Effect of soot on the SCR reactions in an integrated SCR coated DPF

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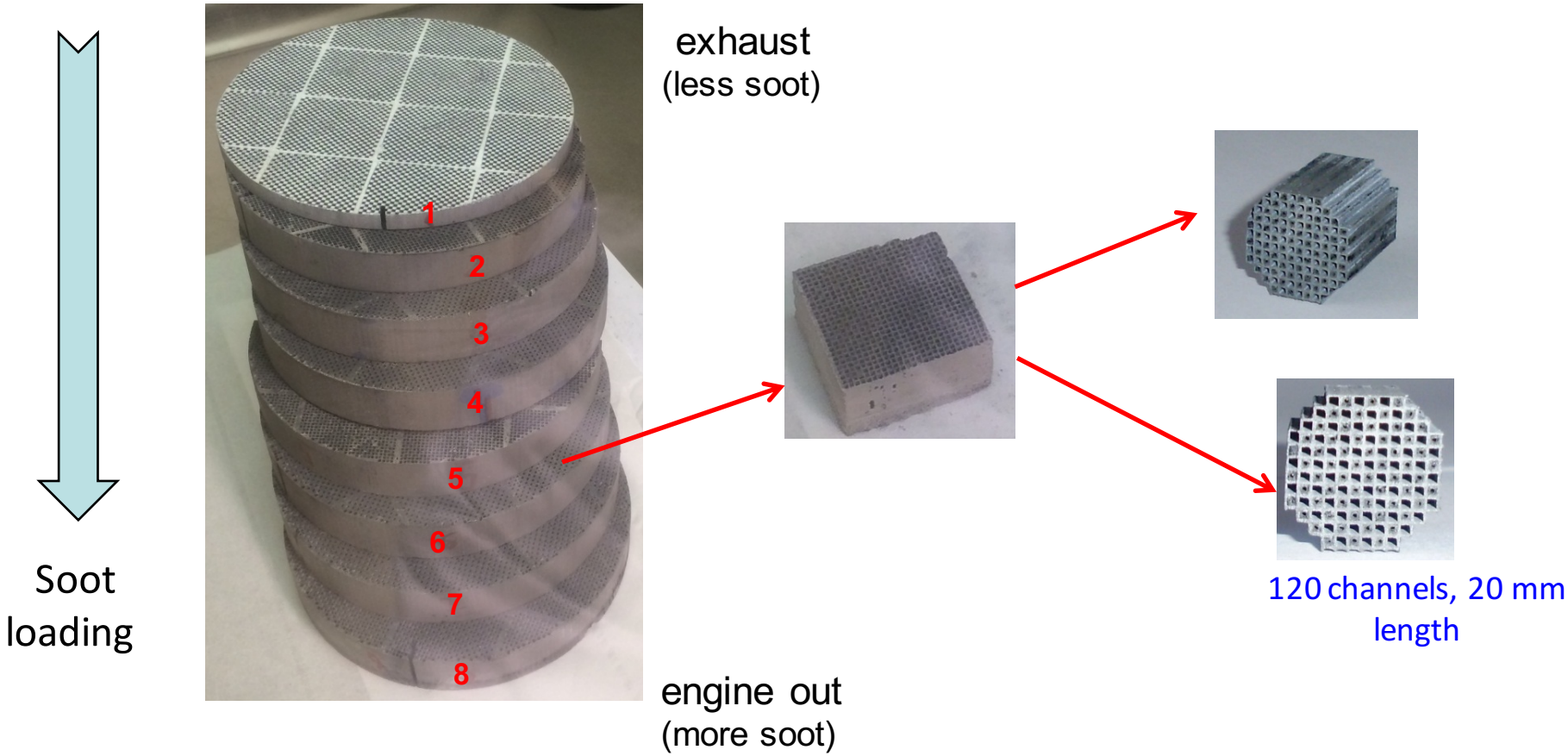
Objective

- To examine the effect of soot on SCR reactions and other functions in SCR coated filters.

SCR coated filter materials



- Copper-zeolite catalyst on DPF filter. Aged at 850 ºC.
- In the next step, SCR coated filter materials were loaded with real soot (by Volvo Cars) using an engine bench.
- Samples from slice no. 6 were used for the flow reactor experiments

Activity measurements

Pre-treatment for every new sample:
500°C, 20 min, Ar

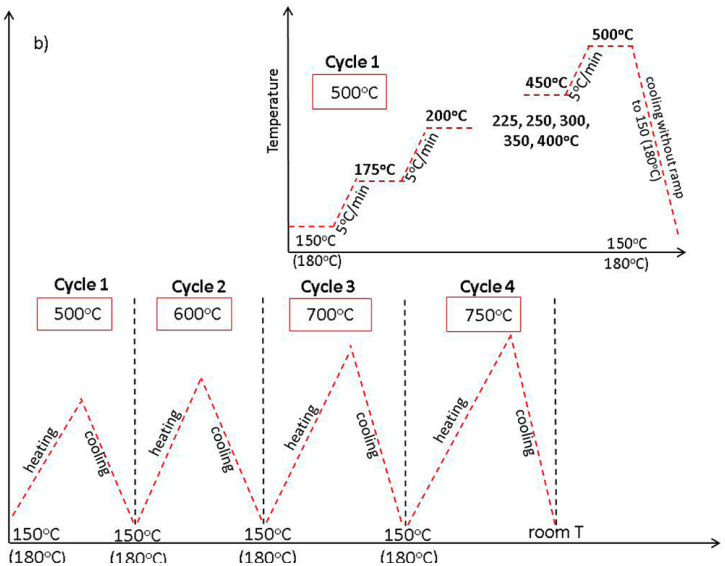
NH_3-SCR: 400 ppm NH_3, 400 ppm NO, 8% O_2, 5% H_2O

Rapid SCR at 150°C and 180°C: 400 ppm NH_3, 200 ppm NO, 200 ppm NO_2, 8% O_2, 5% H_2O

NO oxidation: 400 ppm NO, 8% O_2, 5% H_2O

NH_3 oxidation: 400 ppm NH_3, 8% O_2, 5% H_2O

❖ A single SCR coated filter sample has been employed for the entire test (cycle 1+2+3+4)



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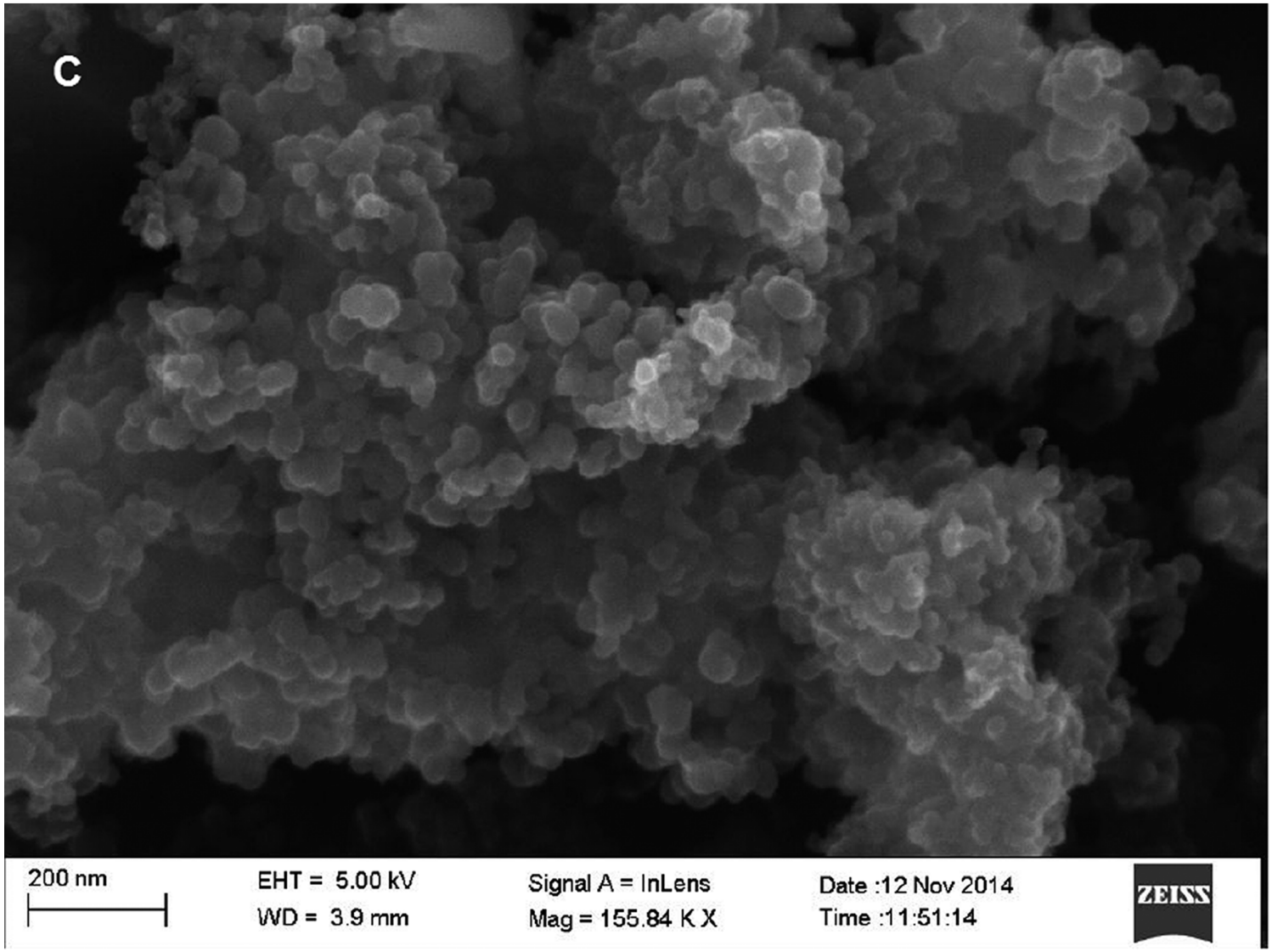
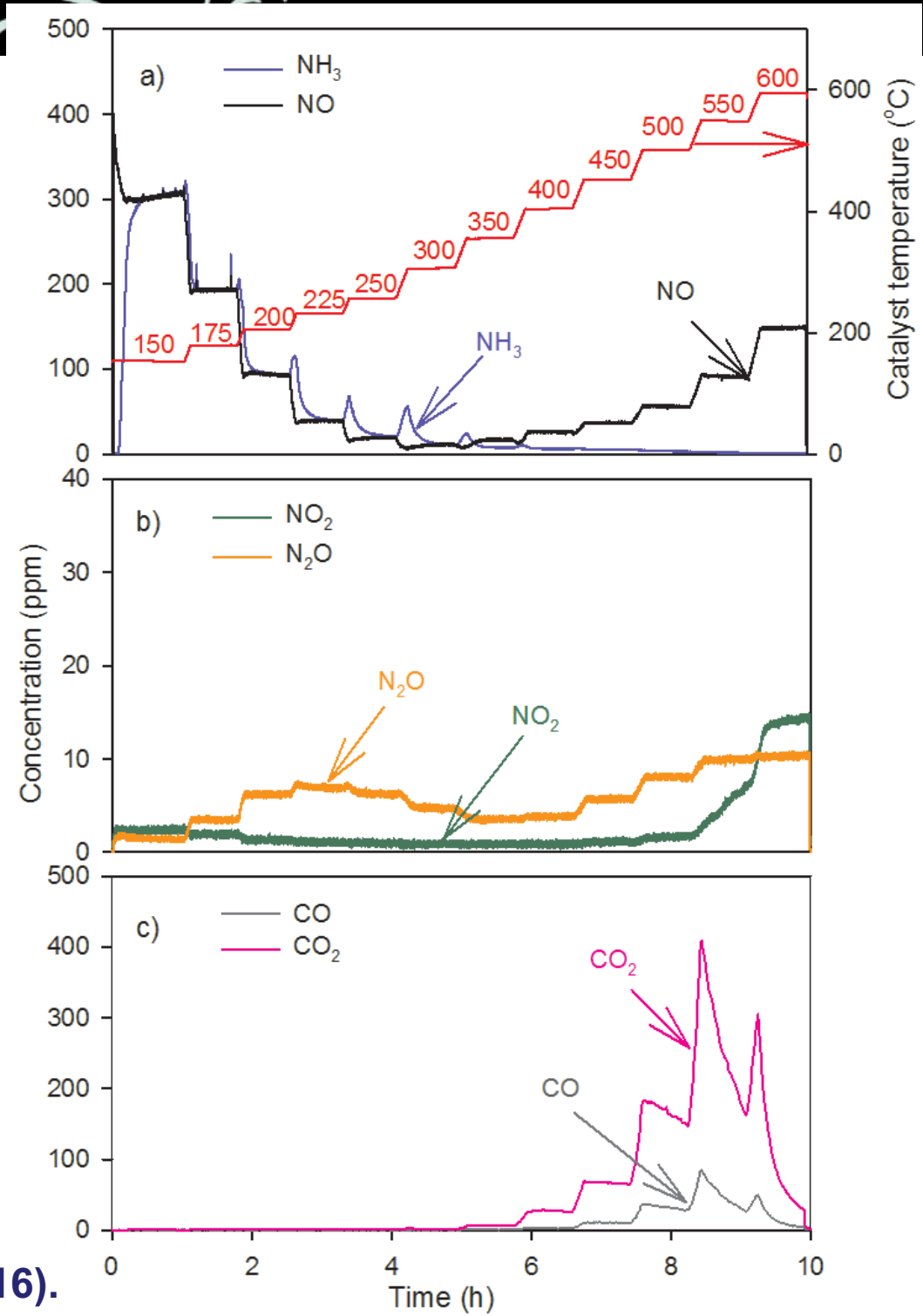
SEM image of soot



Mihai, Tamm, Stenfeldt, Wang Hansen and Olsson, Ind. Eng. Chem. Res. (2016).

NH_3-SCR

NH_3, NO (a), NO_2, N_2O (b), CO, CO_2 (c) on DPF coated with Cu-zeolite SCR catalyst for cycle 2 (from 150 to 600 C).



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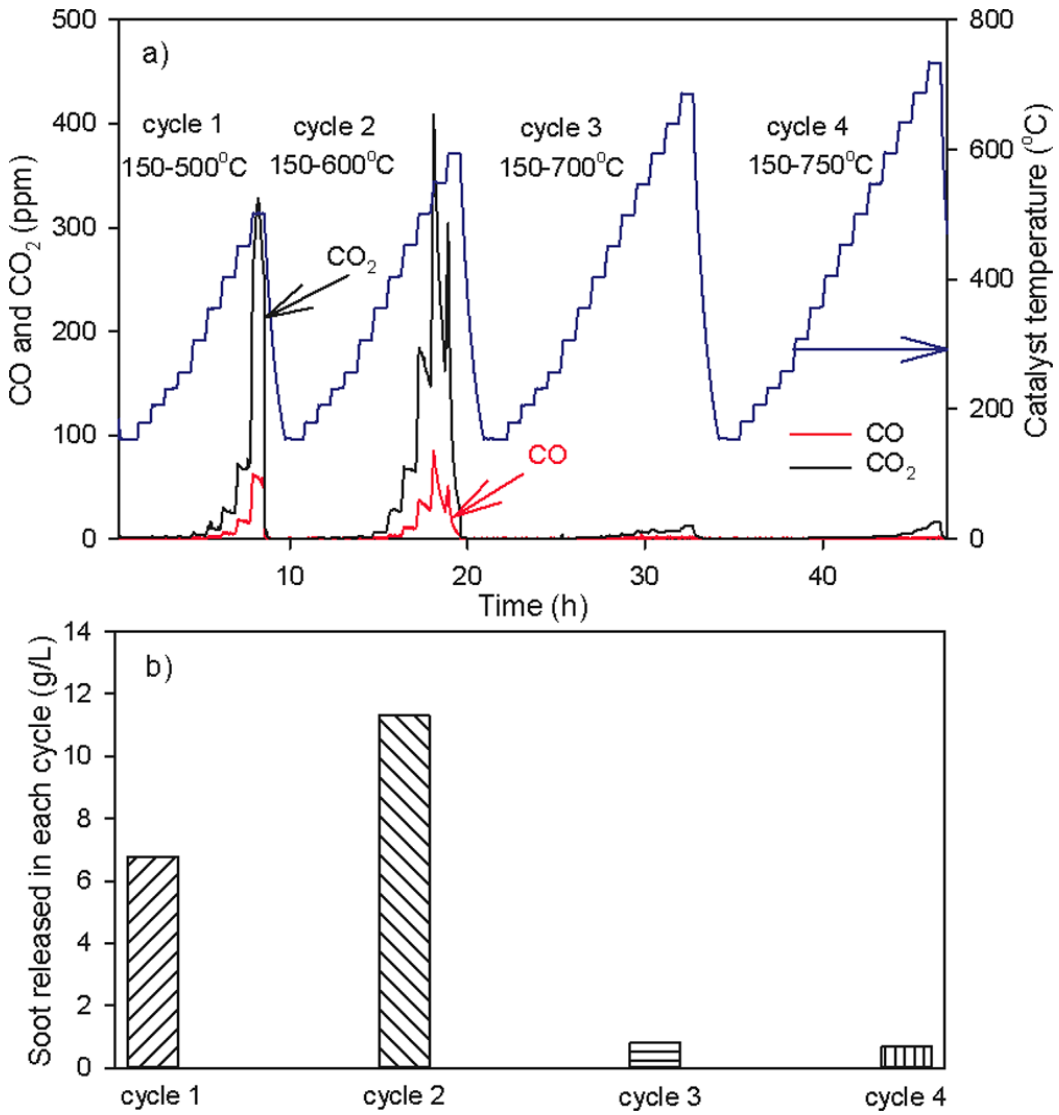
Soot removal in NH_3-SCR



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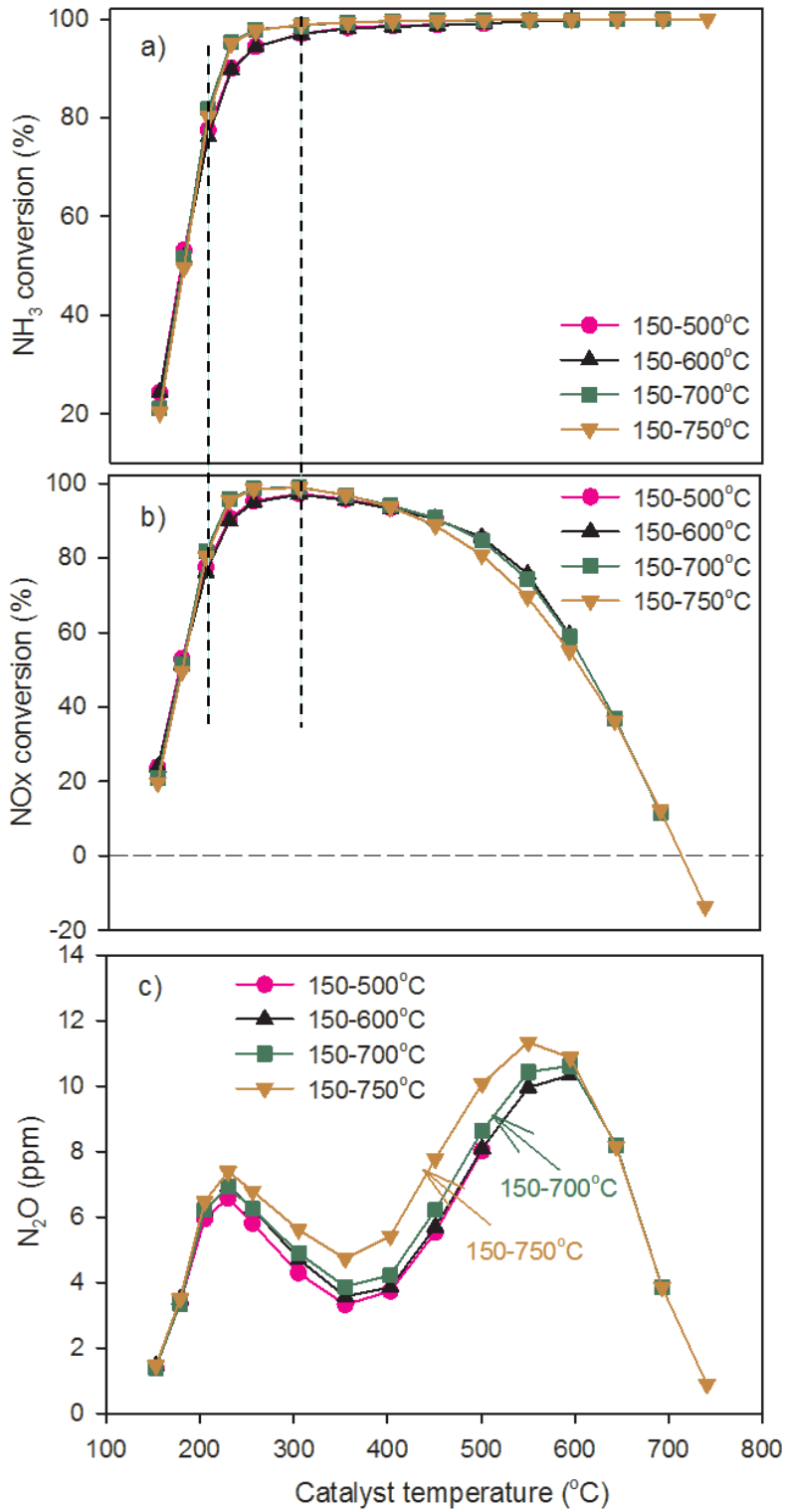
NH_3-SCR



NH_3 conversion (a), NO_x conversion (b), N_2O (c) on DPF coated filter for :
cycle 1 (150- 500 C)
cycle 2 (150- 600 C)
cycle 3 (150 -700 C)
cycle 4 (150- 750 C).

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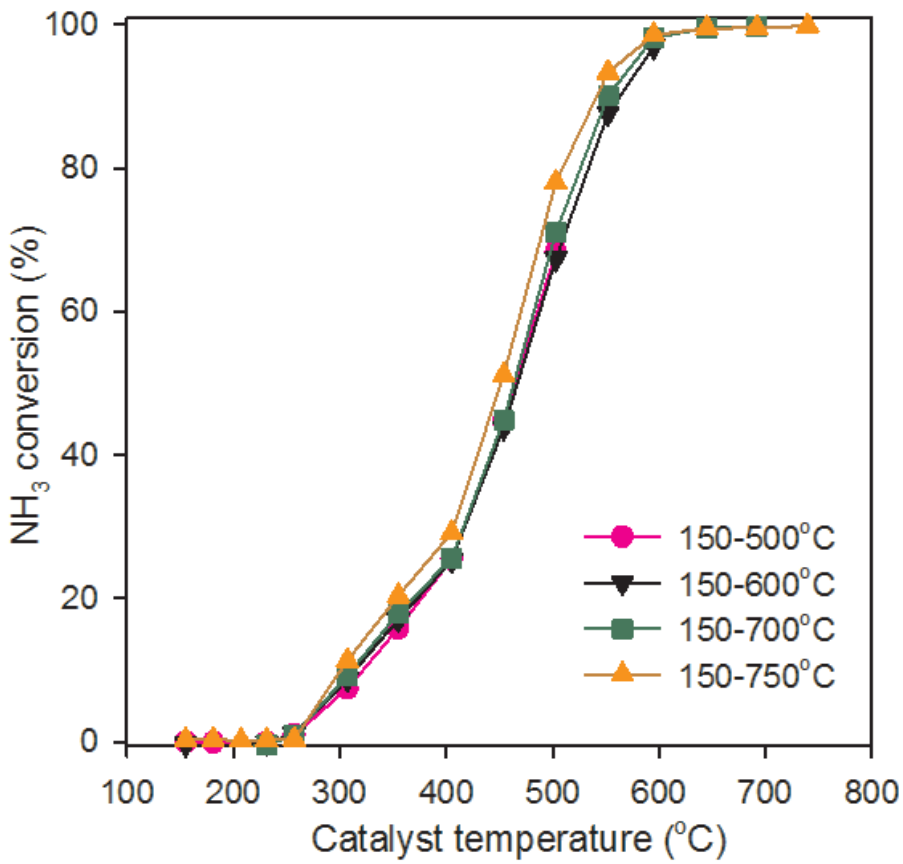
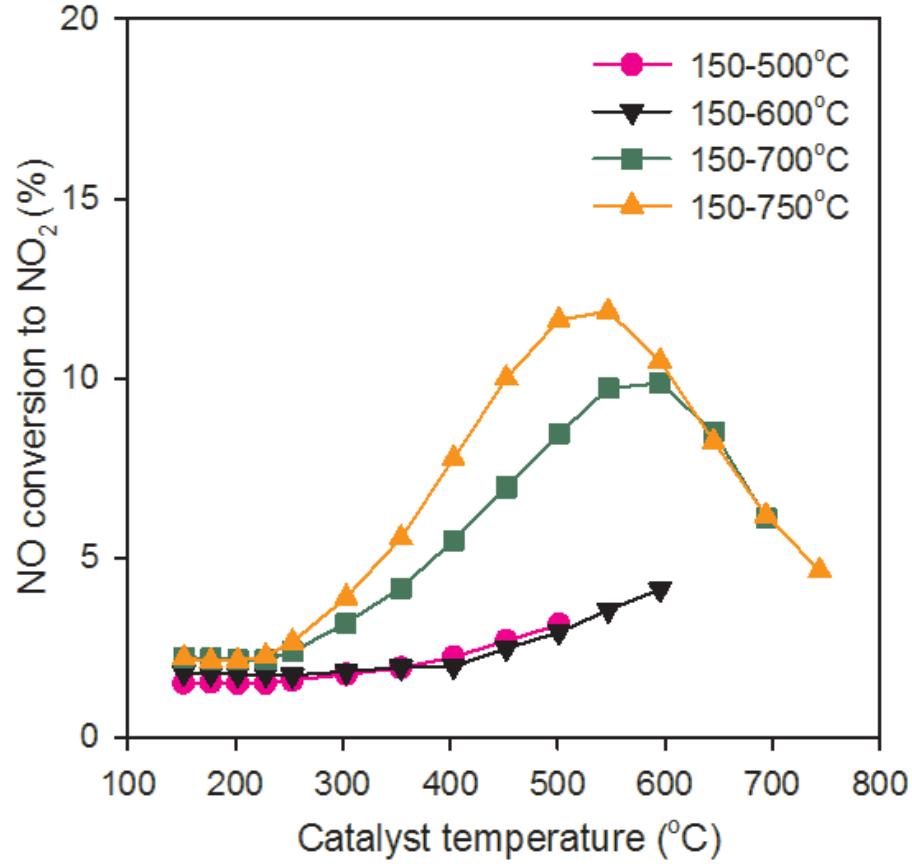
NH_3 and NO oxidation

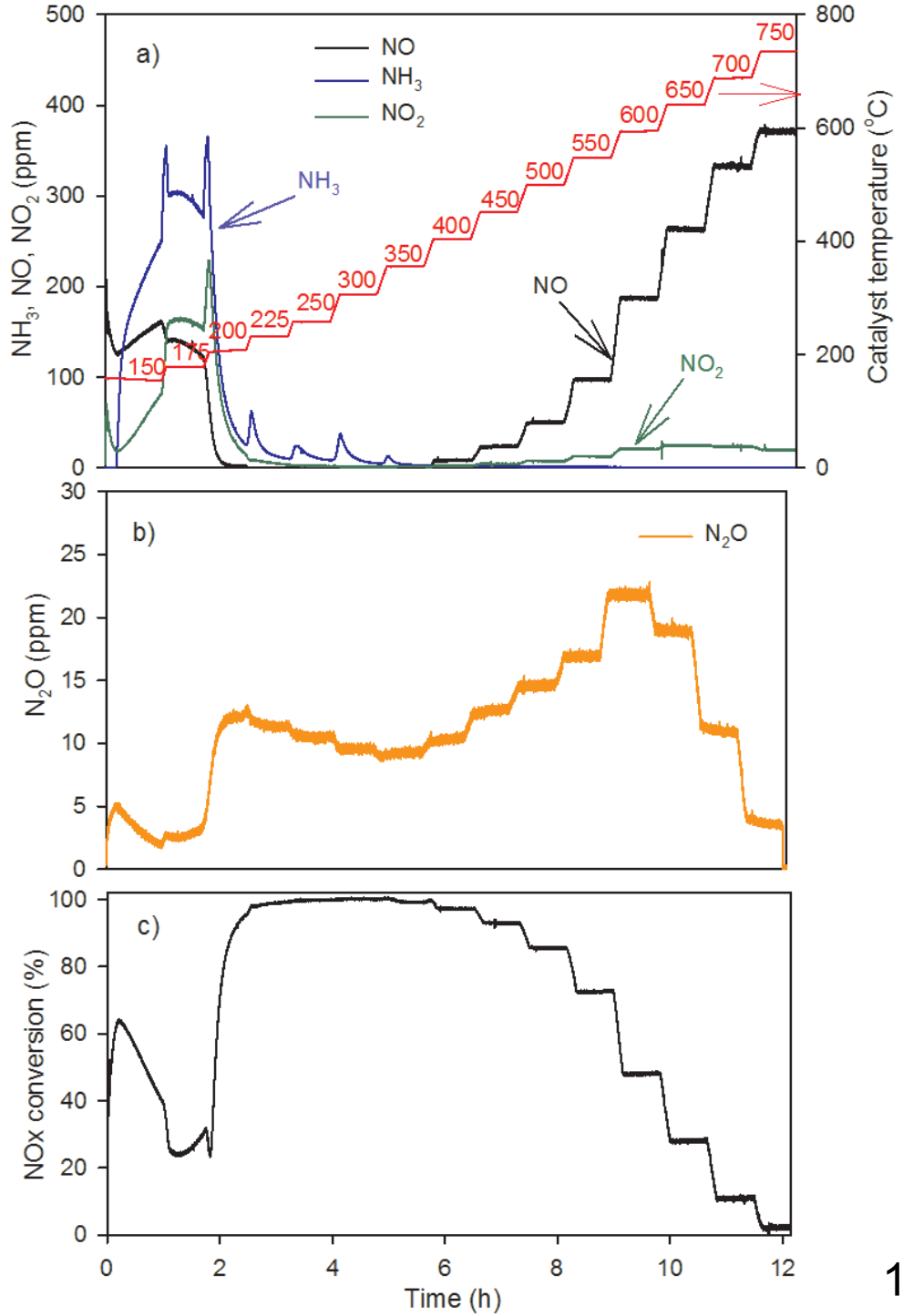




Mihai, Tamm, Stenfeldt, Wang Hansen and Olsson, Ind. Eng. Chem. Res. (2016).

Fast SCR from 150°C

NO, NH_3, NO_2 (a), N_2O, (b), NO_x conversion (c) versus time under Fast SCR at 150°C conducted on SCR coated filter for cycle 4 (150- 750 C)



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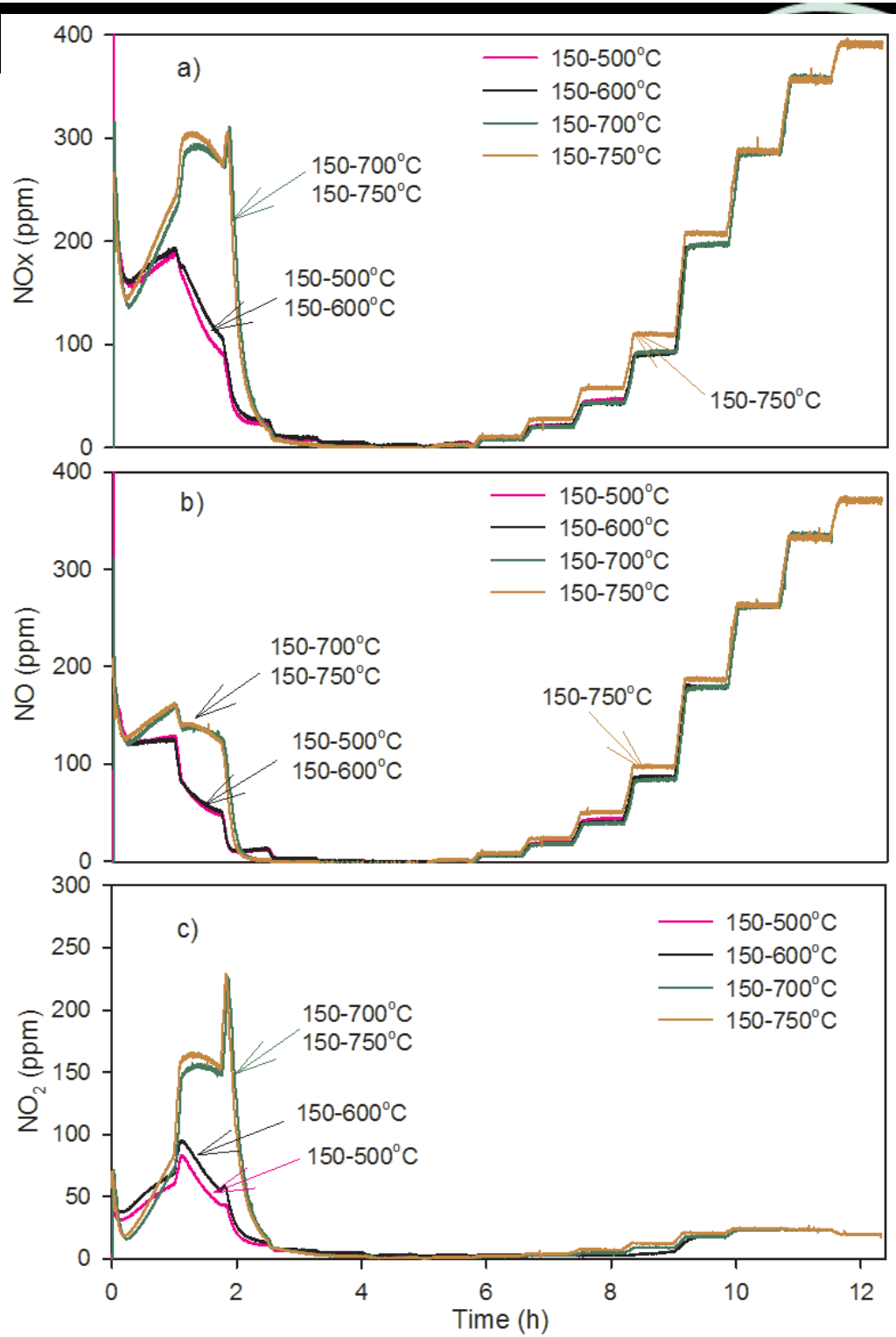

Fast SCR from 150°C

NO_x (a), NO (b), NO_2 (c), as function of the time under Fast SCR at 150°C for cycles:
cycle 1 (150- 500 C),
cycle 2 (150- 600 C),
cycle 3 (150- 700 C)
cycle 4 (150- 750 C).

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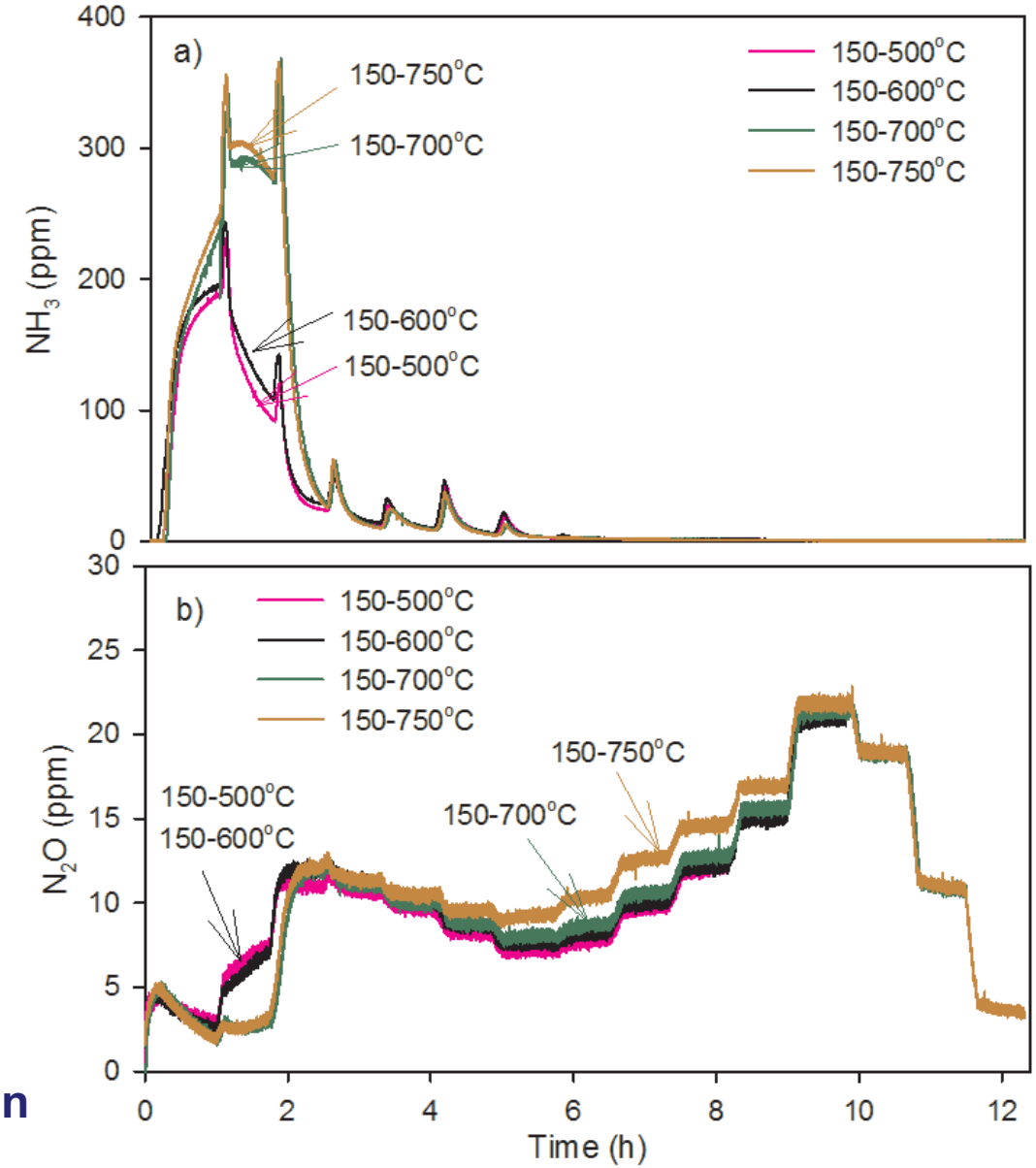
Fast SCR from 150°C

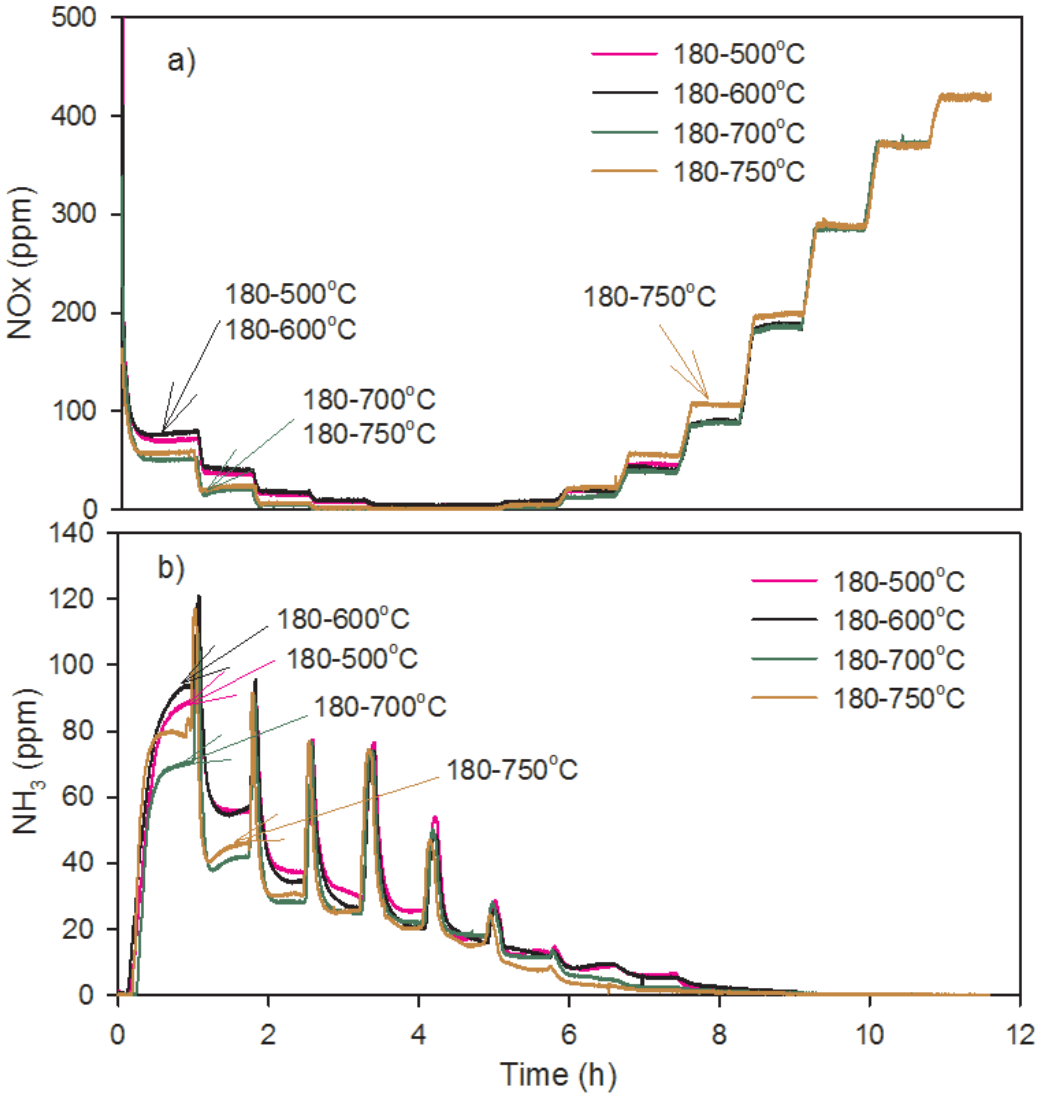
NH_3 (a), N_2O (b), versus time under Rapid SCR at 150°C at various temperatures domains:
150 - 500 C,
150 - 600 C,
150 - 700 C,
150 - 750 C



Mihai, Tamm, Stenfeldt, Wang Hansen and Olsson, Ind. Eng. Chem. Res. (2016).

Fast SCR from 180°C

NO_x (a), NH_3 (b) versus time after Rapid SCR at 180°C for:
cycle 1 (180- 500 C),
cycle 2 (180- 600 C),
cycle 3 (180- 700 C)
cycle 4 (180- 750 C)



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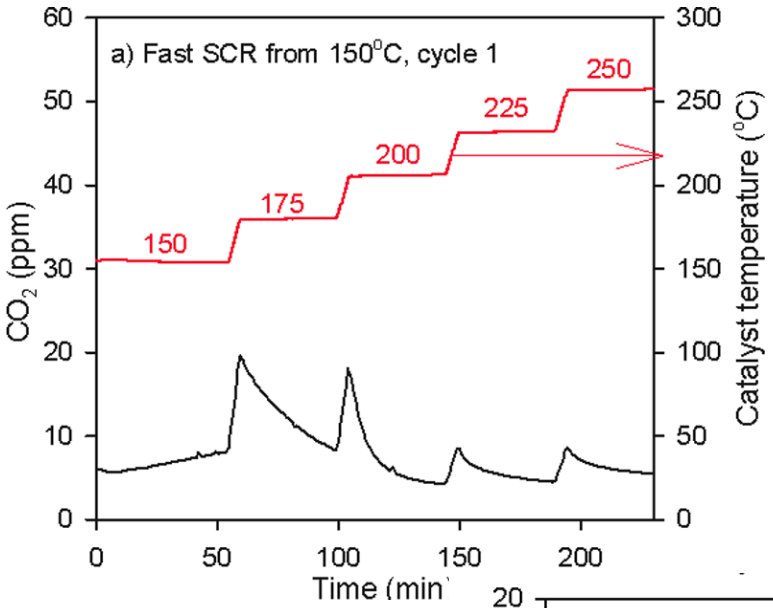
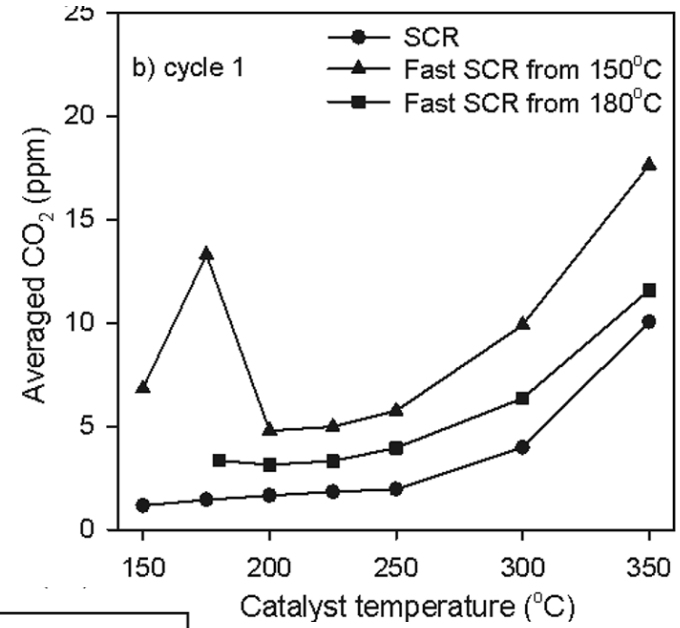
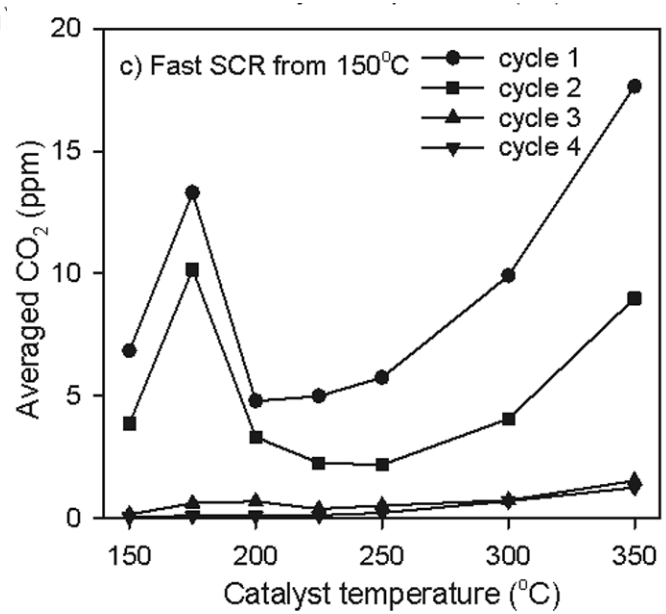
CO_2 production







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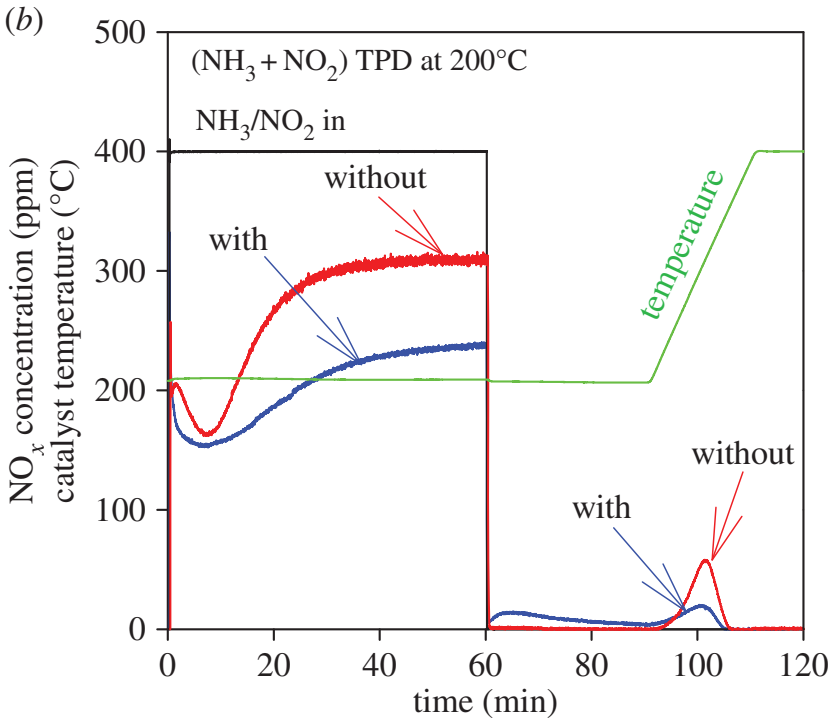
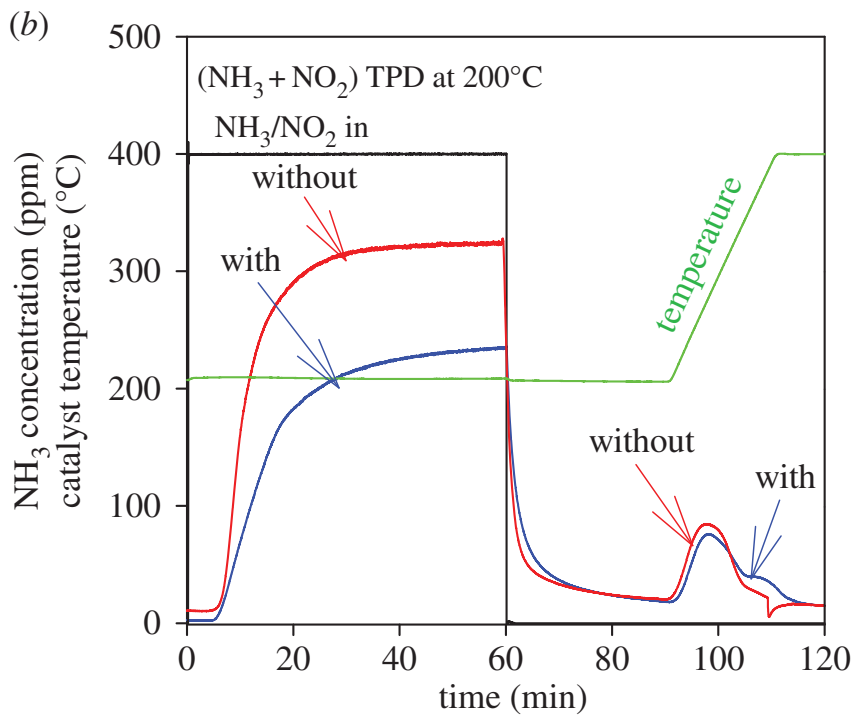
The soot effect on the decomposition of the ammonium nitrate species

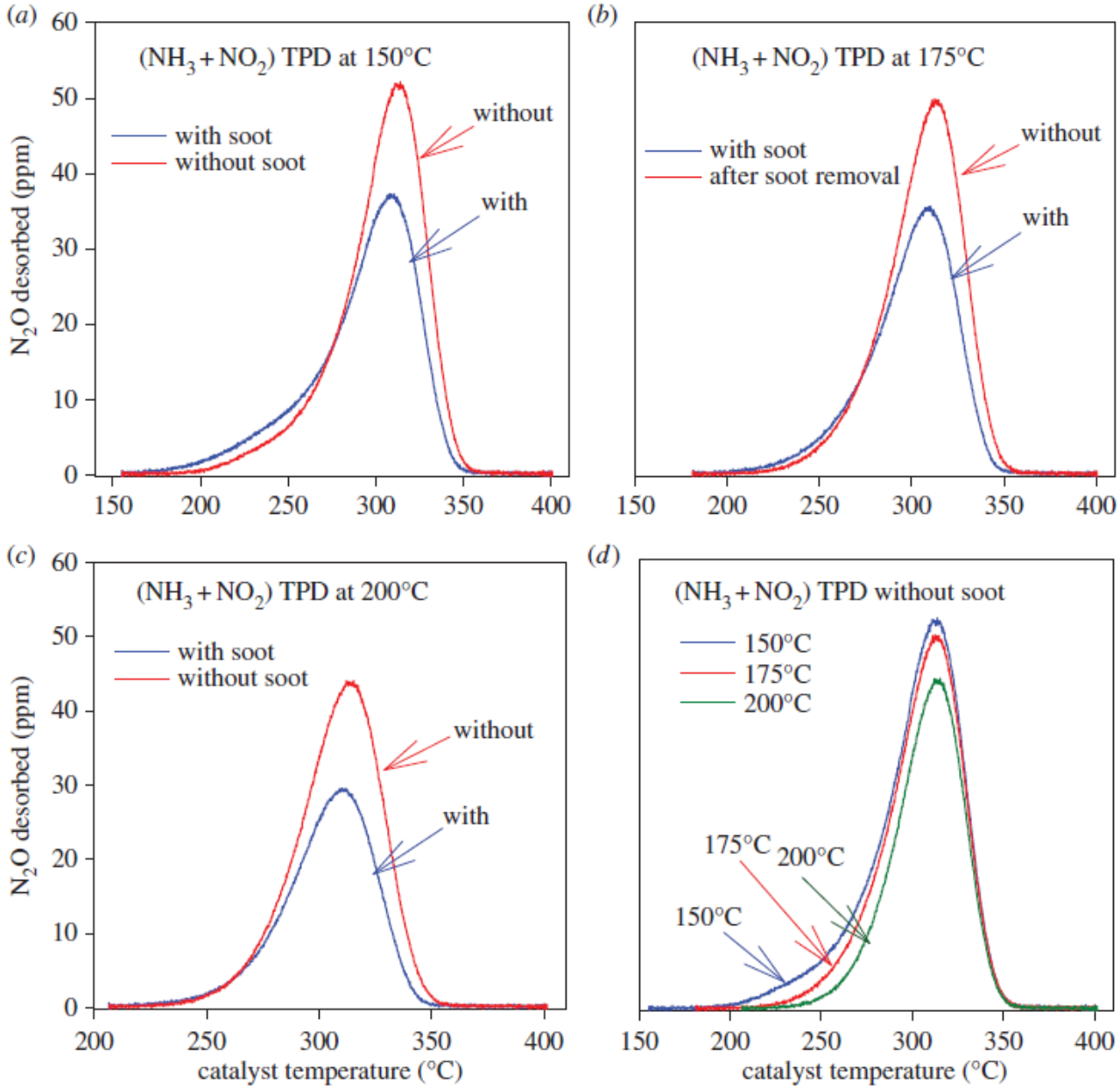




- 400 ppm NH_3, 400 ppm NO_2, 8% O_2 and 5% H_2O for 1 h
- Exposing the catalyst to 5% H_2O in Ar for 30 min
- Temperature ramp to 400°C.

Mihai, Tamm, Stenfeldt, and Olsson, Phil Trans. A, (2016).

The soot effect on the decomposition of the ammonium nitrate species

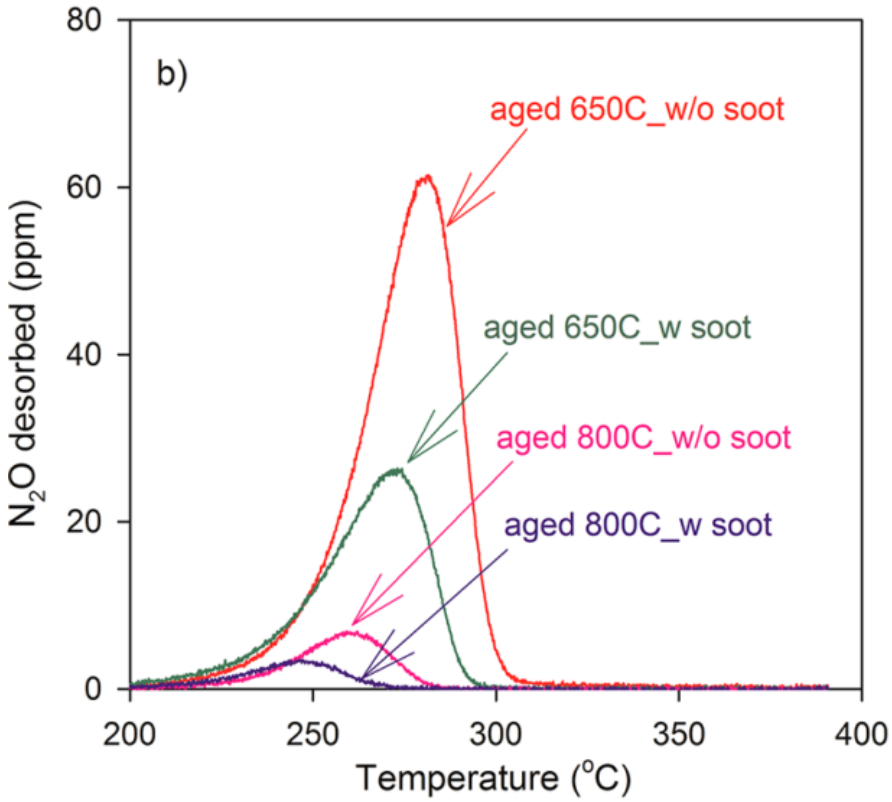


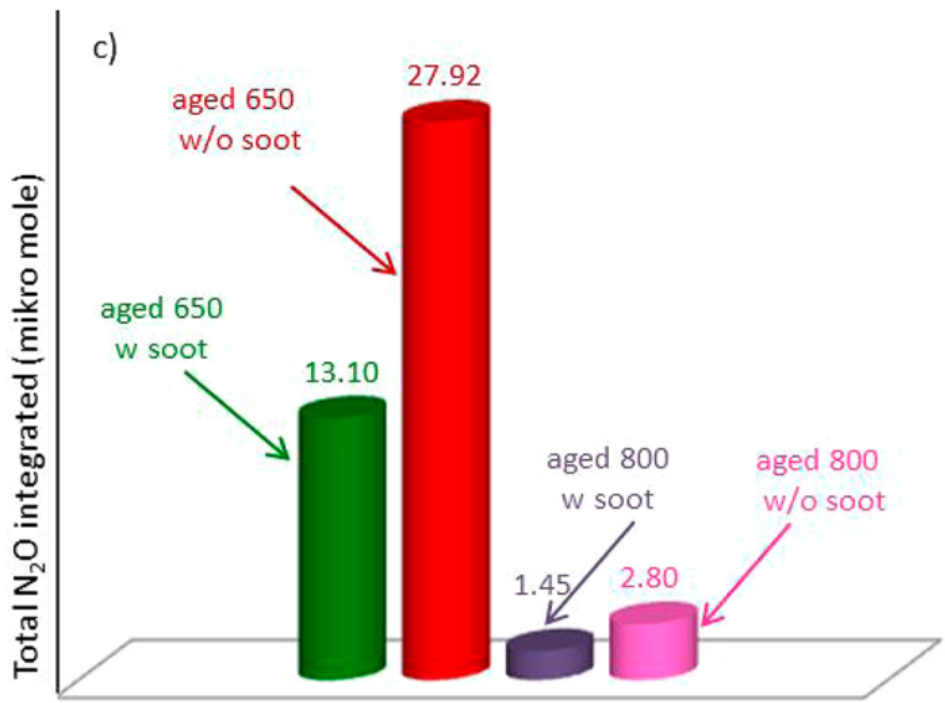
N_2O production during (NH_3 + NO_2) TPD 'with/without' soot presence conducted over an SCR-coated DPF

- 400 ppm NH_3, 400 ppm NO_2, 8% O_2 and 5% H_2O for 1 h
- Exposing the catalyst to 5% H_2O in Ar for 30 min
- Temperature ramp to 400°C.

Mihai, Tamm, Stenfeldt, and Olsson, Phil Trans. A, (2016).

The soot effect on the decomposition of the ammonium nitrate species on model Cu/BEA





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Conclusions

- Largest CO and CO_2 production at around 540 °C under SCR conditions.
- For standard SCR, the NO_x conversion slightly increased between 200 and 300 °C when soot was removed, but decreased somewhat at high temperature.
- NO oxidation decreased significantly in the presence of soot.
- SEM showed soot particles of about 20-40nm. It is possible that the sample contained Cu_xO_y species or other copper species on the outside of the zeolite particles and that those sites were being blocked by the soot. The hydrothermal aging at 850 °C likely enhances formation of Cu_xO_y species.
- Fast SCR starting at 150 °C, the activity was significantly higher in the presence of soot. Soot may inhibit the ammonium nitrate formation or more easily decomposes the soot. Indeed, CO_2 production at low temperature was observed.
- Ammonium nitrate experiments showed less N_2O formation in the presence of soot.

Acknowledgements

❖ This work is a collaboration between Chemical Engineering, Competence Centre for Catalysis, at Chalmers University and Volvo Cars. The funding from Swedish Energy agency (FFI 37190-1) is gratefully acknowledged.