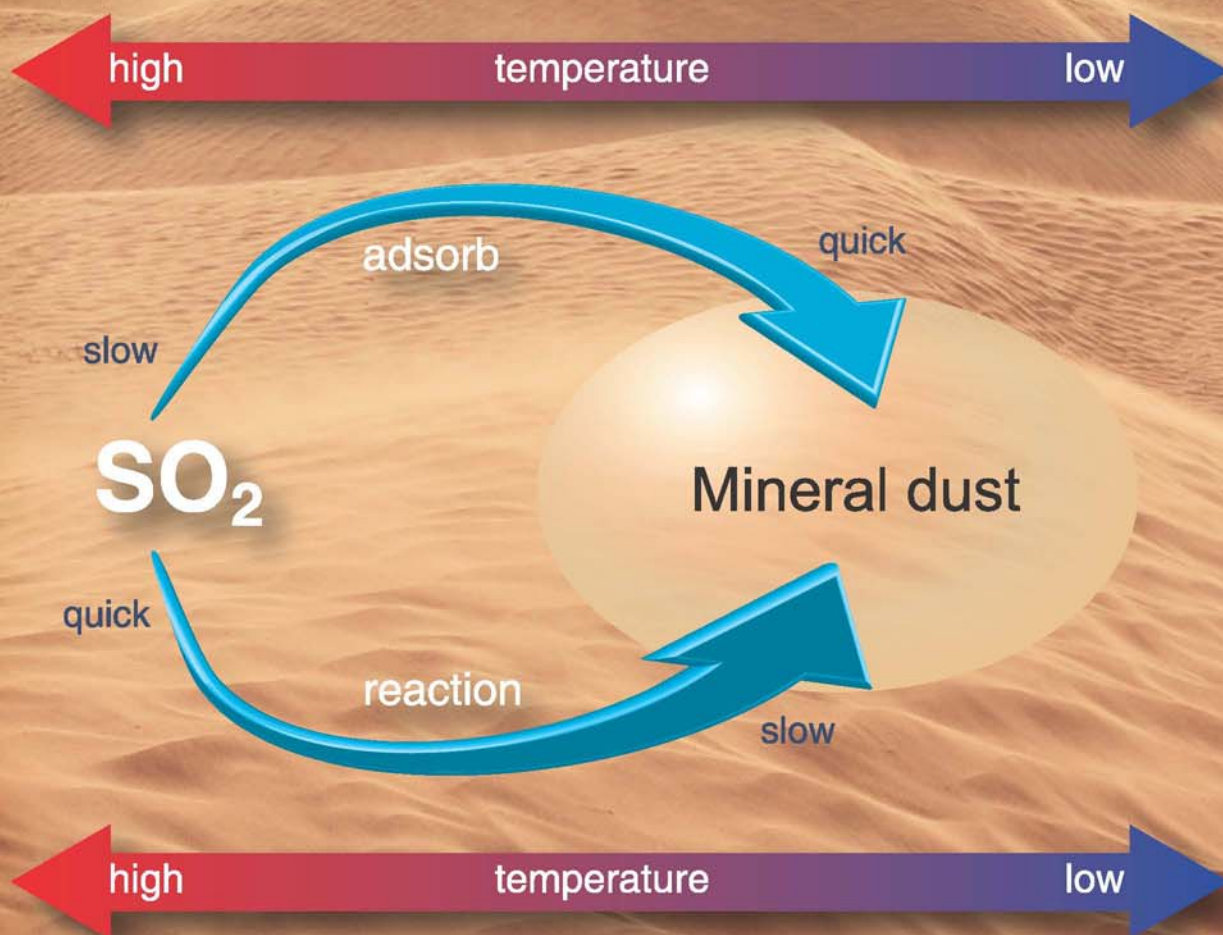


JES

JOURNAL OF
ENVIRONMENTAL
SCIENCES

ISSN 1001-0742
CN 11-2629/X

December 1, 2014 Volume 26 Number 12
www.jesc.ac.cn



Sponsored by
Research Center for Eco-Environmental Sciences
Chinese Academy of Sciences

- 2369 Effects of seasonal climatic variability on several toxic contaminants in urban lakes: Implications for the impacts of climate change
Qiong Wu, Xinghui Xia, Xinli Mou, Baotong Zhu, Pujun Zhao, and Haiyang Dong
- 2379 Preparation of cross-linked magnetic chitosan with quaternary ammonium and its application for Cr(VI) and P(V) removal
Wei Yao, Pinhua Rao, Irene M.C. Lo, Wenqi Zhang, and Wenrui Zheng
- 2387 Formation pathways of brominated products from benzophenone-4 chlorination in the presence of bromide ions
Ming Xiao, Dongbin Wei, Liping Li, Qi Liu, Huimin Zhao, and Yuguo Du
- 2397 Influence of the inherent properties of drinking water treatment residuals on their phosphorus adsorption capacities
Leilei Bai, Changhui Wang, Liansheng He, and Yuansheng Pei
- 2406 Radiation induced decomposition of a refractory cefthiamidine intermediate
Qiburi Bao, Lujun Chen, and Jianlong Wang
- 2412 Characterization of aerosol optical properties, chemical composition and mixing states in the winter season in Shanghai, China
Yong Tang, Yuanlong Huang, Ling Li, Hong Chen, Jianmin Chen, Xin Yang, Song Gao, and Deborah S. Gross
- 2423 Knudsen cell and smog chamber study of the heterogeneous uptake of sulfur dioxide on Chinese mineral dust
Li Zhou, Weigang Wang, Yanbo Gai, and Maofa Ge
- 2434 Experimental study on filtration and continuous regeneration of a particulate filter system for heavy-duty diesel engines
Tao Tang, Jun Zhang, Dongxiao Cao, Shijin Shuai, and Yanguang Zhao
- 2440 Combination of heterogeneous Fenton-like reaction and photocatalysis using Co-TiO₂ nanocatalyst for activation of KHSO₅ with visible light irradiation at ambient conditions
Qingkong Chen, Fangying Ji, Qian Guo, Jianping Fan, and Xuan Xu
- 2451 Atmospheric sulfur hexafluoride *in-situ* measurements at the Shangdianzi regional background station in China
Bo Yao, Lingxi Zhou, Lingjun Xia, Gen Zhang, Lifeng Guo, Zhao Liu, and Shuangxi Fang
- 2459 Direct radiative forcing of urban aerosols over Pretoria (25.75°S, 28.28°E) using AERONET Sunphotometer data: First scientific results and environmental impact
Ayodele Joseph Adesina, Kanike Raghavendra Kumar, Venkataraman Sivakumar, and Derek Griffith
- 2475 Chemical characteristics and source apportionment of atmospheric particles during heating period in Harbin, China
Likun Huang and Guangzhi Wang
- 2484 Microbial community structures in an integrated two-phase anaerobic bioreactor fed by fruit vegetable wastes and wheat straw
Chong Wang, Jiane Zuo, Xiaojie Chen, Wei Xing, Linan Xing, Peng Li, Xiangyang Lu, and Chao Li
- 2493 Persistent pollutants and the patchiness of urban green areas as drivers of genetic richness in the epiphytic moss *Leptodon smithii*
Valeria Spagnuolo, Flavia De Nicola, Stefano Terracciano, Roberto Bargagli, Daniela Baldantoni, Fabrizio Monaci, Anna Alfani, and Simonetta Giordano

CONTENTS

- 2500 Enhanced removal of ethylbenzene from gas streams in biotrickling filters by Tween-20 and Zn(II)
Lu Wang, Chunping Yang, Yan Cheng, Jian Huang, Haining Yang, Guangming Zeng, Li Lu, and Shanying He
- 2508 Enhanced efficiency of cadmium removal by *Boehmeria nivea* (L.) Gaud. in the presence of exogenous citric and oxalic acids
Huaying Li, Yunguo Liu, Guangming Zeng, Lu Zhou, Xin Wang, Yaqin Wang, Chunlin Wang, Xinjiang Hu, and Weihua Xu
- 2517 Comparative sorption and desorption behaviors of PFHxS and PFOS on sequentially extracted humic substances
Lixia Zhao, Yifeng Zhang, Shuhong Fang, Lingyan Zhu, and Zhengtao Liu
- 2526 Inhibitory effects of nisin-coated multi-walled carbon nanotube sheet on biofilm formation from *Bacillus anthracis* spores
Xiuli Dong, Eric McCoy, Mei Zhang, and Liju Yang
- 2535 A comparative study and evaluation of sulfamethoxazole adsorption onto organo-montmorillonites
Laifu Lu, Manglai Gao, Zheng Gu, Senfeng Yang, and Yuening Liu
- 2546 Removal of formaldehyde over $\text{Mn}_x\text{Ce}_{1-x}\text{O}_2$ catalysts: Thermal catalytic oxidation *versus* ozone catalytic oxidation
Jia Wei Li, Kuan Lun Pan, Sheng Jen Yu, Shaw Yi Yan, and Moo Been Chang
- 2554 Humic acid transport in saturated porous media: Influence of flow velocity and influent concentration
Xiaorong Wei, Mingan Shao, Lina Du, and Robert Horton
- 2562 Salinity influence on soil microbial respiration rate of wetland in the Yangtze River estuary through changing microbial community
Xue Fei Xi, Lei Wang, Jia Jun Hu, Yu Shu Tang, Yu Hu, Xiao Hua Fu, Ying Sun, Yiu Fai Tsang, Yan Nan Zhang, and Jin Hai Chen
- 2571 Comments on “Adsorption of 2-mercaptobenzothiazole from aqueous solution by organo-bentonite” by P. Jing, M.H. Hou, P. Zhao, X.Y. Tang, H.F. Wan
Yuhshan Ho
- 2573 Reply to comments on “Adsorption of 2-mercaptobenzothiazole from aqueous solution by organo-bentonite” by Yuhshan Ho
Ping Jing, Meifang Hou, Ping Zhao, Xiaoyan Tang, and Hongfu Wan

Available online at www.sciencedirect.com

ScienceDirect

www.journals.elsevier.com/journal-of-environmental-sciences

Experimental study on filtration and continuous regeneration of a particulate filter system for heavy-duty diesel engines

Tao Tang, Jun Zhang, Dongxiao Cao, Shijin Shuai*, Yanguang Zhao

State Key Laboratory of Automotive Safety and Energy, Tsinghua University, Beijing 100084, China. E-mail: xiangfantt@163.com

ARTICLE INFO

Article history:

Received 14 January 2014

Received 24 March 2014

Accepted 10 April 2014

Available online 18 October 2014

Keywords:

Catalyzed diesel particulate filter

Diesel oxidation catalyst

Filtration

Regeneration

Balance point temperature

ABSTRACT

This study investigated the filtration and continuous regeneration of a particulate filter system on an engine test bench, consisting of a diesel oxidation catalyst (DOC) and a catalyzed diesel particulate filter (CDPF). Both the DOC and the CDPF led to a high conversion of NO to NO₂ for continuous regeneration. The filtration efficiency on solid particle number (SPN) was close to 100%. The post-CDPF particles were mainly in accumulation mode. The downstream SPN was sensitively influenced by the variation of the soot loading. This phenomenon provides a method for determining the balance point temperature by measuring the trend of SPN concentration.

© 2014 The Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences.

Published by Elsevier B.V.

Introduction

Diesel engines are widely used as movers for vehicles, marines and engineering machines due to its high power, high efficiency, long durability and low fuel consumption. One of the challenges for diesel engines is to reduce particulate matter (PM) and nitrogen oxidizes (NO_x) simultaneously with simple and low-cost technologies. PM emissions are believed to have a series of adverse effects on human health, environment and global climate (Prasad and Bella, 2010). Many investigations indicate that ultrafine particles are airborne and penetrate deep into the lungs when breathed in, which makes them more hazardous to human health than larger particles (Peters et al., 1997; Alessandrini et al., 2006). Given the research and evidence on the adverse effects of particulates, both PM mass and particle number (PN) are limited strictly in emission regulations.

The wall-flow diesel particulate filter (DPF) is effective in removing the PM by forcing the exhaust to flow through the

thin walls in the ceramic filter. To meet the Euro VI legislation for heavy-duty diesel engines, the filtration behavior for both PM mass and solid particle number (SPN) should be examined. Because of sufficient sensitivity to measure the exhaust from DPF, the SPN is used to evaluate DPF in place of mass-based method gradually (Giechaskiel et al., 2014).

In Euro VI stage, the aftertreatment of a heavy-duty diesel engine commonly consists of a diesel oxidation catalyst (DOC), a catalyzed DPF (CDPF) followed with a selective reduction catalyst (SCR) system (Cloudt and Willems, 2011; Charlton et al., 2010). The DPF system could reduce PN emission significantly (Liu et al., 2012). The trapped soot in the filter can be oxidized by NO₂ to make the DPF regenerate continuously (Copper and Thoss, 1989). A high conversion rate of NO to NO₂ can be supplied by DOC and CDPF, which helps continuous regeneration achieve a high efficiency level. The NO₂ slip at the outlet of the CDPF can be reduced by the downstream SCR system. Most (or all) of the soot trapped

* Corresponding author. E-mail: sjshuai@tsinghua.edu.cn (Shijin Shuai).

in the filter for HD diesel engines is burned passively by NO_2 (Johnson, 2013).

The engine-out PM is continuously trapped in the CDPF, while the trapped soot is oxidized by the continuous regeneration. At the equilibrium, the PM deposited in the filter is equal to the oxidized mass, and the soot loading of the filter remains constant (Widdershoven et al., 1986). The balance point temperature (BPT) at this equilibrium is a key parameter to evaluate the continuous regeneration performance, and usually defined as the temperature at which the pressure drop of the filter is not changed (Oi-Uchisawa et al., 2003). A DPF system with continuous regeneration should try to decrease BPT, thus the soot can be oxidized catalytically without frequent active regeneration.

In this study a DOC-CDPF integrated aftertreatment system for heavy-duty diesel engines was tested on an engine dynamometer. The effect of DOC and CDPF on NO_2 concentration was investigated and the filtration behavior for PM mass and PN was evaluated. The experiment results showed that the SPN downstream the CDPF was influenced by the soot loading in the filter, which could be used to determine the BPT.

1. Experiment and method

1.1. Engine test bench

The engine test bench with the DOC-CDPF aftertreatment system is presented in Fig. 1. The specifications of the engine are shown in Table 1. The diesel fuel used in the experiment was purchased in Beijing market with the sulfur content below 10 mg/kg.

The gaseous emissions were sampled from the raw exhaust by AVL FTIR (AVL List GmbH, Graz, Austria),

measuring hydrocarbons (HC), CO, NO, NO_2 and N_2O simultaneously. The PM mass and SPN were measured using AVL SPC472 and AVL CPC489 (AVL List GmbH, Graz, Austria), and the number-size spectrum of the particles was obtained by DMS500 (Cambustion Ltd., Cambridge, Britain). The pressure drop of the aftertreatment was monitored by differential pressure sensor, and the temperatures upstream and downstream were measured with thermocouples. The engine was connected to an AC electrical dynamometer FC2005 (Xiangyi Power, Changsha, China). The engine operation parameters and gaseous emissions were recorded by the dynamometer control system.

1.2. DOC and CDPF specifications

The specifications of the DOC and the CDPF are listed in Table 2. The DOC used a cordierite monolithic substrate coated with a catalyst containing platinum (Pt) and palladium (Pd), converting NO to NO_2 for continuous regeneration. The CDPF utilized a wall-flow cordierite substrate, coated with Pt-Pd catalyst to lower the soot oxidation temperature.

1.3. Test method

The DOC, the CDPF and the coupled DOC-CDPF were tested individually on the bench to investigate their effects and performance. The effects of the DOC and CDPF on gaseous emissions were tested under different temperatures and space velocities (SVs) by adjusting the engine operating conditions.

The number-size spectrum of the particles was measured under separate steady state conditions of a 13-mode European steady state cycle (ESC). The engine speeds at A, B and C points

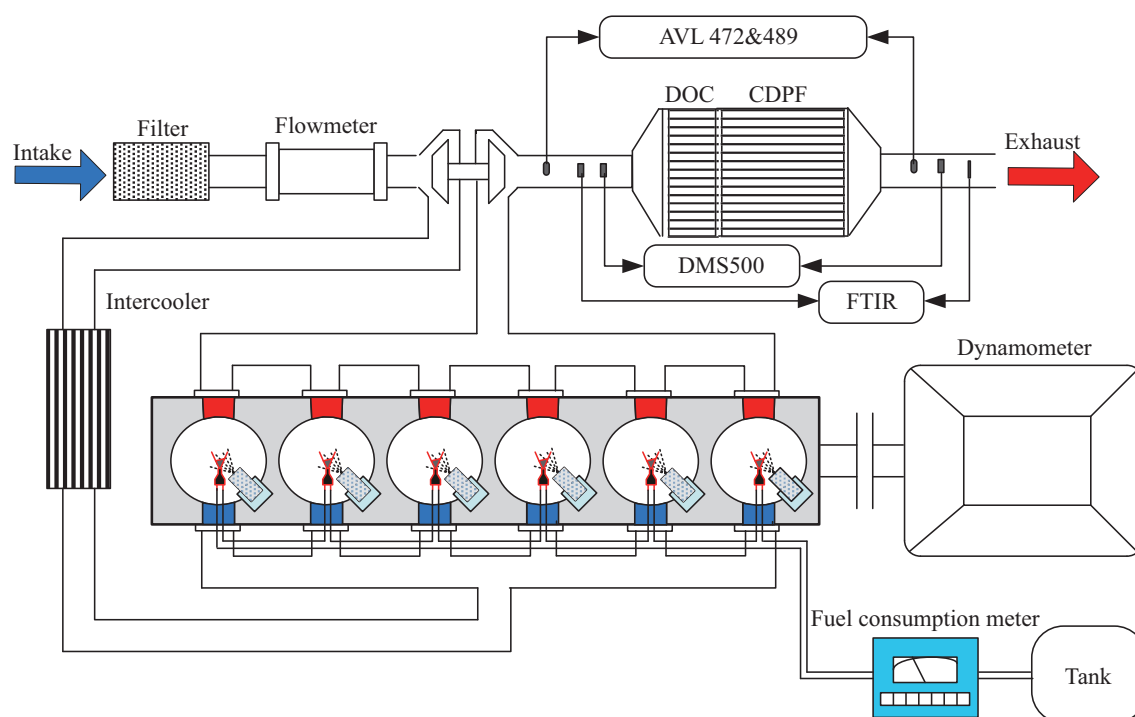


Fig. 1 – Schematic diagram of the engine test bench.

Table 1 – Engine specifications.

| Parameter | Feature/value |
|-----------------------|--|
| Engine type | 4-stroke, intercooling, turbocharging, 6-cylinders in line |
| Bore (mm) | 108 |
| Stroke (mm) | 130 |
| Displacement (L) | 7.14 |
| Compression ratio | 18:1 |
| Fuel injection system | High pressure common rail |
| Rated power | 199 kW at 2300 r/min |
| Maximum torque | 1000 Nm at 1400 r/min |

Table 2 – Specifications of the DOC and CDPF.

| Parameter | DOC | DPF |
|--|----------------|----------------|
| Substrate | Cordierite | Cordierite |
| Cell density (cells/in. ²) | 400 | 200 |
| Diameter × length (mm × mm) | Φ266.7 × 152.4 | Φ266.7 × 304.8 |
| Wall thickness (mm) | 0.18 | 0.30 |
| Volume (L) | 8.5 | 17 |

1 in. = 2.54 cm.
DOC: diesel oxidation catalyst, DPF: diesel particulate filter.

in the ESC test cycle were 1435, 1750, 2050 r/min, respectively. The engine operation conditions of these steady states are represented by the engine modes in the following text. For instance, the engine mode A25 means that the engine ran under the A speed (1435 r/min) at 25% of full load.

The PM mass and SPN at the upstream and downstream of the DOC–CDPF system were measured in both ESC and European transient cycle (ETC) and the filtration efficiency was calculated based on the measurement. To examine the filtration and continuous regeneration behavior, the PM emissions and pressure drop of the filter were tested under different steady engine operation conditions.

2. Results and discussion

2.1. Gaseous emissions

Fig. 2 shows the effect of the aftertreatment on gaseous emissions with a constant SV equaling 30,000 hr^{−1} for the CDPF. Both the DOC and the CDPF could convert NO to NO₂ and remove the HC and CO emissions. The NO₂/NO_x ratio in the engine-out

exhaust was less than 10%. As the exhaust flowed through the DOC, the NO₂/NO_x ratio was above 40% in the temperature range of 300–350°C. In the CDPF, NO₂ was consumed to oxidize the trapped soot. Meanwhile, some part of NO was converted to NO₂ due to the Pt–Pd catalyst on the CDPF. Because the engine-out NO_x/PM ratio was high, the NO₂ consumption by oxidizing the trapped soot had little effect on NO₂/NO_x ratio. In the experiment, the NO₂/NO_x ratio was increased in the temperature range of 200–400°C as the exhaust flowed through the CDPF. When the temperature was above 400°C, the NO₂/NO_x ratios at the outlet of the DOC, the CDPF and the DOC–CDPF were similar, since the conversion was limited by the chemical equilibrium (Olsson et al., 1999).

The soot trapped in the filter can be oxidized by NO₂ and can produce CO or CO₂ (Copper and Thoss, 1989; Majewski et al., 1995). The test results showed that little CO existed at the downstream of the CDPF (Fig. 2c), which was in agreement with a previous study (Liu et al., 2011), indicating that CO₂ was the final product when the trapped soot was oxidized.

It is worth noting that at 160°C the NO₂/NO_x ratio decreased across the DOC and the CDPF. Previous studies show that NO₂ is preferentially consumed relative to O₂ for the oxidation of HC over Pt–Pd/Al₂O₃ catalyst (Irani et al., 2009). At low temperatures the DOC can be a net consumer of NO₂ for oxidizing CO and HC, and the loss of NO₂ increases with DOC aging (Katare et al., 2007).

2.2. Particle emissions and filtration behavior

To understand the filtration behavior on the particles with different sizes, particle number-size distributions were tested under each of the steady-state engine modes according to ESC test cycle. The typical test results at the engine mode C25 and C100 are represented in Fig. 3. The number-size distributions of the engine-out PM had a bimodal character, with the corresponding particle types referred to as the nucleation mode and the accumulation mode. The particles in accumulation mode are carbonaceous agglomerates and associated adsorbed materials, while the nucleation mode consists of volatile organic and inorganic components like sulfates, and maybe also some soot and metal compounds (Kittelson, 1998). After the filter, both the nucleation and accumulation mode particles were reduced significantly.

By fitting each log-normally distributed mode from the number-size spectrum, the nucleation and accumulation mode particles were discriminated automatically by the DMS500 software (Symonds et al., 2007). The break specific PN of these

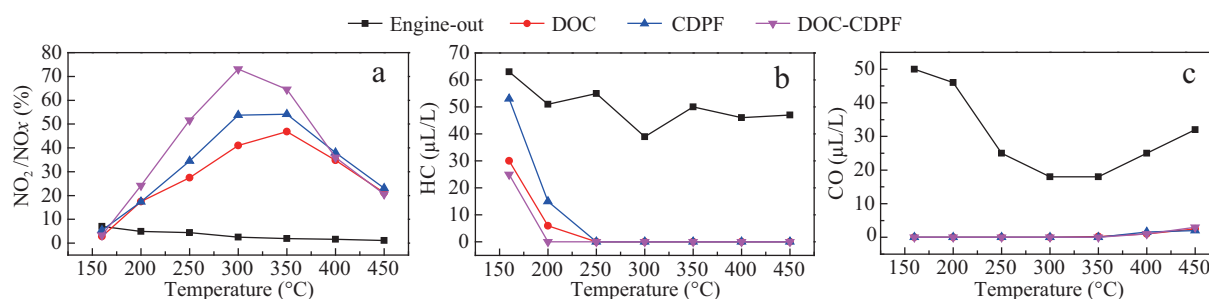


Fig. 2 – Impact of DOC and CDPF on NO₂/NO_x (a), HC (b) and CO (c) at SV = 30,000 hr^{−1} for CDPF. SV: space velocity.

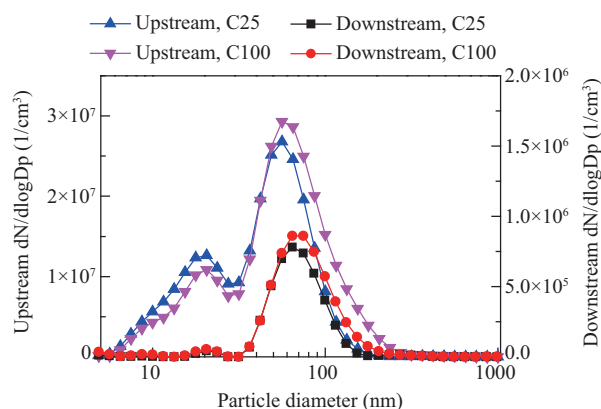


Fig. 3 – Number-size distributions of diesel particles.

two modes upstream and downstream are shown in Fig. 4. After the DOC–CDPF, the brake specific particle number (BSPN) of nucleation mode was much lower than that of accumulation mode at each engine steady state. Most of the volatile components of the nucleation particles were oxidized with the DOC and CDPF. The smaller solid particles, including the nucleation mode particles, were efficiently removed by diffusional deposition in the filter due to their faster Brownian movement (Filippo and Maricq, 2008).

The brake specific PM mass (BSPM) and BSPN of solid particles were measured in ESC and ETC (Table 3). The filtration efficiency of the CDPF on SPN was higher than 99%, while the efficiency on PM mass was relatively low. The PM emissions from the engine contained large part of soluble organic fraction (SOF) and inorganic oxides. The SOF filtration of the CDPF was not as effective as the soot filtration, because the volatile fractions of PM could be vaporized and could flow through the filter as gases, and because they condensed when the PM was collected for weighing (Giechaskiel et al., 2012).

The relationship between the PM mass and the SPN emissions at each steady state of ESC are represented in Fig. 5. In the raw exhaust from the engine, the BSPM and BSPN emissions had a positive correlation. At the outlet of the CDPF, the BSPM showed no correlation with BSPN, as the BSPM was mainly determined by the SOF and inorganic components instead of the number of solid particles.

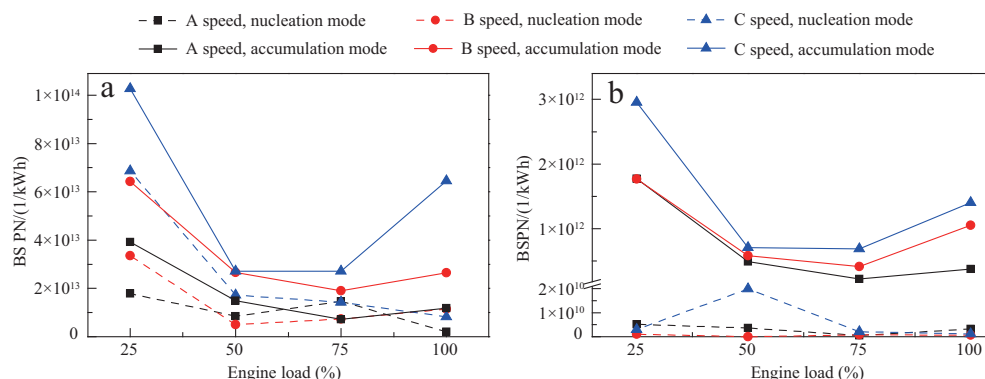


Fig. 4 – Particle number emissions in nucleation and accumulation mode. (a) upstream; (b) downstream. BSPN: brake specific particle number. A, B, C speeds: 1435, 1750, and 2050 r/min of engine speeds at points A, B, and C.

Table 3 – Filtration of PM mass and SPN in ESC and ETC.

| Parameter | ESC test | ETC test |
|-----------------------------------|-----------------------|----------------------|
| Engine-out BSPM (g/kW/h) | 0.019 | 0.021 |
| Post-CDPF BSPM (g/kW/h) | 0.008 | 0.005 |
| PM mass filtration efficiency (%) | 58 | 76 |
| Engine-out BSPN (#/kW/h) | 1.63×10^{13} | 1.9×10^{13} |
| Post-CDPF BSPN (#/kW/h) | 1.17×10^{11} | 4.6×10^9 |
| SPN filtration efficiency (%) | 99.3 | 99.98 |

2.3. Equilibrium regeneration process

The experimental results indicated that the pressure drop increment of the CDPF was less than 0.1 kPa when the engine was operated at each of steady states with low temperatures for 1 hr, which was caused by the low engine-out PM emission and slow soot accumulation in the large-sized CDPF. However, the SPN at the downstream of the CDPF changed obviously and the trend of SPN change was dependent on engine operating conditions (Fig. 6). The SPN decreased at the engine modes B25 and B50 and increased at B75 and B100. The variation of the SPN downstream at steady engine conditions was in response to the change of filtration efficiency, which could be improved with an increase of soot loading (Giechaskiel et al., 2007).

When the exhaust temperature was lower than BPT, the soot oxidation rate was slower than the soot accumulation and the soot loading in the filter increased, resulting in an increase of filtration efficiency and a decrease of SPN downstream. Similarly at higher temperatures the SPN downstream increased. At B50 and B75, SPN changed more slowly than those at B25 and B100, indicating that the exhaust temperature was closer to the BPT. It can be proposed that the slope of the SPN downstream is zero at the equilibrium process, which could be used to define the BPT. To assess BPT of the CDPF for this HD diesel engine, the time consumption was much less by measuring the SPN downstream than by testing pressure drop of the filter.

Actually, the BPT of a continuously regenerating DPF system is a function of many operation parameters, including soot loading, inlet gas composition, SV and test procedure (Schejbal et al., 2010). The BPT of the CDPF, defined as the temperature at which the SPN downstream remained constant, was measured at different SVs with or without DOC (Fig. 7). It was demonstrated that the DOC could help reduce the BPT of CDPF for nearly 50°C, as

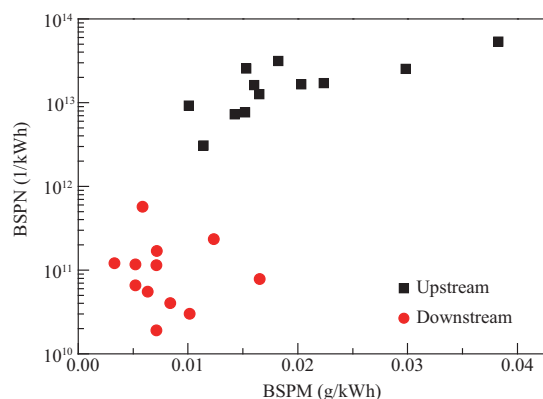


Fig. 5 – Relationship between PM mass and solid particle number. BSPM: brake specific particle mass. BSPN: brake specific SPN particle number.

the DOC increased NO_2 concentration through the CDPF (Fig. 2). The BPT of the CDPF without DOC increased at a higher SV because the residual time for the oxidation of NO to NO_2 was shorter, and the NO_2 concentration was not sufficient to oxidize the soot loaded in the upstream part of the CDPF. For the DOC–CDPF system, the NO_2 concentration at the inlet of the CDPF was already high, so the influence of SV on BPT was not obvious.

3. Conclusions

A DOC–CDPF system was investigated to examine its filtration behavior and passive regeneration process by NO_2 . Both the DOC and the CDPF helped to increase the NO_2/NO_x ratio. The CDPF located downstream of the DOC led to more oxidation of NO to NO_2 at lower temperature, while the conversion was limited by the chemical equilibrium when exhaust temperature was higher than 350°C . The DOC–CDPF system almost completely oxidized the pollutants CO and HC. When the temperature was below 200°C , NO_2 across DOC and CDPF was consumed for the oxidation of CO and HC.

When the DOC–CDPF was tested on a HD diesel engine, most of the particles downstream were in accumulation mode. The filtration efficiency for the particle number was close to 100% in both steady and transient test cycles, while the filtration efficiency for PM mass was relatively low. A positive correlation was found between PM mass and SPN in the raw exhaust, but at

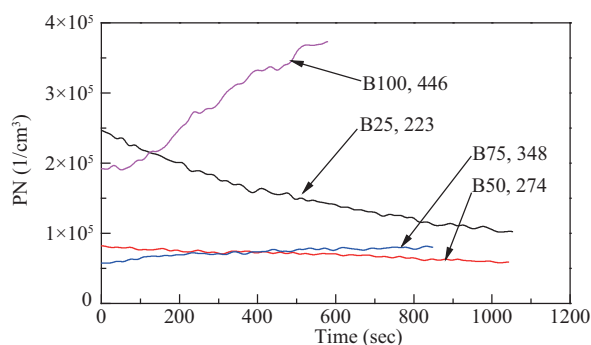


Fig. 6 – Solid particle number profiles downstream of the DOC–CDPF. PN: particle number.

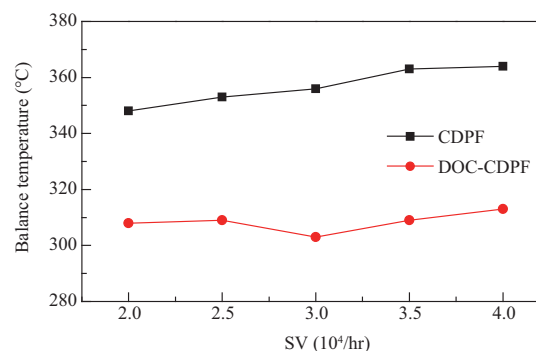


Fig. 7 – Balance point temperature of CDPF with and without DOC at different SVs. SV: space velocity.

the downstream of the CDPF the correlation was not obvious, because most of the PM was SOF and inorganic components.

The SPN at the downstream of the CDPF changed as the soot loading varied. Because the downstream SPN was sensitively influenced by the soot loading, the BPT can be identified by monitoring the trend of SPN. The BPT for the DOC–CDPF system is 303°C at $30,000\text{ hr}^{-1}$, and increased to 356°C for the CDPF without DOC. The BPT of the CDPF without DOC increased slightly with higher SV.

Acknowledgments

This work was supported by the National High Technology Research and Development Program of China (863) (No. 2013AA065304). The authors are grateful to Jianhua Xiao, Yongbiao Ma and Lei Deng for their efforts during the experiment.

REFERENCES

- Alessandrini, F., Schulz, H., Takenaka, S., Lentner, B., Karg, E., Behrendt, H., et al., 2006. Effects of ultrafine carbon particle inhalation on allergic inflammation of the lung. *J. Allergy Clin. Immunol.* 117 (4), 824–830.
- Charlton, S., Dollmeyer, T., Grana, T., 2010. Meeting the US Heavy-duty EPA 2010 Standards and Providing Increased Value for the Customer. SAE Technical Paper, Series No. 2010-01-1934.
- Cloudt, R., Willems, F., 2011. Integrated Emission Management Strategy for Cost-optimal Engine-after Treatment Operation. SAE Technical Paper, Series No. 2011-01-1310.
- Copper, B.J., Thoss, J.E., 1989. Role of NO in Diesel Particulate Emission Control. SAE Technical Paper, Series No. 890404.
- Filippo, A.D., Maricq, M.M., 2008. Diesel nucleation mode particles: semivolatile or solid? *Environ. Sci. Technol.* 42 (21), 7957–7962.
- Giechaskiel, B., Bueno, R.M., Rubino, L., Manfredi, U., Dilara, P., Santi, G.D., 2007. Particle Measurement Programme (PMP): Particle Size and Number Emissions Before, During and After Regeneration Events of a Euro 4 DPF Equipped Light-duty Diesel Vehicle. SAE Technical Paper, Series No. 2007-01-1944.
- Giechaskiel, B., Mamakos, A., Andersson, J., Dilara, P., Martini, G., Schindler, W., et al., 2012. Measurement of automotive nonvolatile particle number emissions within the European legislative framework: a review. *Aerosol Sci. Technol.* 46 (7), 719–749.
- Giechaskiel, B., Maricq, M., Ntziachristos, L., Dardiotis, C., Wang, X., Axmann, H., et al., 2014. Review of motor vehicle particulate

- emissions sampling and measurement: from smoke and filter mass to particle number. *J. Aerosol Sci.* 67, 48–86.
- Irani, K., Epling, W.S., Blint, R., 2009. Effect of hydrocarbon species on NO oxidation over diesel oxidation catalysts. *Appl. Catal. B Environ.* 92 (3–4), 422–428.
- Johnson, T., 2013. Vehicular Emissions in Review. SAE Technical Paper, Series No. 2013-01-0538.
- Katare, S.R., Patterson, J.E., Laing, P.M., 2007. Aged DOC is a Net Consumer of NO₂: Analyses of Vehicle, Engine-dynamometer and Reactor Data. SAE Technical Paper, Series No. 2007-01-3984.
- Kittelson, D.B., 1998. Engines and nanoparticles: a review. *J. Aerosol Sci.* 29 (5–6), 575–588.
- Liu, Z.H., Ge, Y.S., Tan, J.W., He, C., Shah, A.C., Ding, Y., et al., 2012. Impacts of continuously regenerating trap and particle oxidation catalyst on the NO₂ and particulate matter emissions emitted from diesel engine. *J. Environ. Sci.* 24 (4), 624–631.
- Liu, Z.H., Shah, A.N., Ge, Y.S., Ding, Y., Tan, J.W., Jiang, L., et al., 2011. Effects of continuously regenerating diesel particulate filters on regulated emissions and number-size distribution of particles emitted from a diesel engine. *J. Environ. Sci.* 23 (5), 798–807.
- Majewski, W.A., Ambs, J.L., Bickel, K., 1995. Nitrogen Oxides Reactions in Diesel Oxidation Catalyst. SAE Technical Paper, Series No. 950374.
- Oi-Uchisawa, J., Obuchi, A., Wang, S.D., Nanba, T., Ohi, A., 2003. Catalytic performance of Pt/MO_x loaded over SiC-DPF for soot oxidation. *Appl. Catal. B Environ.* 43 (2), 117–129.
- Olsson, L., Westerberg, B., Persson, H., Fridell, E., Skoglundh, 1999. A kinetic study of oxygen adsorption/desorption and NO oxidation over Pt/Al₂O₃ Catalysts. *J. Phys. Chem. B* 103 (47), 10433–10439.
- Peters, A., Wichmann, H.E., Tuch, T., Heinrich, J., Heyder, J., 1997. Respiratory effects are associated with the number of ultrafine particles. *Amer. J. Respir. Crit. Care Med.* 155 (4), 1376–1383.
- Prasad, R., Bella, V.R., 2010. A review on diesel soot emission, its effect and control. *Bull. Chem. React. Eng. Catal.* 5 (2), 69–86.
- Schejbala, M., Štěpanek, J., Marek, M., Kočí, P., Kubíček, M., 2010. Modelling of soot oxidation by NO₂ in various types of diesel particulate filters. *Fuel* 89 (9), 2365–2375.
- Symonds, J.P.R., Reavell, K.S.J., Olfert, J.S., Campbell, B.W., Swift, S.J., 2007. Diesel soot mass calculation in real-time with a differential mobility spectrometer. *J. Aerosol Sci.* 38 (1), 52–68.
- Widdershoven, J., Pischinger, F., Lepperhoff, G., Schick, K.P., Strutz, J., Stahlhut, S., 1986. Possibilities of Particle Reduction for Diesel Engines. SAE Technical Paper, Series No. 860013.



Editorial Board of Journal of Environmental Sciences

Editor-in-Chief

Hongxiao Tang Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, China

Associate Editors-in-Chief

Jiuhui Qu Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, China
Shu Tao Peking University, China
Nigel Bell Imperial College London, United Kingdom
Po-Keung Wong The Chinese University of Hong Kong, Hong Kong, China

Editorial Board

Aquatic environment

Baoyu Gao
Shandong University, China
Maohong Fan
University of Wyoming, USA
Chihpin Huang
National Chiao Tung University
Taiwan, China
Ng Wun Jern
Nanyang Environment &
Water Research Institute, Singapore
Clark C. K. Liu
University of Hawaii at Manoa, USA
Hokyoung Shon
University of Technology, Sydney, Australia
Zijian Wang
Research Center for Eco-Environmental Sciences,
Chinese Academy of Sciences, China
Zhiwu Wang
The Ohio State University, USA
Yuxiang Wang
Queen's University, Canada
Min Yang
Research Center for Eco-Environmental Sciences,
Chinese Academy of Sciences, China
Zhifeng Yang
Beijing Normal University, China
Han-Qing Yu
University of Science & Technology of China

Terrestrial environment

Christopher Anderson
Massey University, New Zealand
Zucong Cai
Nanjing Normal University, China
Xinbin Feng
Institute of Geochemistry,
Chinese Academy of Sciences, China
Hongqing Hu
Huazhong Agricultural University, China
Kin-Che Lam
The Chinese University of Hong Kong
Hong Kong, China
Erwin Klumpp
Research Centre Juelich, Agrosphere Institute
Germany
Peijun Li
Institute of Applied Ecology,
Chinese Academy of Sciences, China

Michael Schlöter

German Research Center for Environmental Health
Germany

Xuejun Wang

Peking University, China

Lizhong Zhu

Zhejiang University, China

Atmospheric environment

Jianmin Chen

Fudan University, China

Abdelwahid Mellouki

Centre National de la Recherche Scientifique
France

Yujing Mu

Research Center for Eco-Environmental Sciences,
Chinese Academy of Sciences, China

Min Shao

Peking University, China

James Jay Schauer

University of Wisconsin-Madison, USA

Yuesi Wang

Institute of Atmospheric Physics,
Chinese Academy of Sciences, China

Xin Yang

University of Cambridge, UK

Environmental biology

Yong Cai

Florida International University, USA

Henner Hollert

RWTH Aachen University, Germany

Jae-Seong Lee

Sungkyunkwan University, South Korea

Christopher Rensing

University of Copenhagen, Denmark

Bojan Sedmak

National Institute of Biology, Slovenia

Lirong Song

Institute of Hydrobiology,
Chinese Academy of Sciences, China

Chunxia Wang

National Natural Science Foundation of China

Gehong Wei

Northwest A & F University, China

Daqiang Yin

Tongji University, China

Zhongtang Yu

The Ohio State University, USA

Environmental toxicology and health

Jingwen Chen

Dalian University of Technology, China

Jianying Hu

Peking University, China

Guibin Jiang

Research Center for Eco-Environmental Sciences,
Chinese Academy of Sciences, China

Sijin Liu

Research Center for Eco-Environmental Sciences,
Chinese Academy of Sciences, China

Tsuyoshi Nakanishi

Gifu Pharmaceutical University, Japan

Willie Peijnenburg

University of Leiden, The Netherlands

Bingsheng Zhou

Institute of Hydrobiology,
Chinese Academy of Sciences, China

Environmental catalysis and materials

Hong He

Research Center for Eco-Environmental Sciences,
Chinese Academy of Sciences, China

Junhua Li

Tsinghua University, China

Wenfeng Shangguan

Shanghai Jiao Tong University, China

Yasutake Teraoka

Kyushu University, Japan

Ralph T. Yang

University of Michigan, USA

Environmental analysis and method

Zongwei Cai

Hong Kong Baptist University,
Hong Kong, China

Jiping Chen

Dalian Institute of Chemical Physics,
Chinese Academy of Sciences, China

Minghui Zheng

Research Center for Eco-Environmental Sciences,
Chinese Academy of Sciences, China

Municipal solid waste and green chemistry

Pinjing He

Tongji University, China

Environmental ecology

Rusong Wang

Research Center for Eco-Environmental Sciences,
Chinese Academy of Sciences, China

Editorial office staff

Managing editor Qingcai Feng
Editors Zixuan Wang Suqin Liu Zhengang Mao
English editor Catherine Rice (USA)

JOURNAL OF ENVIRONMENTAL SCIENCES

环境科学学报(英文版)
(<http://www.jesc.ac.cn>)

Aims and scope

Journal of Environmental Sciences is an international academic journal supervised by Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences. The journal publishes original, peer-reviewed innovative research and valuable findings in environmental sciences. The types of articles published are research article, critical review, rapid communications, and special issues.

The scope of the journal embraces the treatment processes for natural groundwater, municipal, agricultural and industrial water and wastewaters; physical and chemical methods for limitation of pollutants emission into the atmospheric environment; chemical and biological and phytoremediation of contaminated soil; fate and transport of pollutants in environments; toxicological effects of terrorist chemical release on the natural environment and human health; development of environmental catalysts and materials.

For subscription to electronic edition

Elsevier is responsible for subscription of the journal. Please subscribe to the journal via <http://www.elsevier.com/locate/jes>.

For subscription to print edition

China: Please contact the customer service, Science Press, 16 Donghuangchenggen North Street, Beijing 100717, China. Tel: +86-10-64017032; E-mail: journal@mail.sciencep.com, or the local post office throughout China (domestic postcode: 2-580).

Outside China: Please order the journal from the Elsevier Customer Service Department at the Regional Sales Office nearest you.

Submission declaration

Submission of an article implies that the work described has not been published previously (except in the form of an abstract or as part of a published lecture or academic thesis), that it is not under consideration for publication elsewhere. The submission should be approved by all authors and tacitly or explicitly by the responsible authorities where the work was carried out. If the manuscript accepted, it will not be published elsewhere in the same form, in English or in any other language, including electronically without the written consent of the copyright-holder.

Submission declaration

Submission of the work described has not been published previously (except in the form of an abstract or as part of a published lecture or academic thesis), that it is not under consideration for publication elsewhere. The publication should be approved by all authors and tacitly or explicitly by the responsible authorities where the work was carried out. If the manuscript accepted, it will not be published elsewhere in the same form, in English or in any other language, including electronically without the written consent of the copyright-holder.

Editorial

Authors should submit manuscript online at <http://www.jesc.ac.cn>. In case of queries, please contact editorial office, Tel: +86-10-62920553, E-mail: jesc@263.net, jesc@rcees.ac.cn. Instruction to authors is available at <http://www.jesc.ac.cn>.

Journal of Environmental Sciences (Established in 1989)

Vol. 26 No. 12 2014

| | | | |
|------------------------|---|-----------------------|---|
| Supervised by | Chinese Academy of Sciences | Published by | Science Press, Beijing, China |
| Sponsored by | Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences | | Elsevier Limited, The Netherlands |
| Edited by | Editorial Office of Journal of Environmental Sciences P. O. Box 2871, Beijing 100085, China Tel: 86-10-62920553; http://www.jesc.ac.cn E-mail: jesc@263.net , jesc@rcees.ac.cn | Distributed by | Domestic Science Press, 16 Donghuangchenggen North Street, Beijing 100717, China Local Post Offices through China Foreign Elsevier Limited http://www.elsevier.com/locate/jes |
| Editor-in-chief | Hongxiao Tang | Printed by | Beijing Beilin Printing House, 100083, China |
| CN 11-2629/X | Domestic postcode: 2-580 | | Domestic price per issue RMB ¥ 110.00 |

ISSN 1001-0742

