Electronic Supplementary Material (ESI) for New Journal of Chemistry.

SUPPORTING INFORMATION

Nickel and Cobalt Transfigured Natural Clay: A Green Catalyst for Efficient Low-Temperature Catalytic Soot Oxidation

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Contents

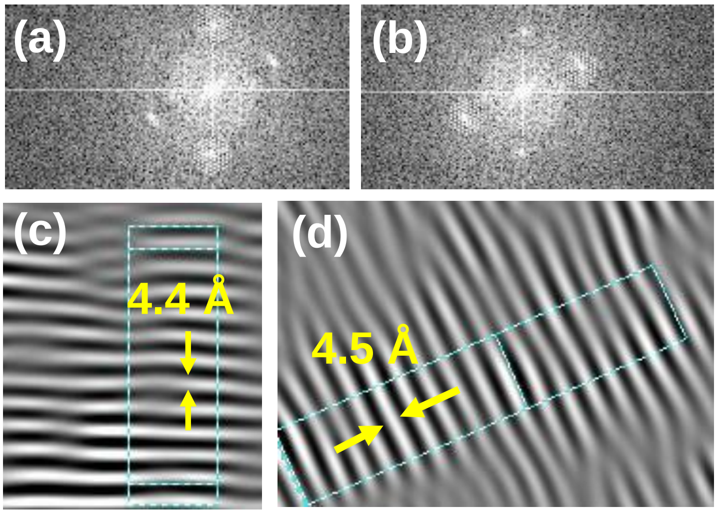

Figure S1. (a, b) FFT image and (c and d) IFFT image showing d-spacing.

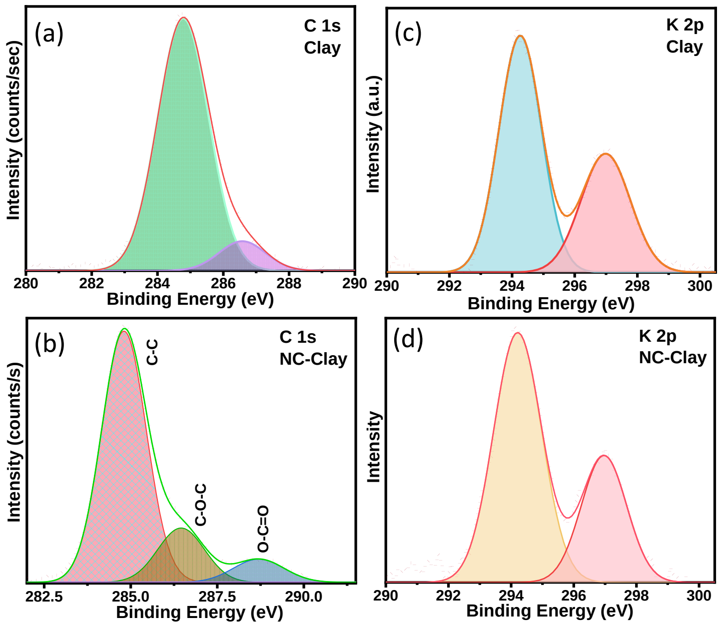

Figure S2. HR XPS of C1s (a, b) and K 2p (c, d) Clay and NC-Clay catalyst.

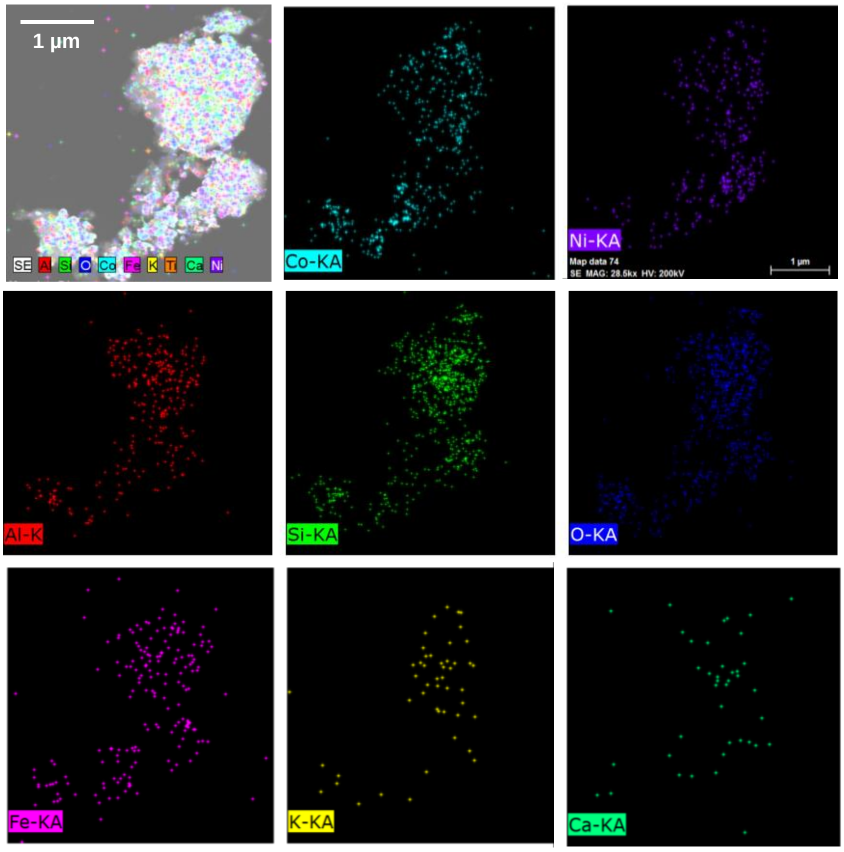

Figure S3. FESEM elemental mapping of NC-Clay catalyst.

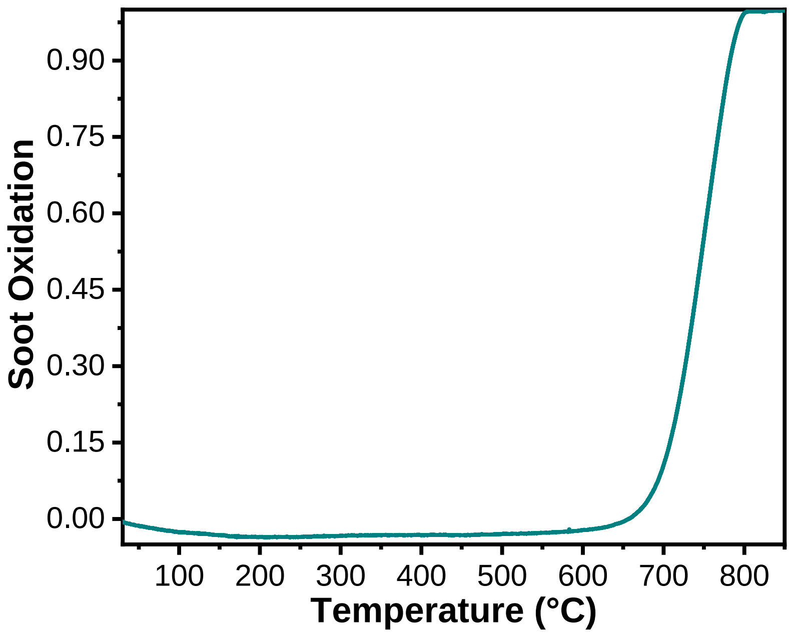

Figure S4. Soot oxidation of bare carbon in the absence of catalyst.

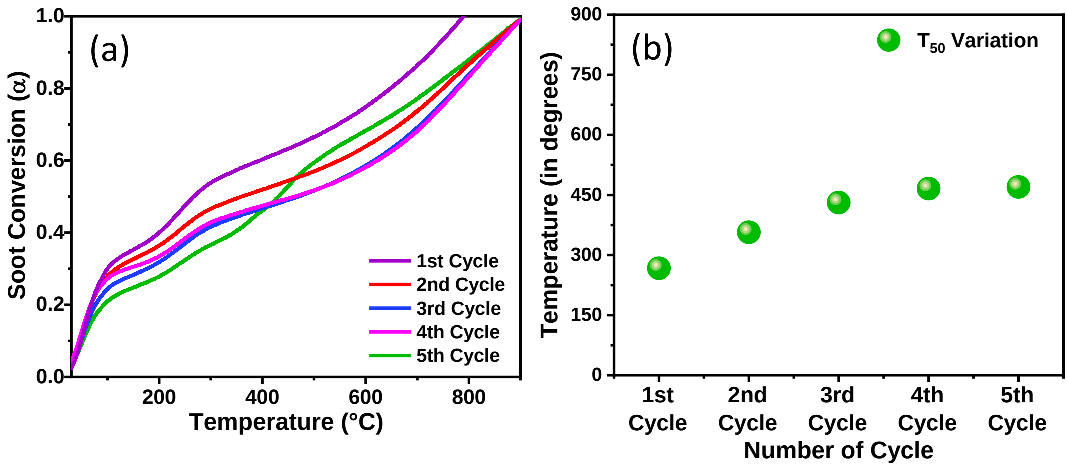

Figure S5. Recyclability test of the synthesized NC-Clay catalyst.

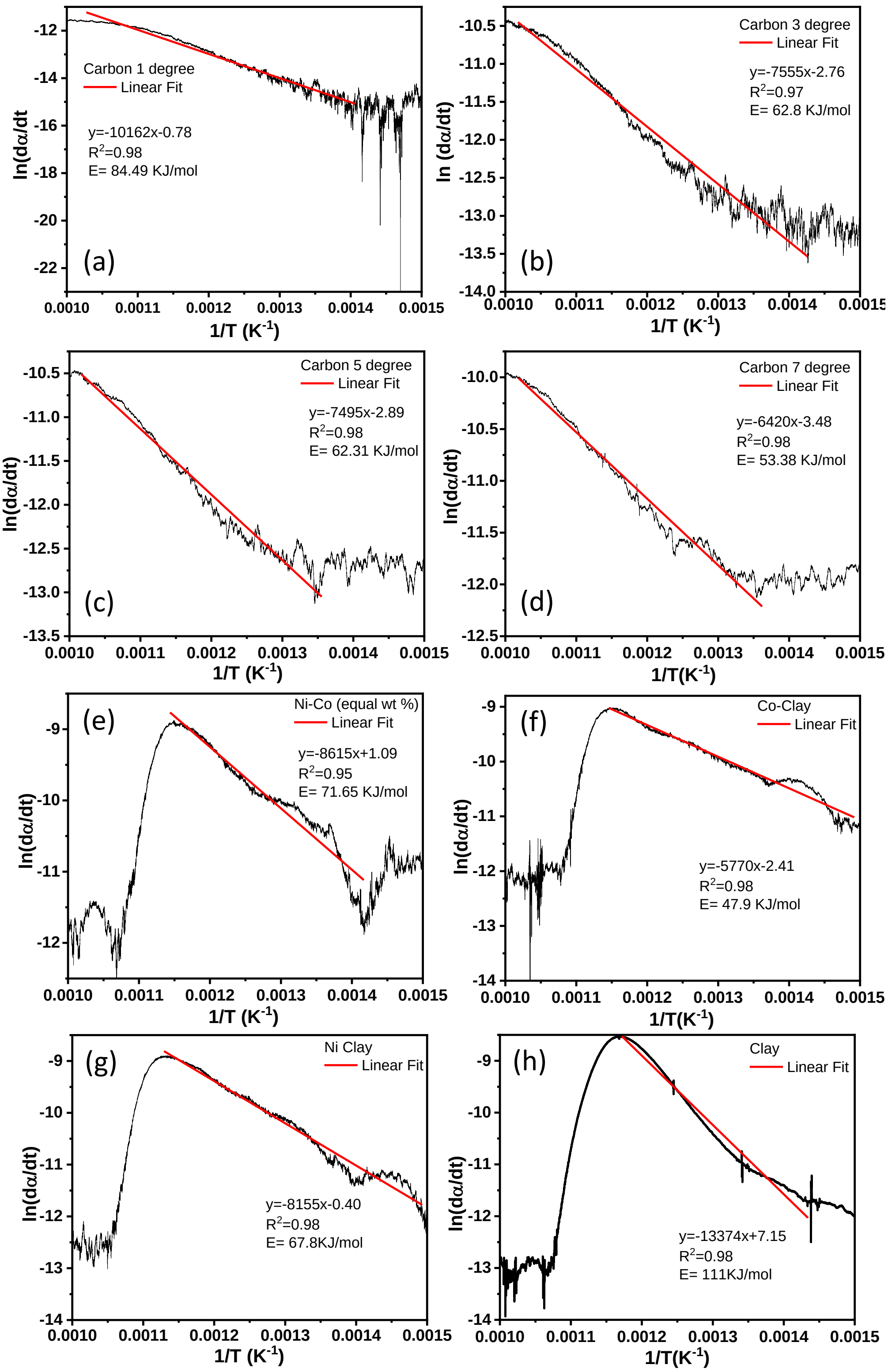

Figure S6. Calculation of activation energies using Friedman method (a-d) Carbon sample at different heating rates without the catalyst and the synthesized catalysts (e) at equal concentration of Ni and Co doped in Clay, (f) and (g) metal doping Co-Clay and Ni-Clay respectively and (h) without any metal dopant only Clay as catalyst.

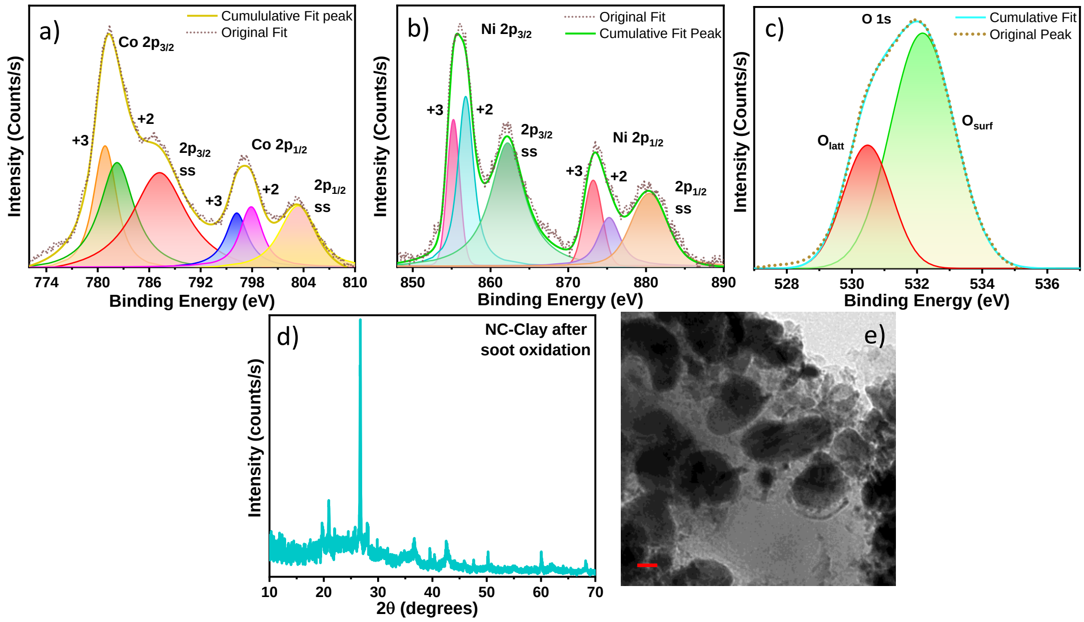

Figure S7. XPS analysis, XRD and TEm characterization of the spent catalyst.

Table S1. O_2 TPD and H_2 TPR peak fitting detail of both Clay and NC-Clay catalyst.

	Peak Index	Peak Type	Area Intg	FWHM	Max Height	Center Grvty	Area IntgP	Max Height	FWHM
H_2 TPR for Clay	1	Gaussian	1350.67	111.49	11.38	553.57	55.61	11.38	111.49
	2	Gaussian	49.24	16.37	2.826	796.87	2.03	2.84	16.37
	3	Gaussian	201.41	91.24	2.07	645.60	8.29	2.07	91.24
	4	Gaussian	767.23	91.50	7.93	793.29	31.59	7.93	91.50
H_2 TPR for NC-Clay	1	Gaussian	3656.54	3656.54	30.62	263.72	263.72	46.15	74.44
	2	Gaussian	4526.62	4526.62	37.90	471.07	471.07	22.97	185.16
	3	Gaussian	2039.03	2039.03	17.07	607.96	607.96	13.64	140.40
	4	Gaussian	1230.03	1216.84	10.19	736.83	736.83	6.69	172.76
	5	Gaussian	504.57	504.33	4.22	208.66	208.67	3.93	120.51
O_2 TPD for Clay	1	PsdVoigt1	59.58	60.43	17.98	512.99	512.99	0.64	92.87
	2	PsdVoigt1	115.35	102.55	30.52	699.69	699.69	0.79	73.97
	3	PsdVoigt1	98.19	97.26	28.94	643.65	643.65	1.81	47.24
	4	PsdVoigt1	77.89	75.77	22.55	611.78	611.78	0.86	72.57
	1	PsdVoigt1	59.58	60.43	17.98	512.99	512.99	0.64	92.87
	1	Gaussian	19.17	19.17	5.59	240.38	240.38	0.24	74.06

O_2 TPD for NC-Clay	2	Gaussian	12.36	12.36	3.60	387.57	387.57	0.22	53.89
	3	Gaussian	13.87	13.87	4.05	438.98	438.98	0.24	54.46
	4	Gaussian	121.38	120.16	35.05	719.52	719.53	0.65	176.09
	5	Gaussian	19.80	19.79	5.77	811.94	811.94	0.32	58.02
	6	Gaussian	157.50	157.50	45.94	485.95	485.95	0.68	217.56

Table S2. Literature survey

Sl No	**Doping material**	**T_{50} (°C)**	**Reaction conditions**	**O_2 TPD**	**References**
1.	Co_3O_4 $Zn_{0.5}Co_{2.5}O_4$ NiO ZnO	412 423 462 575	Loose contact, soot/catalyst = 0.1, 5% O_2 in N_2, NO/5% O_2/N_2, 300 mL min−1.	NA	Zhao *et al.*, *ACS Catal.* 2019, 9, 7548−7567
2.	pure Co_3O_4 pure Sr(NO3)2 Co_3O_4/Sr(NO3)2) 1:2 Co_3O_4/Sr(NO3)2) 1:1 Co_3O_4/Sr(NO3)2)2:1 Co_3O_4/Sr(NO3)2/KNO3) 0.5:0.25:2 Co_3O_4/Sr(NO3)2/KNO3) 0.5:0.5:2 Co_3O_4/Sr(NO3)2/KNO3) 0.5:1:2	554 524 534 519 529 456 469 480	Tight contact, Catalyst/soot=3/1 heating rate 10 °C/min from RT to 650 °C in the air.	NA	Sui *et al*, *Energy & Fuels.* 2007, *21*, 1420-1424
3.	$ZnCo_2O_4$ $CuCo_2O_4$ Co_3O4 $NiCo_2O_4$.	569 574 580 585	Loose contact, soot/catalyst=1/9 N_2 10 vol.% (300 mL min–1). 1000 ppm NO, 5 vol.% H_2O and 100 ppm SO_2	839 805, 863 837 770	Zang *et al.*, *Aerosol and Air Quality Research.* 2017,17, 2317–2327.
4.	0.6Co/Fe-NF	382 °C	Loose contact, Soot/catalyst=1/10 200 -650 °C, heating rate of 2 °C min^{-1}, 300 ppm NO and 5% O_2 balanced by N_2 (50 mL min−1).	NA	Cao *et al.*, Nanoscale. 2016, 8, 5857
5.	p-HfO_2 H-HfO_2 2h H-HfO_2 6h H-HfO_2 10h carbon	644 632 646 649 745	Tight contact, Soot/catalyst=1/4 30-900 °C, 20 mL/min under zero air, 10 °C/min heating rate	187.7 161.4 154.7 126.8 -	Laishram *et al*, *ACS Sustainable Chem. Eng.* 2018, 6, 11286−11294
6.	CeO_2 (conventional) CeO_2-CV CeO_2 –NC CeO_2 -NR	680 720 687 683	Tight contact, soot/catalyst= 1/20 (60mL/min), mixture pre-treated for 1h at 423 K then heating rate (10 K/min) up to 1073 K.		Aneggi et al.*ACS Catal.* 2014, 4, 172−181

7.	PtAl PtZSM5 ZSM5 uncatalyzed	460 440 563 570	Loose contact, soot/catalyst= 1/10 1000 ppm NO/10% O_2/N_2 (500 mL/min) or 10% O_2/N_2 (500 mL/min) temp ramped to 600 °C 10 °C/min heating rate	NO-TPD NH_3-TPD	Liu *et al*, *ACS Catal*. 2015, 5, 909−919
8.	hydrotalcites $Mn_{0.5}Mg_{2.5}AlO$ $Mn_{0.5}Mg_{2.5}Ce_{0.1}Al_{0.9}O$ $Mn_{0.5}Mg_{2.5}Ce_{0.3}Al_{0.7}O$ $Mn_{0.5}Mg_{2.5}Ce_{0.5}Al_{0.5}O$	544 495 498 503	Tight contact, soot/catalyst= 1/9 gas flow with 5% O_2 or 5% O_2+1000 ppm NO balanced by He (100 mL/min)	TPO	Qian et al. *Journal of rare earths*. 2014, 32,176
9.	Pure soot HBeta Mn–HBeta	570 545 485	Loose contact, soot/catalyst =1:10 mixed with 200 mg silica pellets. 500 ppm NO, 10% O2 and balance N_2 was feed with a flow rate 200 mL min^{-1}	NH_3-TPD	Zhou et al.*J. Mater. Chem. A*, 2015, 3, 9745–9753
10.	AgCe-0.03 AgCe-0.02 AgCe-0.01 AgCe-0.04 AgCe-0.05 AgCe-0	449 456 460 462 468 476	Loose contact, soot/catalyst =1:10 mixed with 300 mg silica pellets 1% O_2/N_2 (500 ml min^{-1})	TPO	Wang et al. *Catal. Sci. Technol*. 2017, 7, 2129
11.	Pristine CeO_2 Ce–Sm Ce–Sm/Al_2O_3 Uncatalysed soot	562 419 424 607	Tight contact, catalyst/soot=4/1 heating rate 10 K min^{-1} from RT to 1273 K under oxygen flow 100 mL min^{-1}	NA	Sudarsanam et al, *New J. Chem***.** 2014, 38, 5991
12.	PtZ-1 PtZ-2 PtAl	441 433 446	Loose contact, soot/catalyst =1/5 mixed with 300 mg silica pellets 500 ppm NO/10% O_2/N_2 or 10% O_2/N_2 GHSV= 30 000 h^{-1} heated to 600 °C rate 10 °C min^{-1}.	NO-TPD NH_3-TPD	Gao et al. *Catal. Sci. Technol*. 2017, 7, 3268
13.	WPtAl WPtAl–A WPtAl–SA PtAl PtAl–A PtAl–SA	461 469 473 473 474 489	Loose contact, soot/catalyst =1:10 mixed with 300 mg of silica pellets. 1000 ppm NO/10% O_2/N_2 total flow rate of 500 mL min^{-1}.	NO-TPD TPO	Wu, *et al*., *Catal. Sci. Technol*., 2011, 1, 644–651
14.	h-CeO_2/SiO_2 MnO_x/SiO_2 Soot	430 490 650	Tight contact CeO_2/Si O/soot =7.2/11.8/1. heated from rt to 750 ℃ heating rate of 10℃/min (80 ml/min) of 10 % v/v O_2 balanced with He.	CO-TPR	Wu *et al*., *ACS Appl. Nano Mater*. 2018, 1, 1438−1443
15.	La0.7Ce0.3Fe0.4Co0.6O3 (3DOM)	410	Loose contact, soot: catalyst=1:9 heated from 200-650 ℃ (2 ℃ min^{-1}) in a flow of 500 ppm NO_2 5 vol% O_2, and the balanced N_2 with a rate of 100 mL min^{-1}.	O_2 TPD <150, 150–550, >500 C	Feng *et al*., RSC Adv., 2015, 5, 91609

16.	$Au_{0.04}/LaFeO_3$ (3DOM)	368	Loose Contact, catalyst/soot =10:1, 5% O_2 and 0.2% NO in Ar (50 $mLmin^{-1}$)	TPO	Wei, *et al*., Angew. Chem., Int. Ed., 2011, 50, 2326–2329.