ROADSIDE AIR POLLUTION REDUCTION TECHNOLOGY BY ACTIVATED CARBON FIBERS

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Abstract: The technology against air pollution using Activated Carbon Fibers (ACF) does not use the electric power and utilizes only the natural wind. Our research group has developed the ACF unit for roadside that can remove air pollutants by parallel wind flow through slit shape structure. Japanese Ministry of Land, Infrastructure, Transport and Tourism (MLIT) has been proceeded the installation of ACF unit at the national highway where the air pollution from traffic was very severe since 2007. Observed NO_2 and NO removal at the roadside was 84% and 19% on average, respectively. The duration of ACF is enhanced by catalytic performance to oxidize NOx into $NO3^-$ ion, which can be washed out by rain fall easily. Estimated duration of ACF at the roadside is assumed for over 7 years.

Keywords: Activated Carbon Fibers, Air pollution, Roadside, NOx, Micro porous

INTRODUCTION

Activated Carbon Fibers (ACF) has been developed and manufactured by commercial scale in Japan for over 30 years [1, 2]. It has been also manufactured in China and Korea since 2000. The structure of ACF is porous fibrous carbon which has fiber diameter of 10~20 micron and has excellent performance for the speed of both adsorption and desorption. So far, ACF has been utilized for water purifier and solvent recovery equipment. Recently, a demand on the countermeasure for the air pollution in the urban area has been increased. We have developed Pitch-ACF optimized for counter-measure for the air pollution, especially for the removal of low concentration of NO and NO_2 in the atmosphere [3, 4, 5].

MATERIALS AND METHODS

For optimizing the ACF, we tested ACF listed in Table 1. The surface area of coal tar Pitch-ACF were from 500 m^2/g (A5) to 1500 m^2/g (A15), which were made by ADALL co., ltd., subsidiary of Osaka Gas. A5 was not usual brand product, which was specially produced for this study. The specific surface area and pore size was measured by ASAP2420, made by MICROMERITICS co., ltd. The mean pore size of them calculated by MP method is proportional to the specific surface area, from 0.7nm in A5 to 1.1nm in A15.

PAN-ACF was made by Toho-tenax co., ltd., which has smaller diameter of both fiber and pore size compared to the Pitch-ACF of similar specific surface area.

Adsorption tests of low concentration NOx were done in the fixed bed flow reactor of the 30mm inner diameter. 1g of ACF was set in the reactor, and flow rate of through gas was set at 300~1000ml/min which adjusted NOx concentration for 1~20ppm, temperature at 25degree C and humidity at 0~80%. NOx concentration was measured by chemical luminescence NOx meter

(ECL-88US made by YANACO co., ltd) at the inlet and outlet of the reactor.

Table 1 Properties of the tested ACF

Raw material	Brand	D_{FIBER} [a]	S_{BET} [b]	M_p [c]
Pitch	A5	16-20	500	0.7
↑	A7	16-20	700	0.8
↑	A10	16-19	1000	0.9
↑	A15	14-17	1500	1.1
PAN	FE-200	11-13	700	0.8

[a] Diameter of AC Fiber (μm), [b] Specific surface area (m^2/g),
[c] Mean micro pore size (nm)

RESULTS AND DISCUSSION

Optimization of ACF

Results of NO_2 adsorption tests were not affected by the pore size and the specific surface area, but they were affected by the relative humidity sensitively. It is considered that NO_2 can be easily adsorbed on ACF micro pore because it is condensable at room temperature. On the other hand, NO adsorption was strongly affected by the pore size and the specific surface area of ACF, as shown in Fig.1.

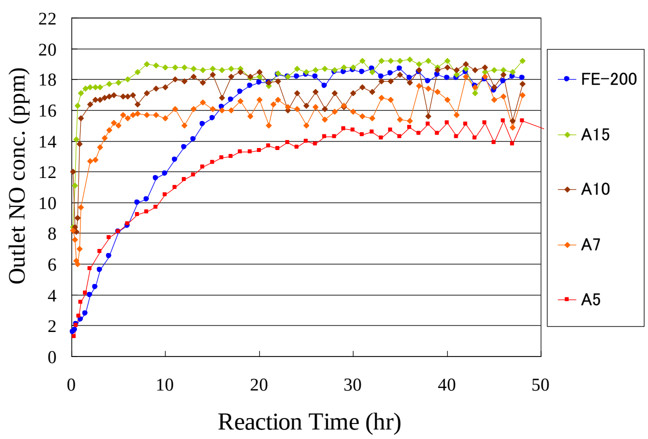

Fig. 1 Breakthrough curve of NO over ACF

In Fig.1, 20ppm NO was flown over ACF in the dry air. A15 and A10, that have larger surface area than others, showed little NO adsorption ability. In the comparison of same surface area around 700m^2/g, PAN FE-200 showed larger NO adsorption ability than Pitch A7 in the initial stage of the adsorption. The difference between the two ACF is the mean micro pore size. So we produced Pitch-ACF of smaller pore size as FE-200 experimentally. As the result, A5 showed the highest NO adsorption ability among the tested ACF (Fig.2).

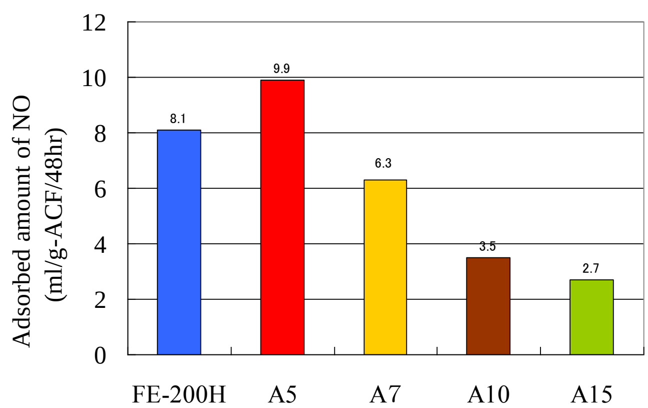

Fig.2 Adsorbed amount of NO on various ACF

Application Of ACF For NOx Removal At The Roadside

Using this ACF, the unit which can reduce the air pollution by NOx at the roadside was developed (Fig.3). Different from conventional filter unit, the ACF unit makes air pass in parallel flow. Pressure drop of ACF unit gives only 200 Pa at the wind velocity of 2 m/sec, which is one fourth of the conventional air filter (Fig.4). It is possible that by this peculiar structure, ACF unit purifies polluted air only by the natural wind without using electric powered fan.

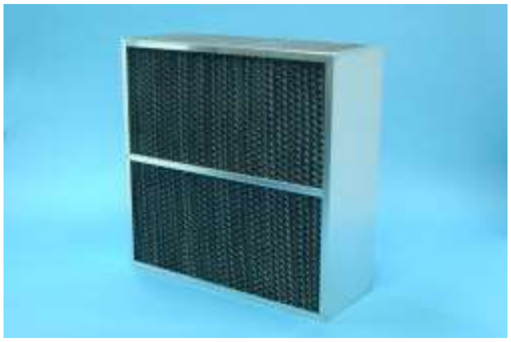

Fig. 3 ACF unit for air pollution reduction

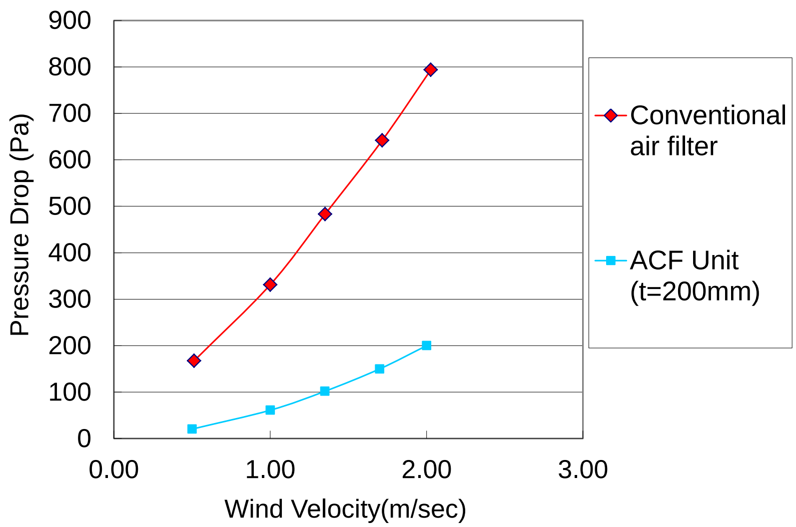

Fig. 4 Pressure drop of ACF unit compared with conventional filter

According to our fundamental study for over 15 years, Japanese MLIT started the installation of ACF unit at the roadside of national highway since 2007. The first installation of ACF was done at the route 43 in Osaka prefecture (Fig.5).

Fig. 5 Installation of ACF fence at the national highway route 43 in Osaka

The NOx removal performance of the ACF unit was measured in actual highway route 43. Fig.6 (Left) and (Right) show the NO_2 and NO removal performance respectively as a function of the natural wind velocity. NO_2 removal performance was stable against wind velocity, and 84% removal ratio was observed on average. On the other hand, the NO removal performance was relatively low, 19 % on average, and it tended to lower by the increase in the wind velocity.

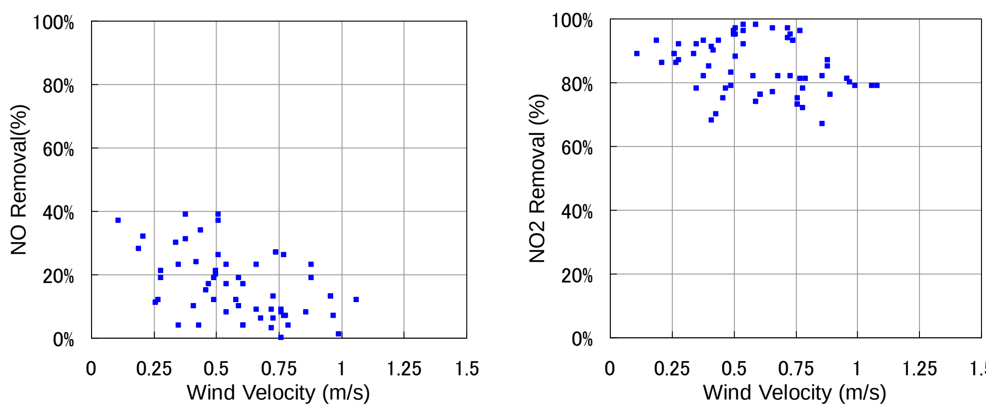

Fig.6 NOx (Left) and NO (Right) removal performance of ACF unit at the highway

According to these results, the roadside air pollution reduction system using ACF was installed at 7 places in Japan and 1 place in China. Especially, large scale of ACF fence was constructed at the national highway in Nagoya prefecture in 2014, and it greatly contributed to the air pollution reduction of the roadside environment. The reduced amount of NOx was equal to the reduction of traffic volume of 5200 large automobiles per day.

CONCLUSIONS

It is considered that Pitch-ACF A5 has the advantage in the adsorption of NO, because it has micro pore around 0.7nm on its fiber surface directly. Using this ACF, the ACF unit of parallel flow can purify NOx from polluted air by only the natural wind. The ACF unit can remove 84% of NO_2 and 19% of NO only by one time passing of wind at the highway in Japan. This technology will be also effective at the heavy traffic zone in Indonesia, such as Jakarta (Fig. 7).

Fig.7 Heavy traffic road at Jakarta, Indonesia

REFERENCES

[1] Shindo N., et al., 1987, Development of Active Carbon Fibers, Chemical Engineering of Japan,32, No.1, p.28

[2] Mochida I., et al., 1994, Oxidation of NO into NO_2 over Active Carbon Fibers, Energy & Fuel, Vol. 8, No. 6, p.1341

[3] Yoshikawa M., Yasutake A. and Mochida I., 1998, Low temperature selective catalytic reduction of NOx by metal oxides supported on active carbon fibers, Applied Catalysis, A: General, 173, p.239

[4] Shimohara T., Niiya S., Mitoma S., Yoshikawa M. and Kitada T., 2011, Air purification technology by Activated Carbon Fibers, J. Japan Soc. Atmos. Environ., Vol.46, 187-195.

[5] Yoshikawa M., Shimohara T., Kitada T., Kanzaki T. and Ichikawa Y., Development of evaluation method of Activated Carbon Fibers unit, 2010, Proceedings of 50th annual meeting of Japan Soc. Atmos. Environ.