Electronic Supplementary Material (ESI) for RSC Advances.

Supporting Information

Soot oxidation performance with HZSM-5 supported Ag nanoparticles catalyst and the characterization of Ag species

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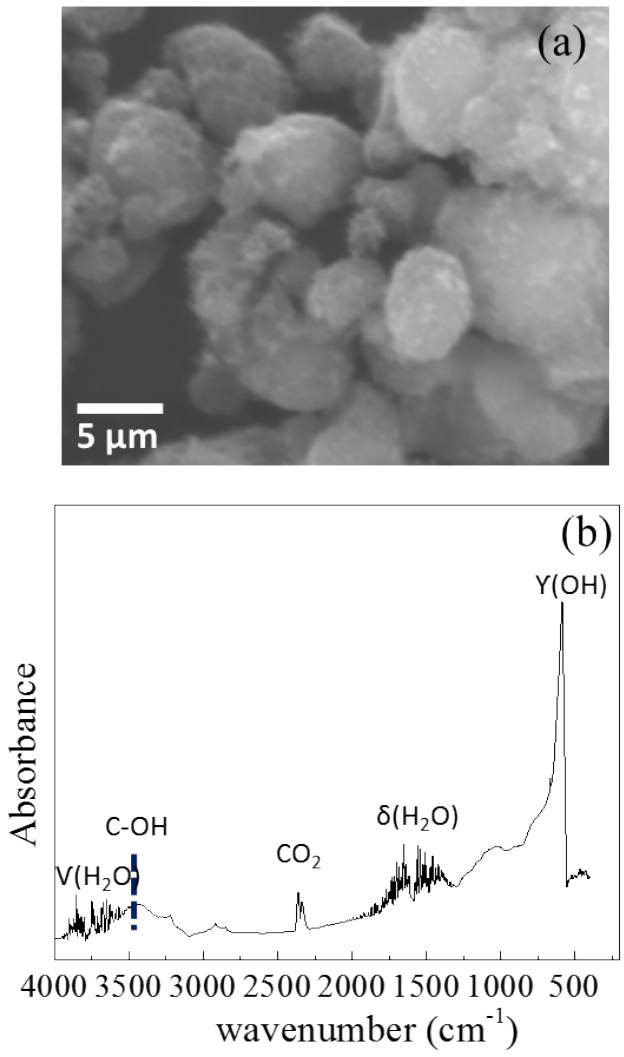

Fig. S1. SEM image (a) and DRIFTs (b) of carbon black at room temperature.

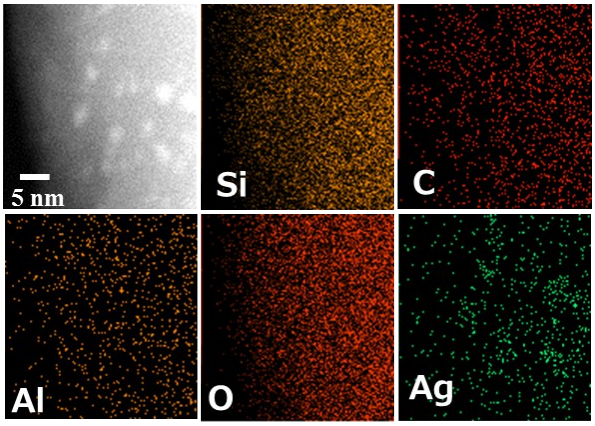

Fig. S2. EDS mapping of different elements of Ag/HZSM-5.

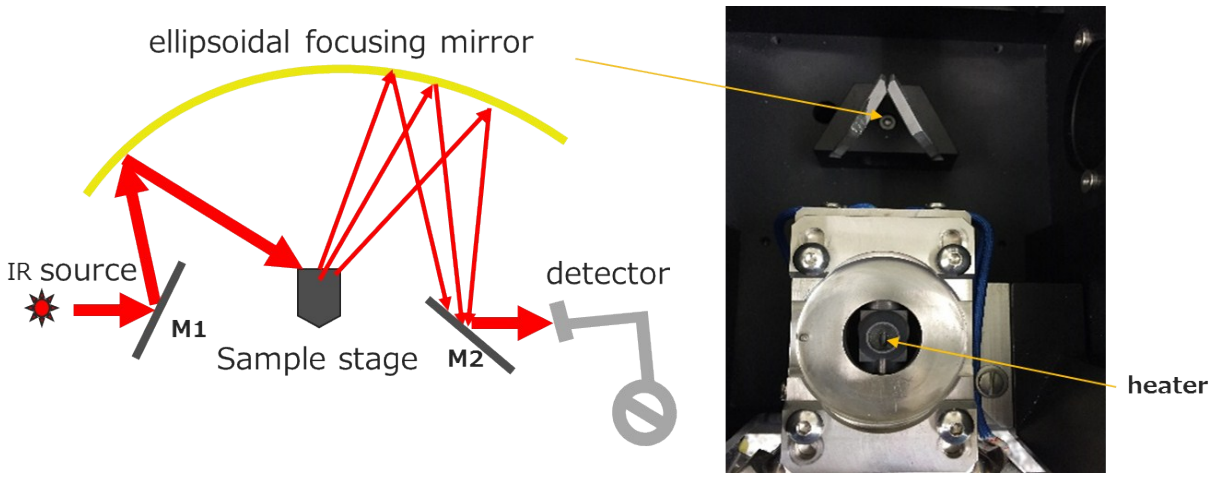

Fig. S3. Schematic of Diffuse Reflectance Infrared Fourier Transform spectroscopy (DRIFTs).

Diffuse Reflectance Infrared Fourier Transform spectroscopy (DRIFTs) measurements were performed on an EQUINOX 55 (Bruker, Germany) equipped with a liquid nitrogen cooled MCT detector. N_2 (99.99% purity) is used as chamber blowing gas at a rate of 100 ml/min. Ex-situ DRIFTs spectra were collected at 25 ^oC in the flowing N_2 , the samples were kept in the flowing N_2 for 30 min as a pretreatment at 25 ^oC. In-situ DRIFTs spectra were collected from 150 to 375 ^oC with an interval of 1 ^oC in a sub-chamber with flowing synthetic air (100 ml/min), the temperature was increased at the rate of 1 ^oC /min and kept at 375 ^oC for 2 h. The samples were conducted in the synthetic air at 50 ^oC for 2 h as a pretreatment before measuring. All of the spectra, determined at a resolution of 4 cm^{-1}, were analyzed by OPUS (Bruker, Germany) software.

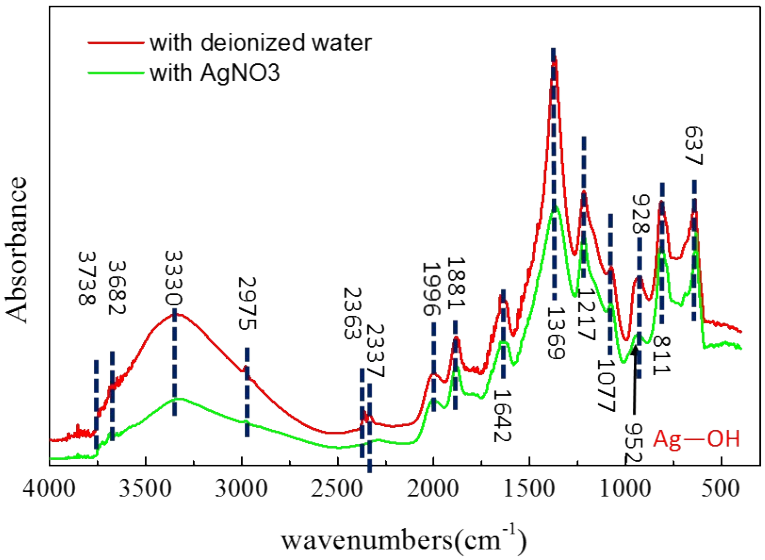

Fig. S4. DRIFTs spectra of HZSM-5 (red line) and Ag /HZSM-5 (green line) at room temperature.

Table S1. Infrared parameters of various modes of HZSM-5.

HSZ891HOA(Si/Al= 1500)	
Wavenumbers (cm^{-1})	Modes[1-5]
3738	Si-OH located at the external surface
3682	γ(OH)
3330	H-bonded OH group
2975	ν(CH)
1996, 1881	lattice vibrations
1642	δ(HOH)
1369	δ(OH)
1217, 811	External linkages between tetrahedral
1077	Internal vibrations of [Si, Al]O_4

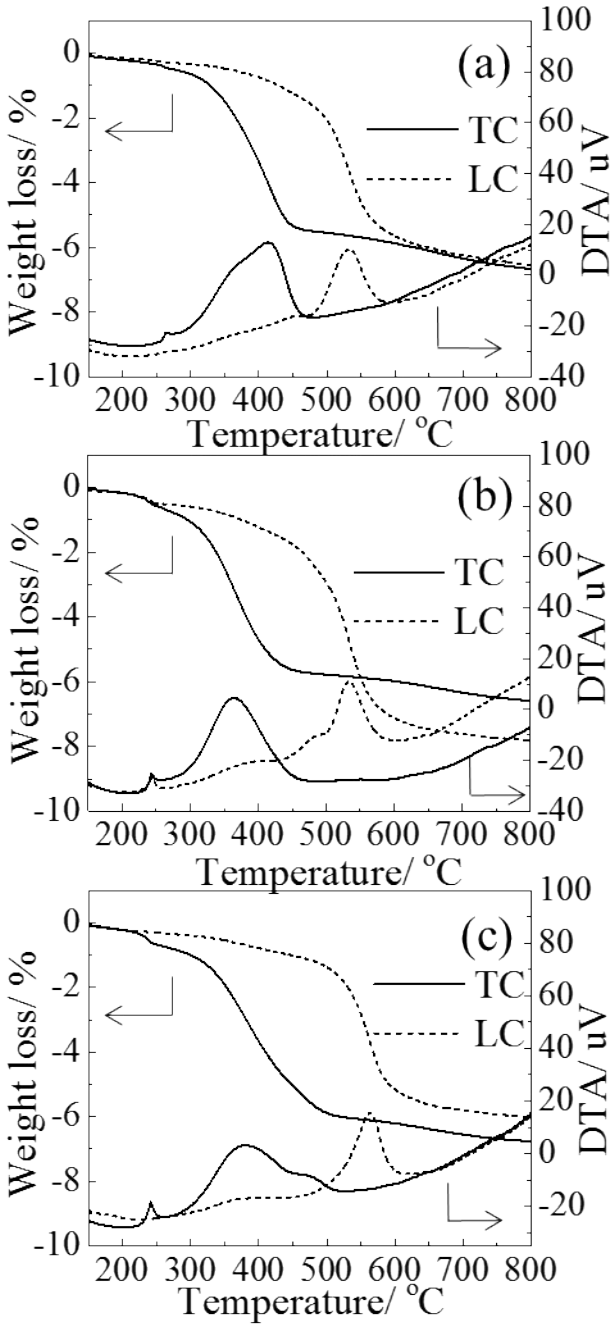

Fig. S5. TG-DTA curves of the soot combustion with x Ag/HZSM-5 catalysts in TC and LC modes, (a) 2%, (b) 4.5% and (c) 8%.

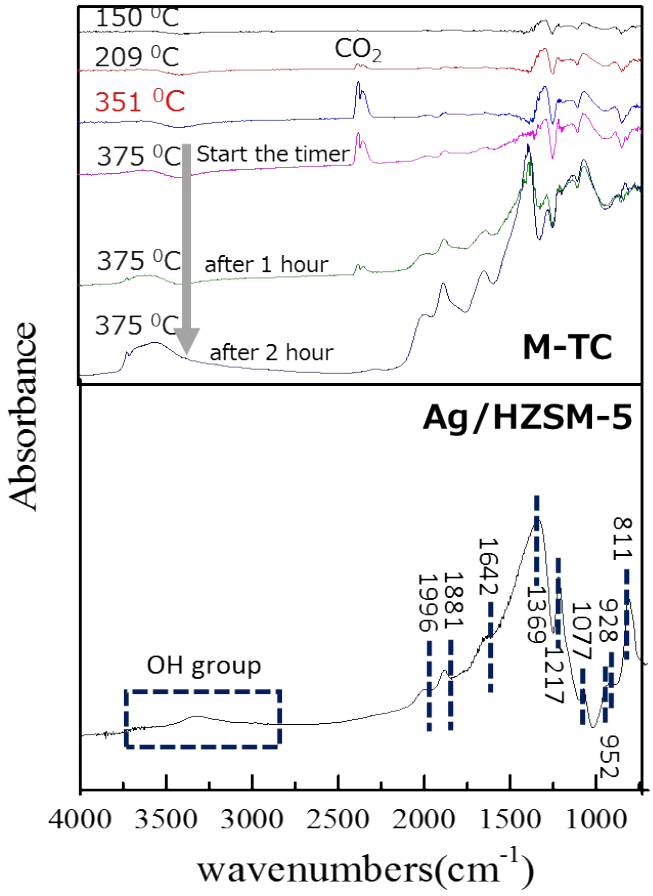

Fig. S6. In-situ DRIFTs spectra of soot oxidation with 4.5% Ag/HZSM-5 with increasing temperature. All the spectra were divided by the spectrum measured at 149 °C.

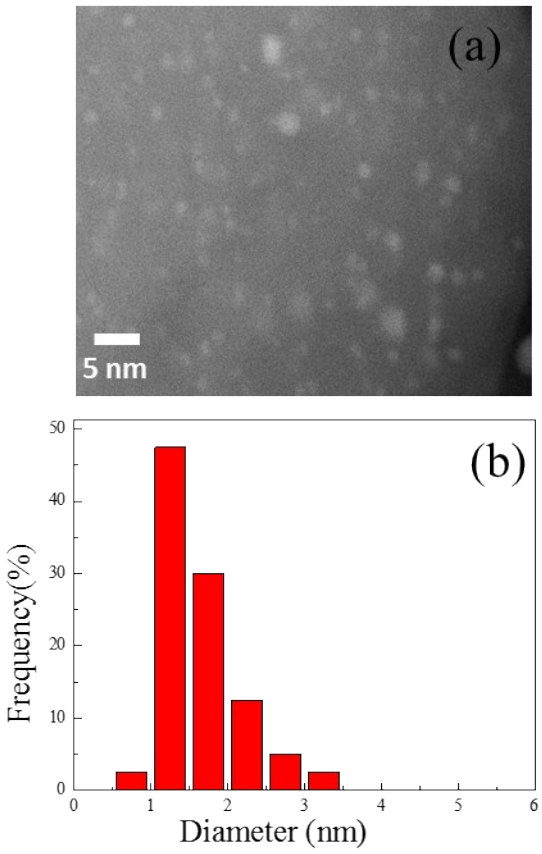

Fig. S7. STEM images and size distribution of Ag particles of Ag/HZSM-5 after high temperature (800 ^{o}C) treatment.

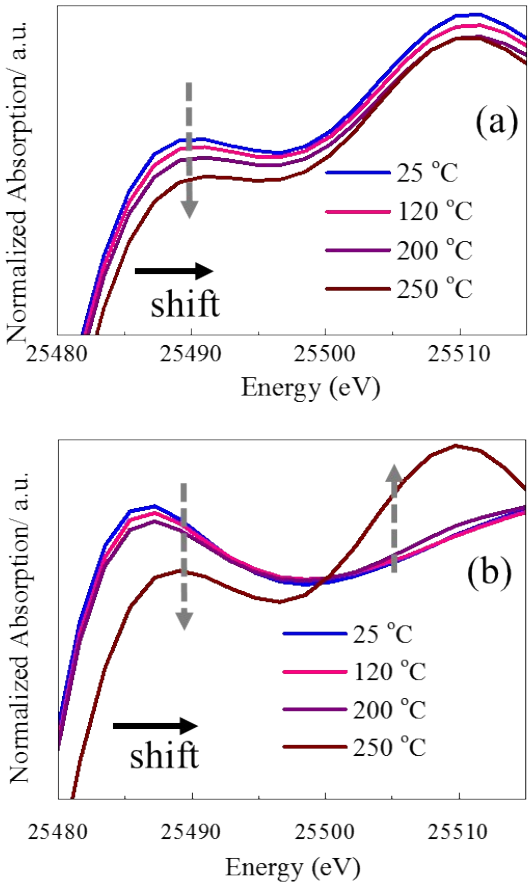

Fig. 8. In-situ Ag K–edge absorption XANES spectra after normalization for M-TC (a) and M-LC (b) from 25 °C to 250 °C.

Table S2. Catalytic performances for soot combustion with catalysts x Ag /HZSM-5 for M-TC and M-LC.

Catalysts xAg/HZSM-5[a]	CB oxidation performance (°C)[b]			
	M-TC		M-LC	
	T_{ig}	T_{max}	T_{ig}	T_{max}
2%	308	414	357	534
4.5%	300	366	339	533
8%	307	379	347	563

[a] x is the weight percentage of silver in catalyst Ag/HZSM-5;

[b] Definition of T_{ig} (ignition temperature of soot combustion) and T_{max} (peak temperature of DTA curves);

Table S3. Catalytic performance for soot oxidation with various catalysts published already.

Catalysts	Experimental method	T_{so} (°C)	comments	Ref.
Ag/CeO_2, Ag/ZrO_2, Ag/Al_2O_3 (1-10 wt%)	IW impregnation, Cal. 500 °C for 3 h	334–345 °C (T_{50} in TC mode)[a], 460–436 °C (T_{50} in LC mode),	Soot /cata.=1 : 20, T_{50} (50% of weight loss)	6
Cu/Mn–Ce mixed oxides	sol–gel method Cal. 500 °C for 3 h	356–390 °C (T_{max} in TC mode)[b], 503–553 °C (T_{max} in LC mode),	Soot /cata.=1 : 10, T_m (max oxidation rate temp.)	7
Pt/MO_x (MO_x = TiO_2, ZrO_2, Al_2O_3)	IW impregnation, Cal. 400-600 °C for 3 h.	410–540 °C (T_{50})[b],	Soot /cata.=1 : 20, T_{50} (50% of weight loss)	8
Ag-loaded sepiolite–Zr–K–O	IW impregnation, Cal. 600 °C for 1 h.	490 °C (T_{50} in TC mode)[a],	Soot /cata.=1 : 5, T_{50} (peak temp. of DTA curve)	9
Ag(1-15 wt%)/perovskite	impregnation, Cal. 500 °C for 4 h.	398–493 °C (T_{50})[b],	Soot /cata.=1 : 10 T_{50} (50% conversion rate of soot)	10
ZSM5, PtZSM5, PtAl	IW impregnation, Cal. 500-585 °C for 2 h	440–563 °C (T_{50})[b],	Soot /cata.=1 : 10	11
perovskite	Electrospinning technique, Cal. 800 °C for 6 h	490–505 °C ($T_{max, L}$), 585–597 °C ($T_{max, H}$), LC mode[a]	Soot /cata.=1 : 19	12
Co, K and/or Ba supported on MgO, La_2O_3 and CeO_2	impregnation, Cal. 400 °C and 700 °C for 4 h	350–400 °C (T_{max})[b]	Soot /cata.=1 : 20,	13
$Ag-CeO_2$	Co-precipitation method, Cal. 500 °C for 5 h.	315–480 °C (T_{max} in TC mode), 376–596 °C (T_{max} in LC mode)[b],	Soot /cata.=1 : 19,	14
Ag/HZSM-5	impregnation, Cal. 500 °C for 5 h	366 °C (T_{max} in TC mode), 533 °C (T_{max} in LC mode)[a],	Soot /cata.=1 : 19	this work

MnO_x-CeO_2	Citric acid complex method. Cal. 550 °C for 5 h	299–387 °C ($T_{CO2,\ max}$ in LC mode)[a]	Soot /cata.=1 : 9, Two types O-vacancies favored to the migration and transformation of active species	15
Manganese oxide (MnO_2, Mn_2O_3 and Mn_3O_4)	Commercially obtained or FSP method	305–390 °C ($T_{CO2,\ max}$ in LC mode)[a]	A strong contribution of bulk oxygen (ca. 60%) occurred for tight as well as loose contact.	16
MnCeO	Hydrothermal method, impregnation method	MnO_x/CeO_2 nanorod 317 °C (T_{50} in TC mode)[a]	MnO_x/CeO_2 nanorods exhibits better catalytic activity due to its larger surface area and higher oxygen release rate	17
$Ag/CexNd_{1-x}O_2$	Hydrothermal method,	394–458 °C ($T_{CO2,\ max}$ in LC mode)[a]	Soot /cata.=1 : 10, Introduction of Nd can lower soot oxidation activity but improve the catalysts' thermal stability effectively	18
Co-CeO_2	Sol-gel method.	335 °C (without H_2O, $T_{CO2,\ max}$ in TC mode)[a], 310 °C (with H_2O, $T_{CO2,\ max}$ in TC mode)[a]	Co in Co-Ce-O_x can improve its catalytic activity for NO oxidation. Ce in Co-Ce-O_x can promote its capacity for NO_2 storage.	19

[a] Temperature of soot oxidation measured by temperature programmed combustion; [b] Temperature of soot oxidation measured by thermogravimetric methods.

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