Electronic Supplementary Information

Methane and nitrogen oxides abatement from marine exhaust gases: A review on available plasma-catalytic systems

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Table S1: CH_4 conversion (%) and SEI ($J{\cdot}mL^{-1}$) for low content (up to 1 vol%) CH_4 feedstocks over different plasma reactor configurations

Conf.[1]	Feed composition	Plasma Technology	CH_4 conv. (%)	SEI ($J{\cdot}mL^{-1}$)	Comments	Ref.
P	**0.5% CH_4** – 10% O_2 – 5.5% CO_2 – 7% H_2O – balance N_2	AC high voltage power supply (PVM500) and a nanosecond pulse generator (Megaimpulse Ltd. NPG-18/3500). Plasma tests: frequency = 20 kHz, voltage = 5-12 kV.	~59 ~95%	1.8 4	Reactor: Al_2O_3 tube (99.7%), OD=6 mm, ID=4 mm. The plasma reactor was in the traditional **DBD** cylindrical configuration. **F = 100 ml·min^{-1}** Negligible solid carbon deposition. Increasing SEI → CO_2 yield increases & CO yield decreases	27
IPC	**0.5% CH_4** – 10% O_2 – 5.5% CO_2 – 7% H_2O – balance N_2	≠≠	~25% ~60%	4 6	Reactor: Al_2O_3 tube (99.7%), OD=6 mm, ID=4 mm. The plasma reactor was in the traditional DBD cylindrical configuration. Negligible solid carbon deposition Catalyst: 2wt% Pd/Al_2O_3 (Johnson Matthey)	27
P	**0.5% CH_4** – 10% O_2 – 5.5% CO_2 – 7% H_2O – balance N_2	Nano-pulsed generated plasma Plasma tests: frequency = 20 kHz, voltage = 5-12 kV.	~95%	~2	Reactor consisted of an Al_2O_3 tube (99.7% purity, 6 mm OD – 4 mm ID). Increasing SEI → CO_2 yield increases & CO yield decreases	27
IPC	**0.5% CH_4** – 10% O_2 – 5.5% CO_2 – 7% H_2O – balance N_2	≠≠	~95%	~1.3	Reactor consisted of an Al_2O_3 tube (99.7% purity, 6 mm OD – 4 mm ID). Increasing SEI → CO_2 yield increases & CO yield decreases	27
P PPC IPC	**0.3% CH_4** – 4.0% CO_2 – 2% H_2O – balance air	**DBD** - electrodes were connected to a high voltage monopolar pulse generator (40 kV, 1.5 kW, A2E Technologies-Enertronic. Frequency of the voltage pulse in the range of 100–500 Hz.	49% 44% 27%	1.8 1.8 1.8	Space velocities = 30400 h^{-1} T = 200ºC, P = 12.2 W, **Fin = 400 mL·min^{-1}** Plasma only configuration → CO production PPC configuration → CO_2 production due to oxidation of CO Catalyst: 0.15wt% Pd/alumina 15wt% wash-coated monolith of cordierite ($Mg_2Al_4Si_5O_{18}$)	26

[1] **Reactor configuration:** **P**: Plasma only, **IPC**: in-plasma catalysis, **PPC**: Post-plasma catalysis

Table S1: *(Continued)*

Conf.[1]	Feed composition	Plasma Technology	CH_4 conv. (%)	SEI ($J \cdot mL^{-1}$)	Comments	Ref.
P PPC IPC	**1.0% CH_4** – 4.0% CO_2 – 2% H_2O – balance air	DBD - electrodes were connected to a high voltage monopolar pulse generator (40 kV, 1.5 kW, A2E Technologies-Enertronic. Frequency of the voltage pulse in the range of 100–500 Hz.	~33% 33% 20%	1.5 1.8 1.8	Space velocity = 30400 h^{-1} T = 200°C, P = 12.2 W, **Fin = 400 $mL \cdot min^{-1}$** Plasma only configuration → CO production PPC configuration → CO_2 production due to oxidation of CO Catalyst: 0.15wt% Pd/alumina 15wt% wash-coated monolith of cordierite ($Mg_2Al_4Si_5O_{18}$)	26
P	**0.15% CH_4** – 4.0% CO_2 – 2% H_2O – balance air	≠≠	38	1.8	Space velocity = 45500 h^{-1} T = 200°C, P = 12.2 W, **Fin = 600 $mL \cdot min^{-1}$**	26
P	**1000 ppm CH_4** – balance air	DBD cylindrical configuration	5 (T = 200°C) 30 (T = 300°C) ~65 (T = 400°C)	0.148	Discharge volume = 18 cm^3 Reactor was heated up at constant SEI = 148 J/L_{feed}	29
IPC	**1000 ppm CH_4** – balance air	≠≠	5 (T = 200°C) 42.5 (T = 300°C) ~95 (T = 400°C)	0.148	Discharge volume = 18 cm^3 Catalyst mass = 2.1 or 3.1 g Reactor was heated up at constant SEI = 148 J/L_{feed} Catalyst: 0.5 and 1.0 wt% Pd/Al_2O_3	29
PPC	**1000 ppm CH_4** – balance air	≠≠	5 (T = 200°C) 40 (T = 300°C) ~95 (T = 400°C)	0.148	≠≠	29
P	**500 ppm CH_4** – 21% O_2 – balance N_2	DBD powered by RF unit	68 72 81 90 100	8 12 16 20 24	Feed composition: 500 ppm CH_4, 21% O_2- balance N_2.	30

[1] **Reactor configuration:** **P**: Plasma only, **IPC**: in-plasma catalysis, **PPC**: Post-plasma catalysis

Table S1: *(Continued)*

Conf.[1]	Feed composition	Plasma Technology	CH_4 conv. (%)	SEI ($J\cdot mL^{-1}$)	Comments	Ref.
IPC	**500 ppm CH_4** – 21% O_2 – balance N_2	≠≠	78 85 90 95 100	8 12 16 20 24	Feed composition: 500 ppm CH_4, 21% O_2- balance N_2.	30
IPC	**0.36% CH_4** – 3% O_2 – balance **N_2**	The plasma was ignited with a surfatron device connected to a MW power supply. A MW power of 75 W was used and the pressure of the gases was maintained at 4 Torr. Estimated energy density=10 $W\cdot cm^{-3}$.	~100%	–	Treatment at **Room Temperature** **Pressure = 450-530 Pa** Catalyst: Perovskite $La_{0.5}Sr_{0.5}CoO_{3-d}$ **or** SiO_2 (100 mg) **Selectivity towards CO_2 ~ 10%**	35
IPC	**0.36% CH_4** – 3% O_2 – balance **Ar**	≠≠	~100%	–	Treatment at **Room Temperature** **Pressure = 450-530 Pa** Catalyst: Perovskite $La_{0.5}Sr_{0.5}CoO_{3-d}$ **or** SiO_2 (100 mg) **Selectivity towards CO_2 ~ 40%**	35
IPC	**0.36% CH_4** – 3% O_2 – balance **N_2**	≠≠	~100%	–	Treatment at **190ºC** Catalyst: Perovskite $La_{0.5}Sr_{0.5}CoO_{3-d}$ (100 mg) **Pressure = 450-530 Pa** **Selectivity towards CO_2 ~ 90%** **The use of SiO_2 achieved CO_2 selectivity up to 10% & 45% when N_2 and Ar were used as carrier respectively**	34, 35
P	**0.25% CH_4 –** 2.5% O_2 –balance He	**DBD** reaction system: length of discharge zone=200 mm, gap=5 mm, reaction volume=2.5 cm^3. Experimental conditions: waveform (sinusoid) and driving frequency (4 kHz) with varying voltage amplitude from 2 to 4 kV_{p-p} with 1 kV step.	~6 ~18 ~32	0.032 (2 kV_{p-p}) 0.092 (3 kV_{p-p}) 0.165 (4 kV_{p-p})	**Fin = 200 $mL\cdot min^{-1}$** Space velocity = 24000 h^{-1} **Room temperature**	28

[1] **Reactor configuration:** **P**: Plasma only, **IPC**: in-plasma catalysis, **PPC**: Post-plasma catalysis

Table S1: *(Continued)*

Conf.[1]	Feed composition	Plasma Technology	CH_4 conv. (%)	SEI ($J \cdot mL^{-1}$)	Comments	Ref.
P	**0.25% CH_4** – 2.5% O_2 – balance He	≠≠	~10 ~25 ~31	0.032 (2 kV_{p-p}) 0.091 (3 kV_{p-p}) 0.165 (4 kV_{p-p})	Space velocity = 24000 h^{-1} **Temperature = 180ºC**	28
IPC	**0.25% CH_4** – 2.5% O_2 – balance He	≠≠	~10 ~25 ~43	0.023-0.040 (2 kV_{p-p}) 0.101-0.110 (3 kV_{p-p}) 0.172-0.227(4 kV_{p-p})	**Fin = 200 mL·min^{-1}** Space velocity = 24000 h^{-1} **Temperature = 180ºC** **Catalyst: 2wt%Pd /TiO_2**	28
IPC	**0.25% CH_4** – 2.5% O_2 – balance He	≠≠	~8 ~20 ~55	0.008-0.032 (2 kV_{p-p}) 0.083-0.094 (3 kV_{p-p}) 0.169-0.193 (4 kV_{p-p})	Space velocity = 24000 h^{-1} **Temperature = 180 ºC** **Catalyst: 2wt%Pd /SiO_2**	28
IPC	**0.25% CH_4** – 2.5% O_2 – balance He	≠≠	~10 ~28 ~70	0.018-0.034 (2 kV_{p-p}) 0.088-0.097 (3 kV_{p-p}) 0.163-0.193 (4 kV_{p-p})	Space velocity = 24000 h^{-1} **Temperature = 180 ºC** **Catalyst: 2wt%Pd /γ-Al_2O_3**	28
PPC	**0.25% CH_4** – 2.5% O_2 – balance He	≠≠	~45	0.163-0.193 (4 kV_{p-p})	Space velocity = 24000 h^{-1} **Temperature = 180 ºC** **Catalyst: 2wt%Pd /γ-Al_2O_3**	28
IPC	**0.096% CH_4** – balance Air	**DBD coaxial reactor** Cylindrical electrode ID=10mm, OD=30mm, L=50mm, gap=10mm AC high voltage power supply, operating at 50 Hz; electric field strength: 1-5 kV/cm	~7 ~18 ~20 ~26	~0.27 ~0.93 ~1.20 ~1.44	**Fin** = 200 ml/min in air (N_2/O_2=80/20) containing 1000 ppm CH4 (958.6 ppm) **Residence time**: ~3.6 s **Catalyst**: ferroelectric 1-mm $BaTiO_3$ pellets (relative dielectric constant of ~15,000)	31
IPC	**0.02-0.04% CH_4** in Air	**Coaxial DBD** packed-bed plasma reactor ID=44 mm, OD=54 mm, 120 mm length 20-kHz AC power supply	**IPC:** >20% (BaTiO3: 55%) **P:** 11% **IPC:** 63% Pd(0.03%)/Al_2O_3	0.6-0.7 @ 150-180°C 0.11 + heat @ 240°C	(N_2/O_2=80/20) containing 200-400 ppm CH_4 **Catalyst**: 13X zeolite, $BaTiO_3$ and Pd/Pt on alumina	59

[1] **Reactor configuration:** **P**: Plasma only, **IPC**: in-plasma catalysis, **PPC**: Post-plasma catalysis

Table S1: *(Continued)*

Conf.[1]	Feed composition	Plasma Technology	CH_4 conv. (%)	SEI ($J{\cdot}mL^{-1}$)	Comments	Ref.
IPC	**0.05% CH_4** in Air	**Coaxial DBD** reactor of 24 mm internal diameter. Use of AC power unit ($V_{pk\text{-}pk}$=0-20 kV) operating at 10.25-13.25 kHz.	5.4%	0.118	1 l/min (N_2/O_2=80/20) containing ~500 ppm of CH_4 **Residence time**: 0.25 s **Catalyst**: BaTiO3, 3.5-mm beads. Good trade-off between the number of beads Contact points (discharge enhancement) and bed porosity (low pressure drop)	32
IPC	**0.03% CH_4** in Air	**Coaxial pulsed corona** Ground electrode: aluminum cylinder,ID=50mm HV electrode: 0.075-mm tungsten wire, length of 10 mm. Pulsed DC power unit, Applied voltage: 28 kV positive polarity **Voltage** rise-time: 70 ns & decay time: 4.5 µs.	Plasma alone: 10% Plasma alone: 3% Plasma-material: 5%	35 J/L 8.5 J/L 3.5 J/L	0.1 l/min (N_2/O_2=80/20) containing ~300 ppm of CH_4 **Material:** Silica gel beads (transparent spherical beads of 3-5 mm diameter, with a surface area of 76 m^2/g, pore volume 0.119 cm^3/g and density 0.691 g/ cm^3)	37
P	**0.03% CH_4** in Air	**Glow discharge in a Micro hollow cathode and a planar anode** DC power unit at 470V and 12-22mA atmospheric pressure electron density on the order of 10^{12} cm^{-3} and a gas temperature of 2000 K	80%	4 kJ/L	**F_{in}** = 100 ml/min of dry air containing ~300 ppm of CH_4 The atomic oxygen impact reactions play a dominant role in CH4 removal in this kind of glow discharge	38
P IPC PPC	**0.1% CH_4** in Air	**Coaxial DBD** HV electrode: 0.9-mm tungsten wire quartz tube: 15 mm inner diameter, 300 mm long ground: copper-made grid wrapped around the quartz tube discharge length: 100 mm discharge volume: 18 cm^3 Pulsed HV generator of 20 kV into 500 ns pulses (FWHM) at a maximum pulse frequency of ~1 kHz	67% 100% 100%	148 J/L	**F_{in}** = 1 L/min of dry air containing 1000±5 ppm CH_4 ~2.2 g catalyst was used for the catalytic and plasma-catalytic trials Catalytic bed volume: 4.1 mL gas hourly space velocity (GHSV): of 21 500 h^{-1} At <400°C, ~20% higher conversion was attained in plasma-catalysis than thermal catalysis for the same temperature	39

[1] **Reactor configuration:** **P**: Plasma only, **IPC**: in-plasma catalysis, **PPC**: Post-plasma catalysis

Table S1: *(Continued)*

Conf.[1]	Feed composition	Plasma Technology	CH_4 conv. (%)	SEI ($J \cdot mL^{-1}$)	Comments	Ref.
P	**0.1% CH_4** in N_2:O_2:H_2O= 81:9:10	**Coaxial DBD** reactor 1.5 mm discharge gap Dielectric barrier: Pyrex borosilicate glass of 3 mm thickness (ID=22 mm, OD=25 mm) HV electrode: stainless steel rod of 19 mm diameter Ground electrode: copper-made tape/metallic mesh wrapped around the Pyrex tube Discharge length: 10 cm AC power supply of 300-8000 Hz and maximum applied peak voltage of 10 kV	40%	1500	**Fin** = 2 L/min 1000±5 ppm CH_4 Feed preheating up to 105°C Water changed the electrical and physical properties of the discharge (ions' mobility) and more reactive species (OH radicals) were formed via direct electron water dissociation reactions The increase in CH_4 removal was attributed to the enhancement of the following reaction: $CH_4 + OH \rightarrow CH_3 + H_2O$ NO concentration decreased drastically while NO_2 decreased slightly. Nitrous oxide concentration was less affected by the water vapor content as compared to NO and NO_2.	61
P IPC	**2500 ppm CH_4**, 2.5% O_2 in He	**DBD** reactor 1000:1 high voltage probe (Tektronics P6015A) Current probe (Pearson electronics 6585) Capacitor (1000 pF) HV electrode: stainless steel rod of 3 mm diameter Discharge gap: .5 mm Discharge length: 2.2 cm Reaction volume: 1.7 cm^3 Driving frequency =4 kHz, Applied voltage =4 kV_{p-p}	Plasma alone: ~36 @ 25°C 80% @ 410°C Plasma-catalyst: ~32 @ 25°C >95% @ 410°C	186 J/L 168 J/L	**Fin** = 0.2 L/min Catalytic bed length: 5-7 mm Catalyst beads: d_p=425–600 µm 0.5g of catalyst $Co_1Ni_1O_x$ catalyst calcined at 500 °C exhibited the best performance, with high selectivity toward CO_2 (>85%) even at ambient temperature	33

Table S1: *(Continued)*

[1] **Reactor configuration:** **P**: Plasma only, **IPC**: in-plasma catalysis, **PPC**: Post-plasma catalysis

Conf.[1]	Feed composition	Plasma Technology	CH_4 conv. (%)	SEI ($J{\cdot}mL^{-1}$)	Comments	Ref.
P IPC	**131 ppm CH_4** ($8.20{\cdot}10^{-3}$ mol/m^3), 2.5% O_2 in He	**DBD** reactor Pulse power supply (DP-12K5-SCR, PECC, Japan): 0.5W HV electrode: stainless steel rod of 6 mm diameter Discharge gap: 2 mm Discharge length: 5 cm Reaction volume: 1.7 cm^3 (d_p=425–600 μm) Sinusoid waveform Driving frequency =4 kHz, Applied voltage =4 kV_{p-p}	Plasma alone: <10% @ 25ºC ~12% @ 150ºC Plasma-catalyst: ~16% @ 25ºC ~22% @ 150ºC	186 J/L 168 J/L	**Fin** = 0.1 L/min 1.23–1.33 g of catalyst Catalyst beads: d_p=425–600 μm Temperature programmed discharge experiments were carried out from 25ºC to 150 ºC with a heating rate of 10 ºC /min after an initial 4h saturation step under the feed stream Au addition improved the performance of the catalyst, facilitating the release of of gaseous CO_2 from the formed surface bidentate carbonate species	36

[1] **Reactor configuration:** **P**: Plasma only, **IPC**: in-plasma catalysis, **PPC**: Post-plasma catalysis

Table S2: NO_x removal (%) and SEI (J·mL-1) for low content NO_x feedstocks over different plasma reactor configurations

Configuration[1]	Feed composition	Plasma Technology	NO_x removal (%)	SEI ($J\cdot mL^{-1}$)	Comments	Ref.
P	**1000 ppm NO** – N_2 – Air **Relative humidity =42%** **1000 ppm NO** – N_2 – Air **Relative humidity =68%**	Direct current Corona discharge	~70% >60%	10 W 8W	The vapor in the flue gas restrains the discharge, reduces the discharge current but enhances the $DeNO_x$ efficiency.	48
IPC	**300-500 ppm NO, 15-50 ppm NO_2, 10 % O_2, 5% CO_2 and N_2 balance**	Pulsed Corona discharge	~20%	0.1	Catalyst: γ-Al_2O_3 **Without additive as reductant**	46
IPC	**300-500 ppm NO, 15-50 ppm NO_2, 10 % O_2, 5% CO_2 and N_2 balance**	Pulsed Corona discharge	~70%	0.1	Catalyst: γ-Al_2O_3 **With additive as reductant (1000 ppm CH_3OH)**	46
P	**786 ppm NO, 106 ppm NO_2, 191 ppm CO, 4.2 % H_2O, 5.1% CO_2 and O_2 + N_2 balance**	DBD	~20%	0.1	**T_{gas} = 160ºC** **Without additive as reductant**	47
P	**786 ppm NO, 106 ppm NO_2, 191 ppm CO, 4.2 % H_2O, 5.1% CO_2 and O_2 + N_2 balance**	DBD	~50%	0.1	**T_{gas} = 160ºC** **With additive as reductant (730 ppm C_3H_6)**	47
P	**953 ppm NO, 141 ppm NO_2, 176 ppm CO, 6.1 % H_2O, 6.3% CO_2 and O_2 + N_2 balance**	DBD	~50%	0.1	**T_{gas} = 160ºC** **With additive as reductant (730 ppm C_3H_6)**	47
P	**Actual flue gas (up to 40ppm of NO) from a 0.56 kW CH_4 burner**	DBD	~90%	0.03	**Highest NO removal efficiency was reached at SEI=21 and 10 J/L for flue gases from lean combustion mixtures (air equivalence ratios of 1.2 and 1.4 respectively)** Required power for plasma below 1% of the power generated by the CH_4 burner.	49
P IPC	**163 ppm NO (*200 mg·m^{-3}*), [382 ppm SO_2 (*1000 mg·m^{-3}*)] + N_2 balance**	DBD	Plasma only: 62.5% IPC: 98.7%	0.3	Catalyst: hierarchically structured MnO_X@CuO_X **NO removal efficiency dropped to 76.6% when *382 ppm* of SO_2 were added in the feed**	50

[1] **Reactor configuration:** **P**: Plasma only, **IPC**: in-plasma catalysis, **PPC**: Post-plasma catalysis

Table S2: *(Continued)*

Configuration[1]	Feed composition	Plasma Technology	NO_x removal (%)	SEI ($J \cdot mL^{-1}$)	Comments	Ref.
P IPC	**450 ppm N_2O, 0-20%O_2 + N_2 balance**	DBD	Plasma only: 59% IPC: ~94%	25.6 kV	Catalysts: [Ru, Ag, Ce, Co, Cu, Fe, Ni, V] supported on γ-Al_2O_3 **N_2O decomposition efficiency dropped to ~65% and to <10% for the IPC plasma only configurations respectively when O_2 content increased to 20%**	50

[1] **Reactor configuration:** **P**: Plasma only, **IPC**: in-plasma catalysis, **PPC**: Post-plasma catalysis

Table S3: CH_4 and NO_x removal (%) along with SEI ($J \cdot mL^{-1}$) over different plasma reactor configurations

Configuration[1]	Feed composition	Plasma Technology	Conversion (%)		SEI ($J \cdot mL^{-1}$)	Comments	Ref.
			CH_4	NO_x			
P	**0.36% CH_4** – 3% O_2 – **3000 ppm NO** – balance N_2 **0.36% CH_4** – 3% O_2 – balance N_2	The plasma was ignited with a surfatron device connected to a MW power supply of 75 W Pressure of the gases was maintained at 4 Torr Estimated energy density = 10 $W \cdot cm^{-3}$	97-99 95-99	68 –	– –	Total flowrate = 100 ml/min Selectivity towards CO_2 = 6-8% (CO & H_2O are the main products) The products from NO removal were not specified for the plasma only configuration.	35
P	**0.36% CH_4** – 3% O_2 – **3000 ppm NO** – balance Ar **0.36% CH_4** – 3% O_2 – balance Ar	≠≠	97-99 95-99	88 –		Selectivity towards CO_2 = 8-10% (CO & H_2O are the main products) The products from NO removal were not specified for the plasma only configuration.	35
IPC	**0.36% CH_4** – 3% O_2 – **3000 ppm NO** – balance N_2 **0.36% CH_4** – 3% O_2 – **3000 ppm NO** – balance Ar	≠≠	– –	~18 ~65	– –	Catalyst: Perovskite $La_{0.5}Sr_{0.5}CoO_{3-d}$ (100 mg) The implementation of catalyst decreased the NO removal, as a result of recombination processes between plasma species occurring on the catalyst surface. XPS analysis showed that NO_x and NO_2 adsorbed species were formed onto the surface of the perovskite exposed to these plasmas.	35
P	**0.1% CH_4** – 8% O_2 – **150 ppm NO** – balance N_2	DBD plasma quartz reactor	3 (300°C) 5 (300°C) 9 (300°C) ~14 (375°C) ~25 (375°C) ~31 (375°C) ~30 (450°C) ~45 (450°C) ~60 (450°C)	–	0.036 0.058 0.080 0.036 0.058 0.080 0.036 0.058 0.080	Total flowrate = 250 ml/min Reaction volume = 14.5 cm^3 Discharge pulse energy = 15 $mJ \cdot pulse^{-1}$ NO_x are not removed at temperatures up to 375°C. **NO is just oxidized to NO_2** (total NO_x constant). However, **at temperatures > 375°C NO_x are produced due to NO formation** from N_2 + O_2 in the feed.	57

[1] **Reactor configuration:** **P**: Plasma only, **IPC**: in-plasma catalysis, **PPC**: Post-plasma catalysis

Table S3: *(continued)*

Configuration[1]	Feed composition	Plasma Technology	Conversion (%)		SEI ($J \cdot mL^{-1}$)	Comments	Ref.
			CH_4	NO_x			
P	**0.1% CH_4** – 8% O_2 – **7% CO_2 – 150 ppm NO** – balance N_2	≠≠	≠≠		≠≠	**Addition of CO_2 in the feed stream did not affect CH_4 removal**. However, in the plasma only configuration CO was produced from CO_2 decomposition	57
PPC	**0.1% CH_4** – 8% O_2 – **7% CO_2 – 150 ppm NO** – balance N_2	≠≠	2 (300°C) 4 (300°C) ~8 (300°C) ~18 (375°C) ~25 (375°C) ~31 (375°C) ~72 (475°C) ~85 (475°C) ~91 (475°C)		0.036 0.058 0.080 0.036 0.058 0.080 0.036 0.058 0.080	Total flowrate = 250 ml/min Reaction volume = 14.5 cm^3 Discharge pulse energy = 15 $mJ \cdot pulse^{-1}$ Catalyst: γ-Al_2O_3	57
PPC	**0.1% CH_4** – 8% O_2 – 7% CO_2– **150 ppm NO** – balance N_2	DBD plasma quartz reactor Tungsten electrode of 0.9 mm thickness Discharge zone: 15 cm Discharge gap: 5.5 mm Voltage probe: TEKTRONIX P6015A, 1000x Current probe: EUROPULSE 9001	10 (338°C) 10 (325°C) 30 (412°C) 30 (388°C) ~70 (475°C) ~90 (475°C)		0.036 0.058 0.036 0.058 0.036 0.058	Total flowrate = 250 ml/min Discharge pulse energy = 35 $mJ \cdot pulse^{-1}$ 0.5, 1.6 wt.% Pd or 0.36 wt.% Pt supported on γ-Al_2O_3 Slight improvement in complete CH_4 oxidation toward CO_2 was observed with water vapor addition in the feed at SEI=0.036 $J \cdot mL^{-1}$ at 450°C, at much lower temperature for SEI=0.058 $J \cdot mL^{-1}$ at(300°C) Negligible NO_x detected in the product stream for temperatures below 475°C	58

[1] **Reactor configuration:** **P**: Plasma only, **IPC**: in-plasma catalysis, **PPC**: Post-plasma catalysis

Table S3: *(continued)*

Configuration[1]	Feed composition	Plasma Technology	Conversion (%)		SEI (J·mL^{-1})	Comments	Ref.
			CH_4	NO_x			
IPC	**1.67%CH_4** – 5%O_2 – balance N_2 **(NO_x were adsorbed on the materials in the previous step)**	DBD quartz reactor – powered by AC source	100 100 100 100	~52 ~72 ~85 ~92	–	Catalyst/adsorbent: commercial H-ZSM-5 (Si/Al=22, without further modifications) Total flowrate = 30 ml/min The process included a cyclic operation: 1) NO_x adsorption stage (plasma off) 2)Discharge stage (plasma on) NO_x to N_2 conversion	56
PPC	**610 ppm CH_4** – 0-10.4% H_2O – 0-10% O_2 – 0-10 % CO_2– **600 ppm NO** – balance N_2 **simulating an actual LNG exhaust gas**	DBD ceramic tube reactor, ID=20mm, OD=24mm Toothed stainless steel discharge electrode with a diameter of 16 mm Discharge zone: 15 cm Discharge gap: 5.5 mm HAVC power supply (CTP2000K) 5 - 25 kHz Output voltage = 0 - 25 kV	50% (400°C) 94.3% (481°C)	50% (350°C) 84.5% (481°C)	0.33	Total flowrate = 3300 l/min Reaction volume = 12.5 cm^3 Catalyst: 3.9wt.% In/BEA	60

[1] **Reactor configuration:** **P**: Plasma only, **IPC**: in-plasma catalysis, **PPC**: Post-plasma catalysis

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