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Influence of SCR Activity on Soot Regeneration on a Vanadia-SCRF®

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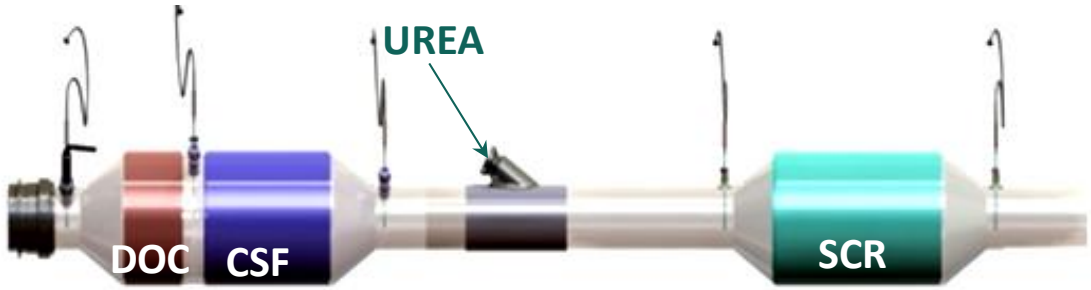
Outline

- System design options
- Experimental setup
- SCR and soot oxidation reactions
- Influence of urea on soot characteristics
- Influence of SCR activity on soot regeneration
- Impact of soot regeneration on SCR activity
- Numerical model development and validation

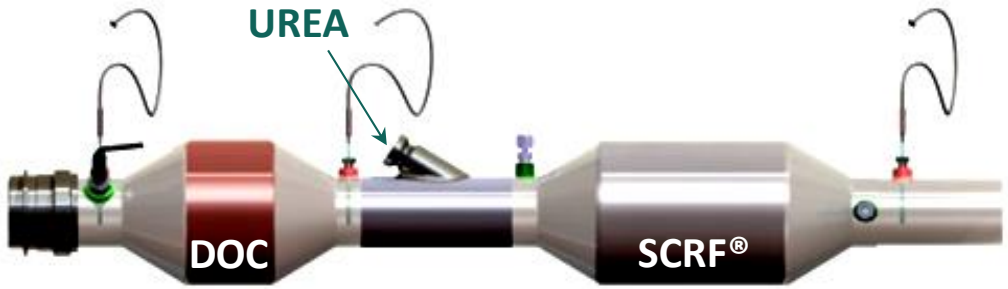
System design options

Solutions for NO_X and particulate matter control

Option 1



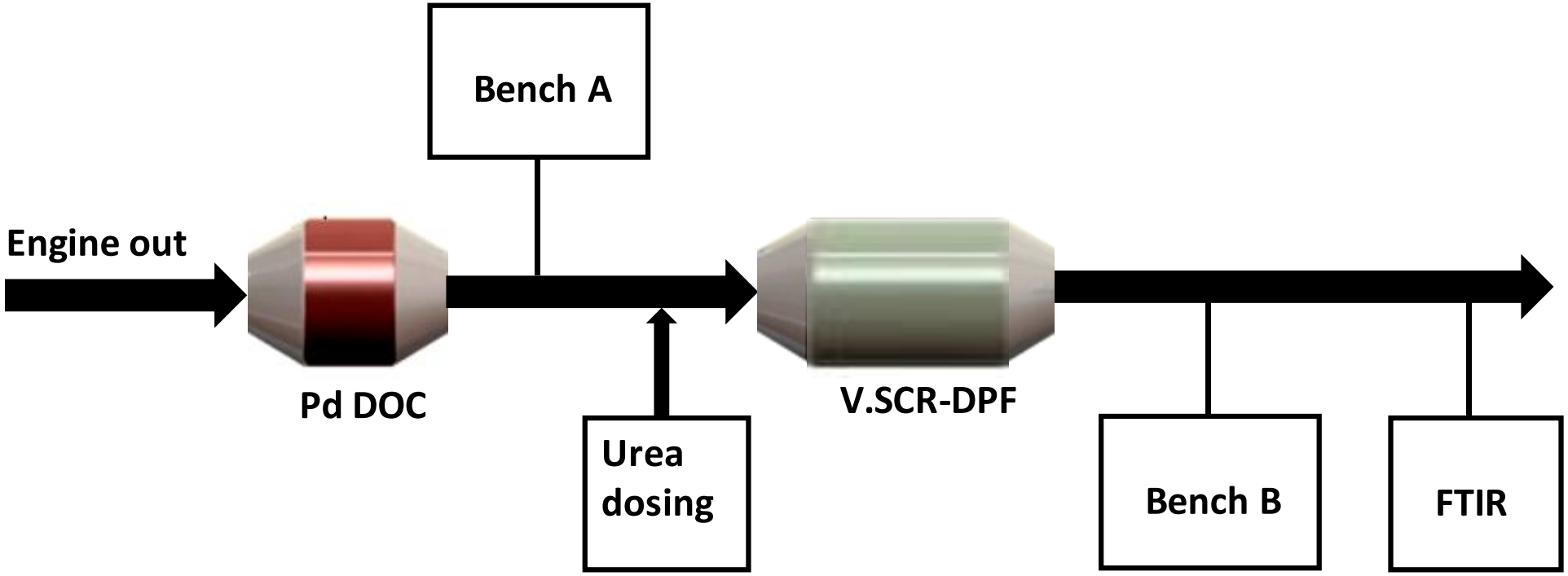
Option 2



Experimental setup

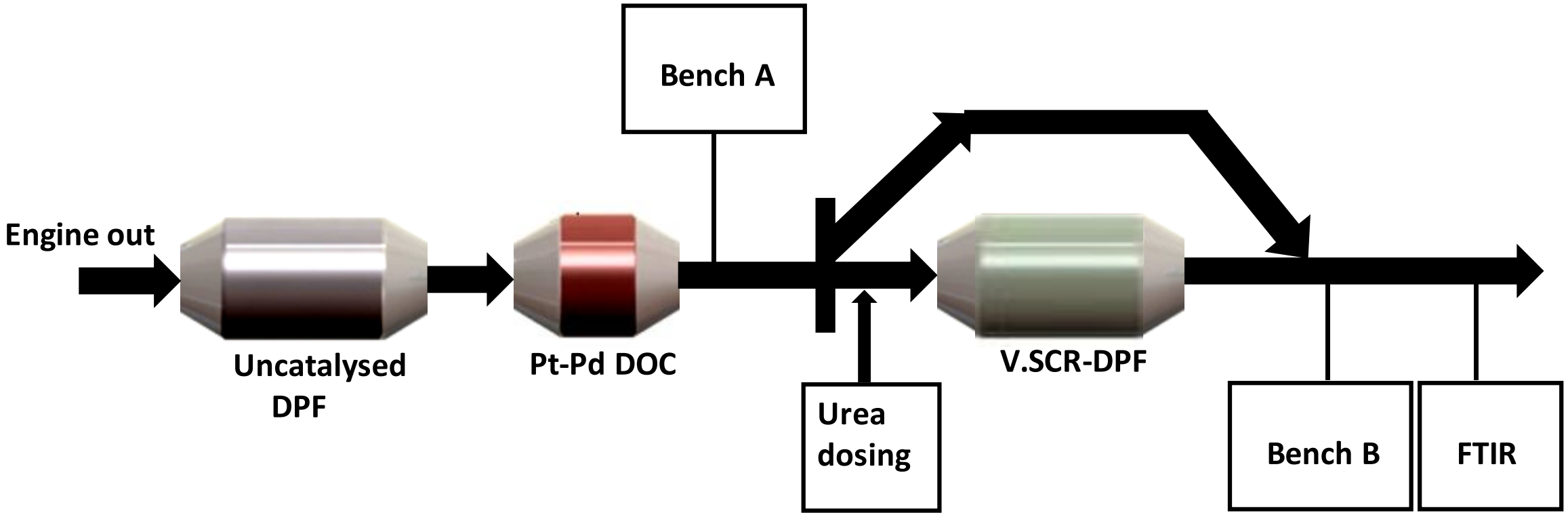
Soot loading

- Target soot load of 3g/l



Experimental setup

Soot regeneration and steady-state light-off



- DPF for capturing any incoming soot
- High PGM loading on DOC
- Regular interval weighing of SCRF®

Key descriptors of catalyst samples

System	Volume (L)	Substrate cell density (cpsi) /wall thickness (mil)
Pd DOC	5.2	300/5
Pt-Pd DOC	11.1	300/5
Bare DPF	12.5	200/12
V.SCR-DPF	13.9	200/12

Soot oxidation reactions

Reactions with NO_2:

- $C + NO_2 \rightarrow CO + NO$
- $C + 2NO_2 \rightarrow CO_2 + 2NO$

Reactions with O_2:

- $C + ½O_2 \rightarrow CO$
- $C + O_2 \rightarrow CO_2$

- Developed kinetics considered to have lumped water enhancing effects

SCR reactions

- $NH_{3(g)} \rightleftharpoons NH_{3(ads)}$
- $4NH_{3(ads)} + 4NO + O_2 \rightarrow 4N_2 + 6H_2O$
- $4NH_{3(ads)} + 2NO + 2NO_2 \rightarrow 4N_2 + 6H_2O$
- $4NH_{3(ads)} + 3NO_2 \rightarrow 3½N_2 + 6H_2O$
- $2NH_{3(ads)} + 2NO_2 \rightarrow N_2O + N_2 + 3H_2O$
- $2NH_{3(ads)} + 2NO_2 \rightarrow NH_4NO_{3(ads)} + N_2 + H_2O$
- $2NH_4NO_{3(ads)} + NO \rightarrow 3NO_2 + 2NH_3 + H_2O$
- $NH_4NO_{3(ads)} \rightarrow N_2O + 2H_2O$
- $4NH_{3(ads)} + 3O_2 \rightarrow 2N_2 + 6H_2O$
- $4NH_{3(ads)} + 5O_2 \rightarrow 4NO + 6H_2O$
- $2NH_{3(ads)} + 2O_2 \rightarrow 2N_2O + 3H_2O$
- $NO_2 \rightleftharpoons NO + ½O_2$

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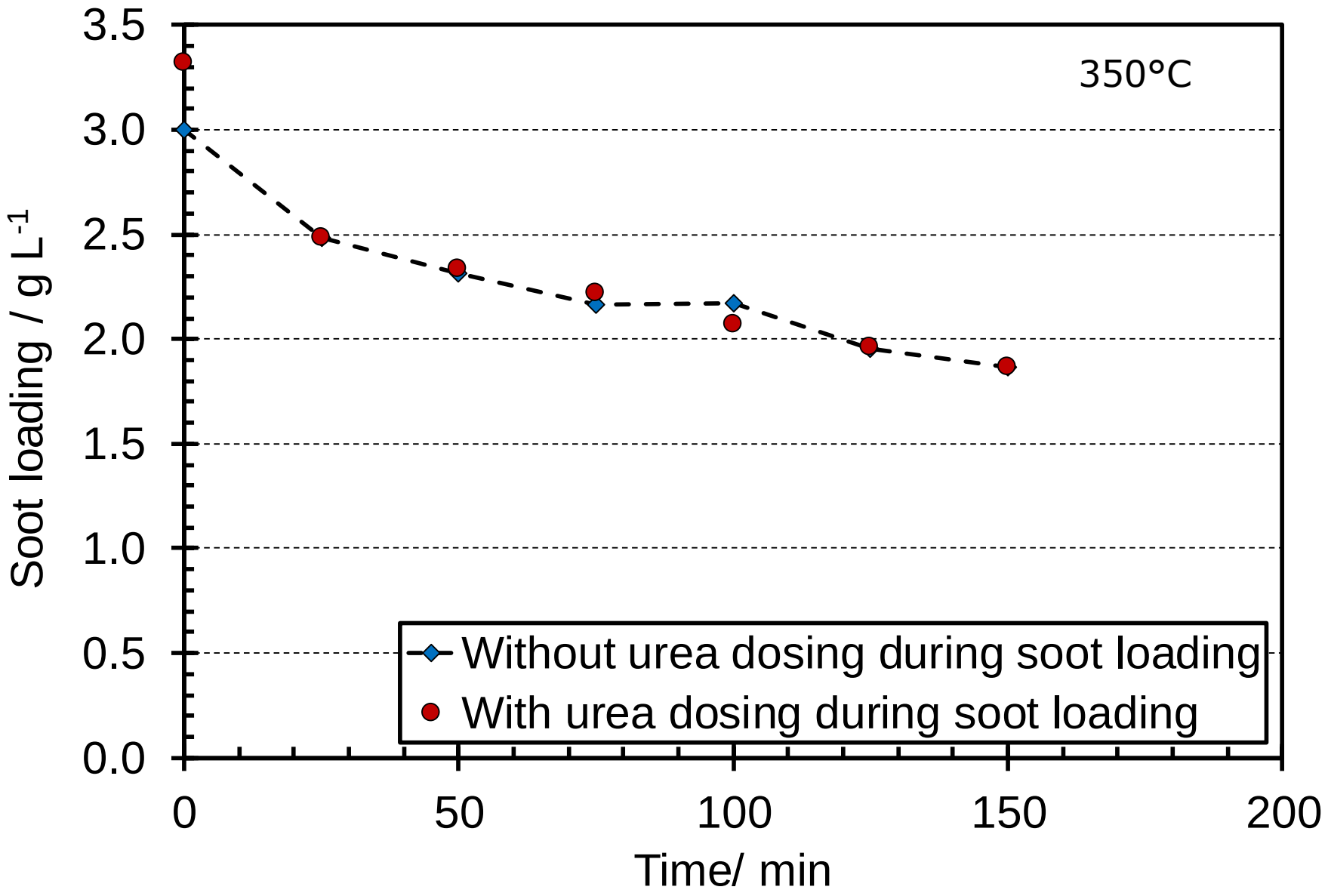
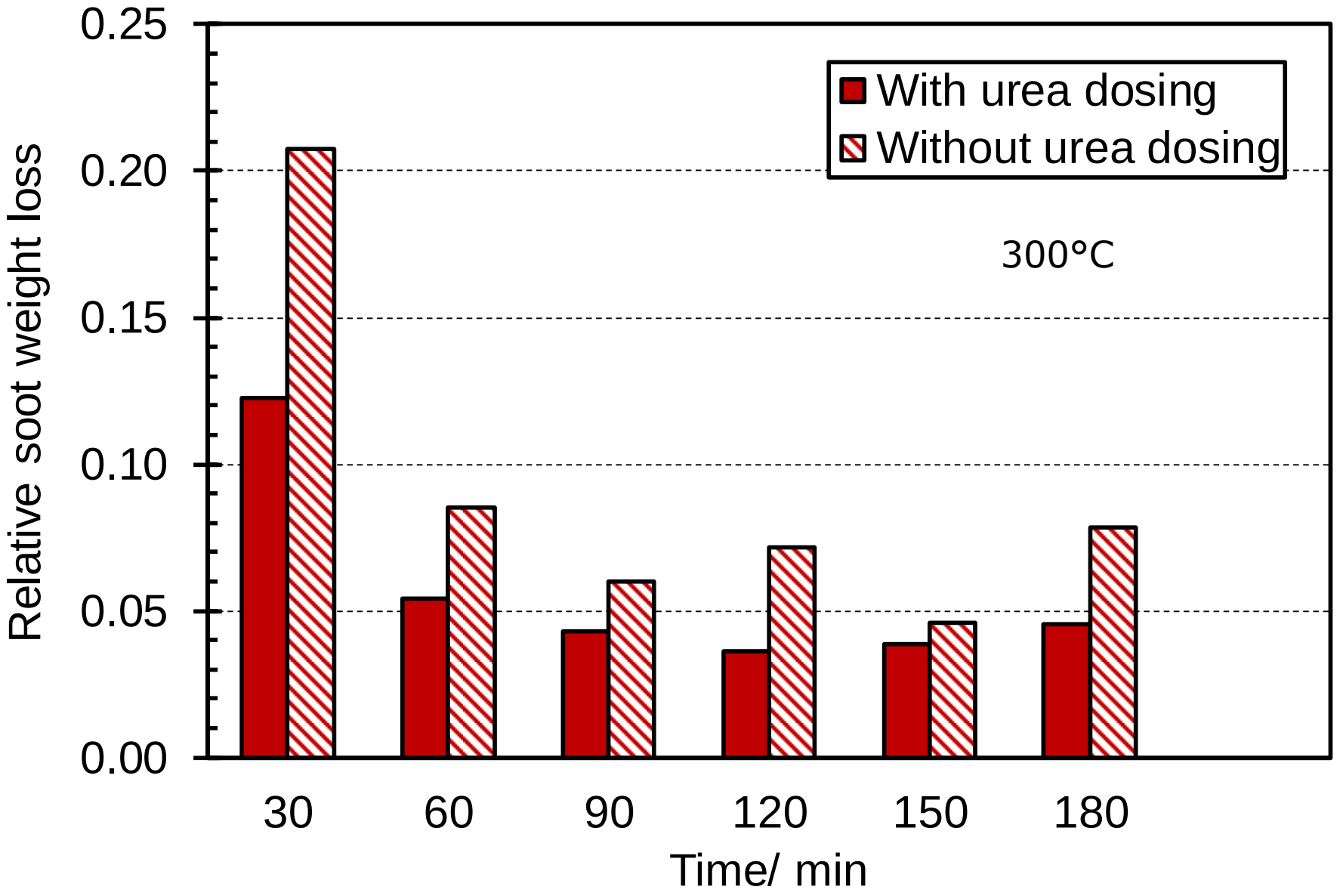
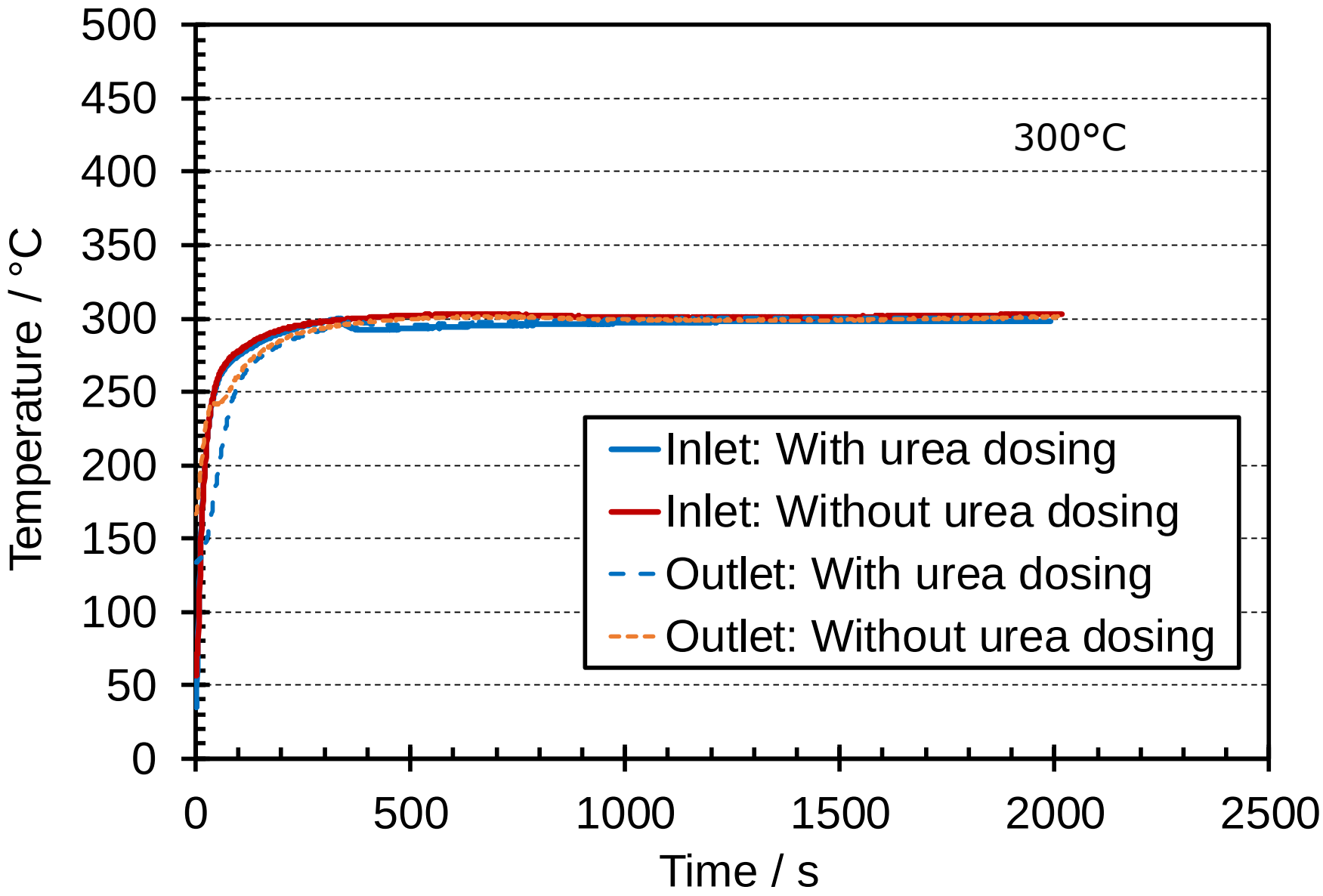
Influence of urea dosing on soot characteristics



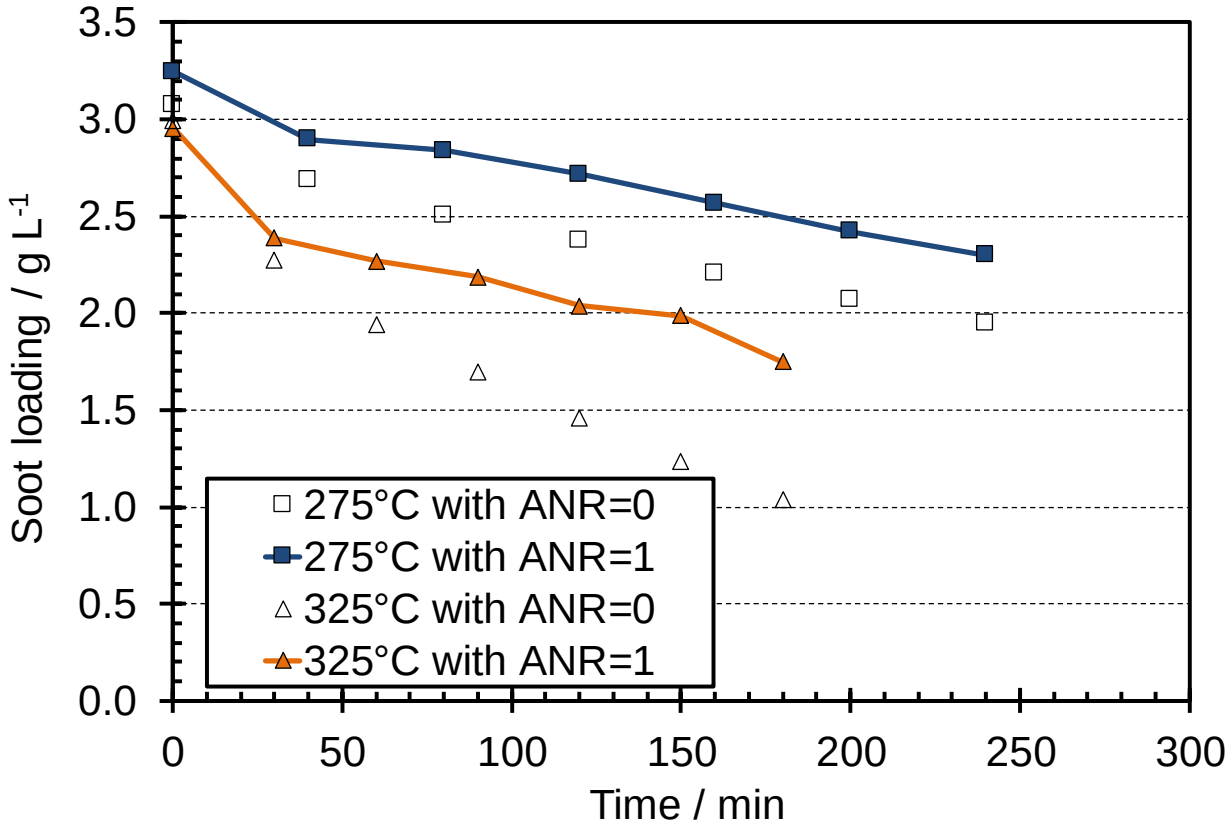
Influence of SCR activity on soot regeneration

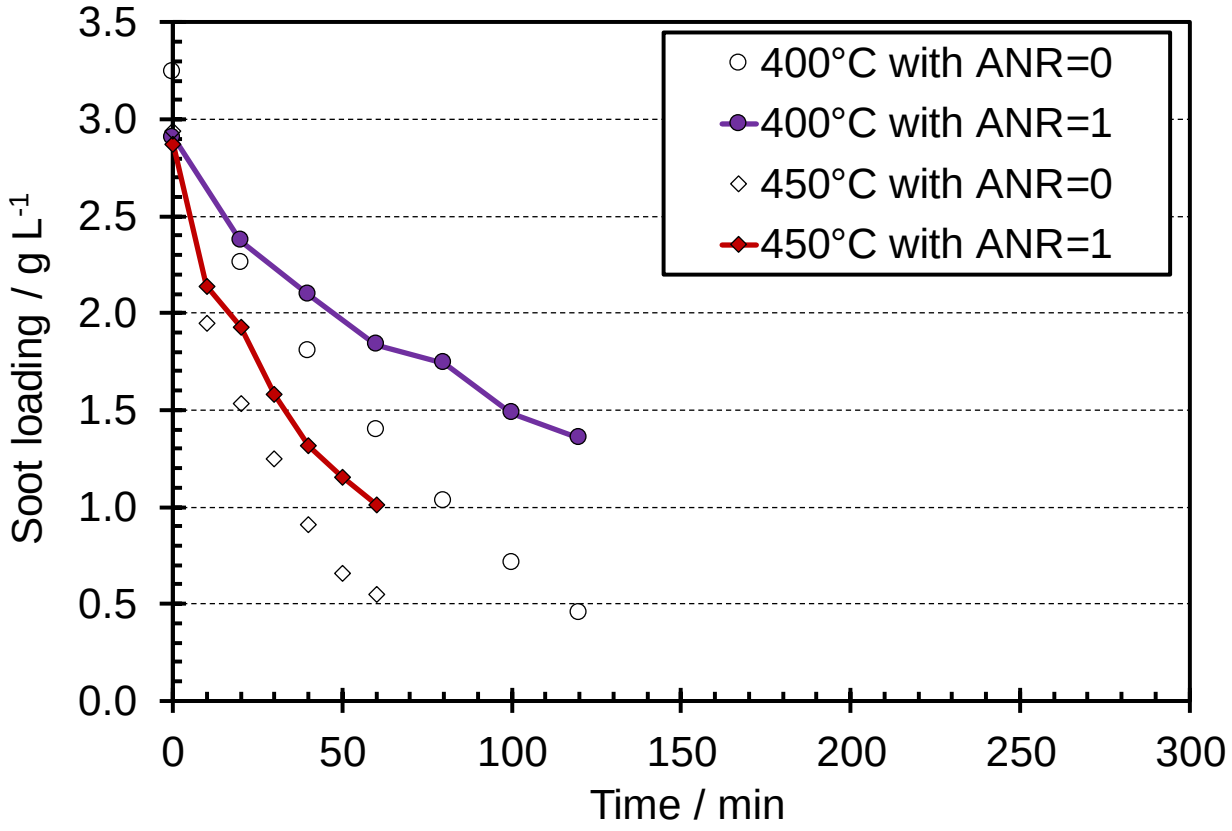


Influence of SCR activity on soot regeneration



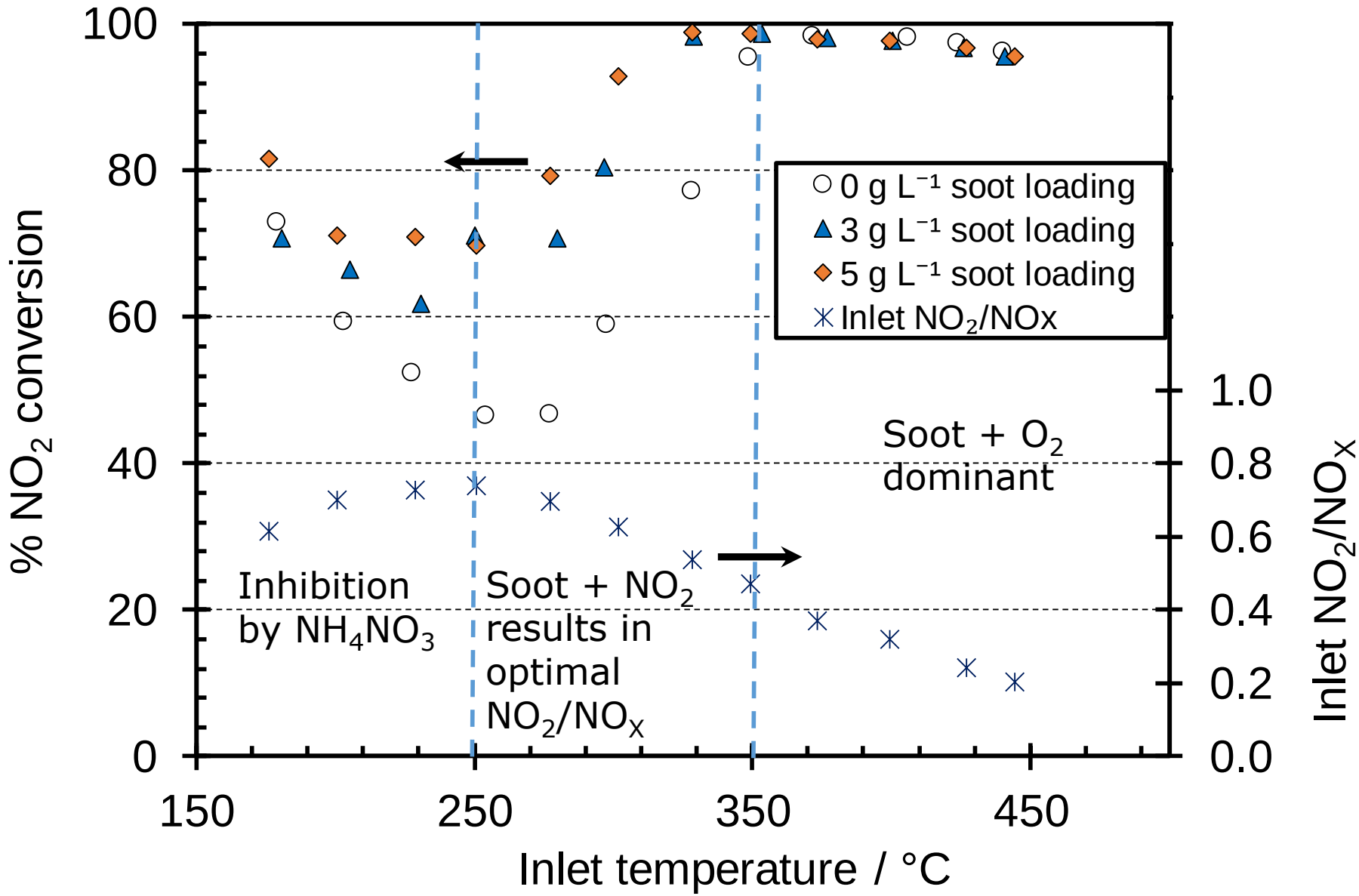
Influence of SCR activity on soot regeneration



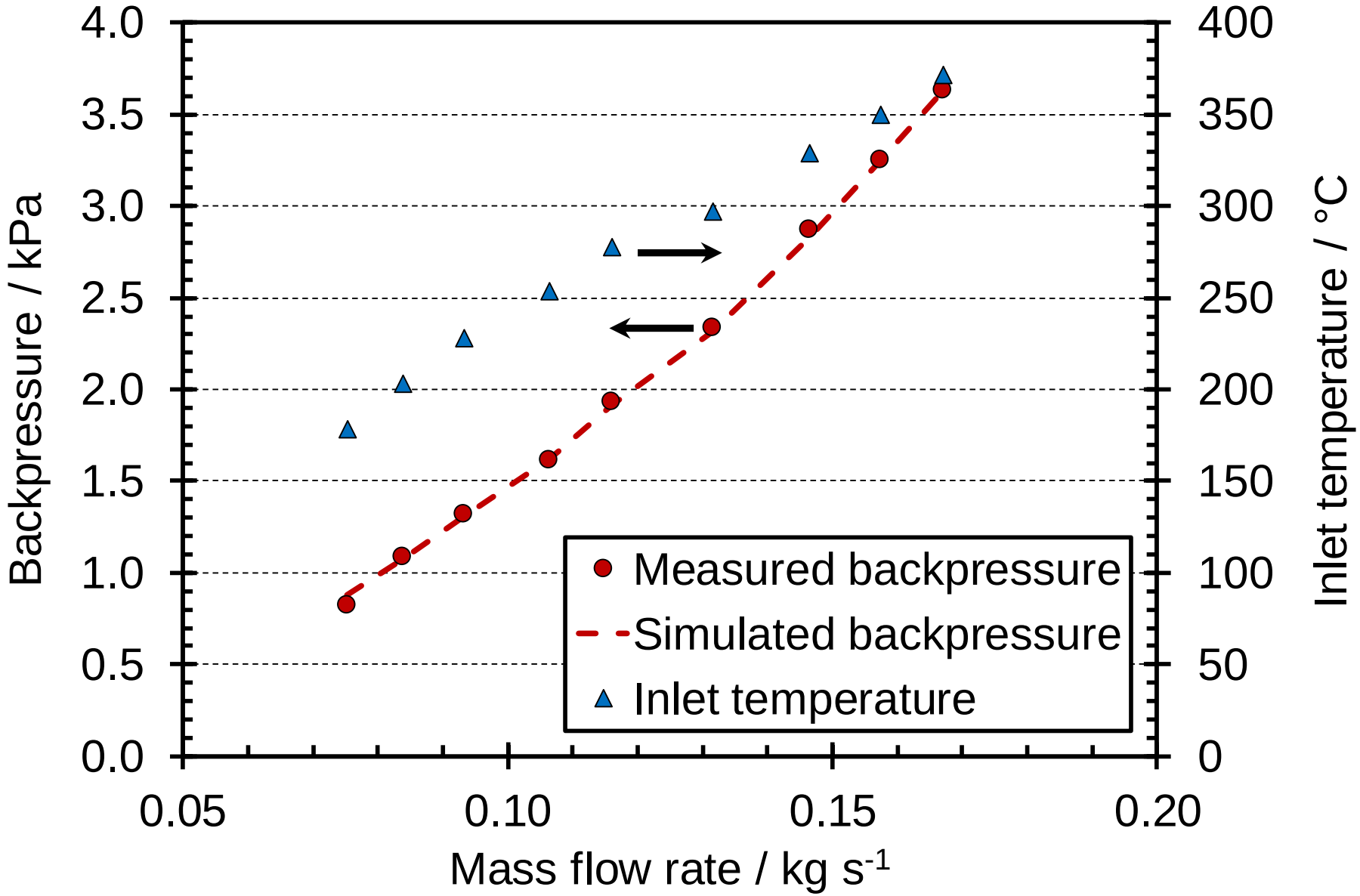


- Rate of soot oxidation increases with increasing temperature
- Rate of soot regeneration slower with SCR activity due to NO_2 competition

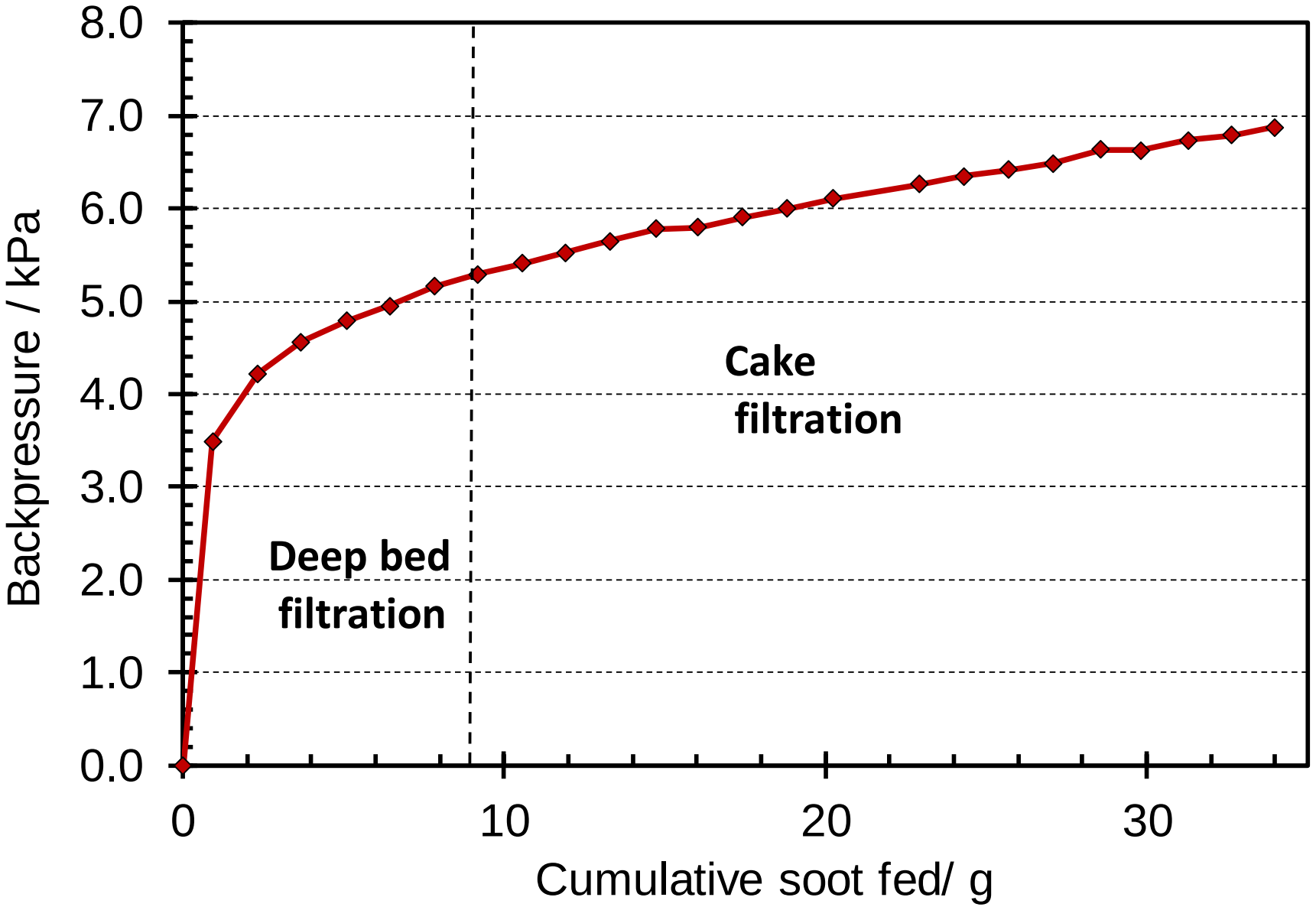
Impact of on soot regeneration on SCR activity



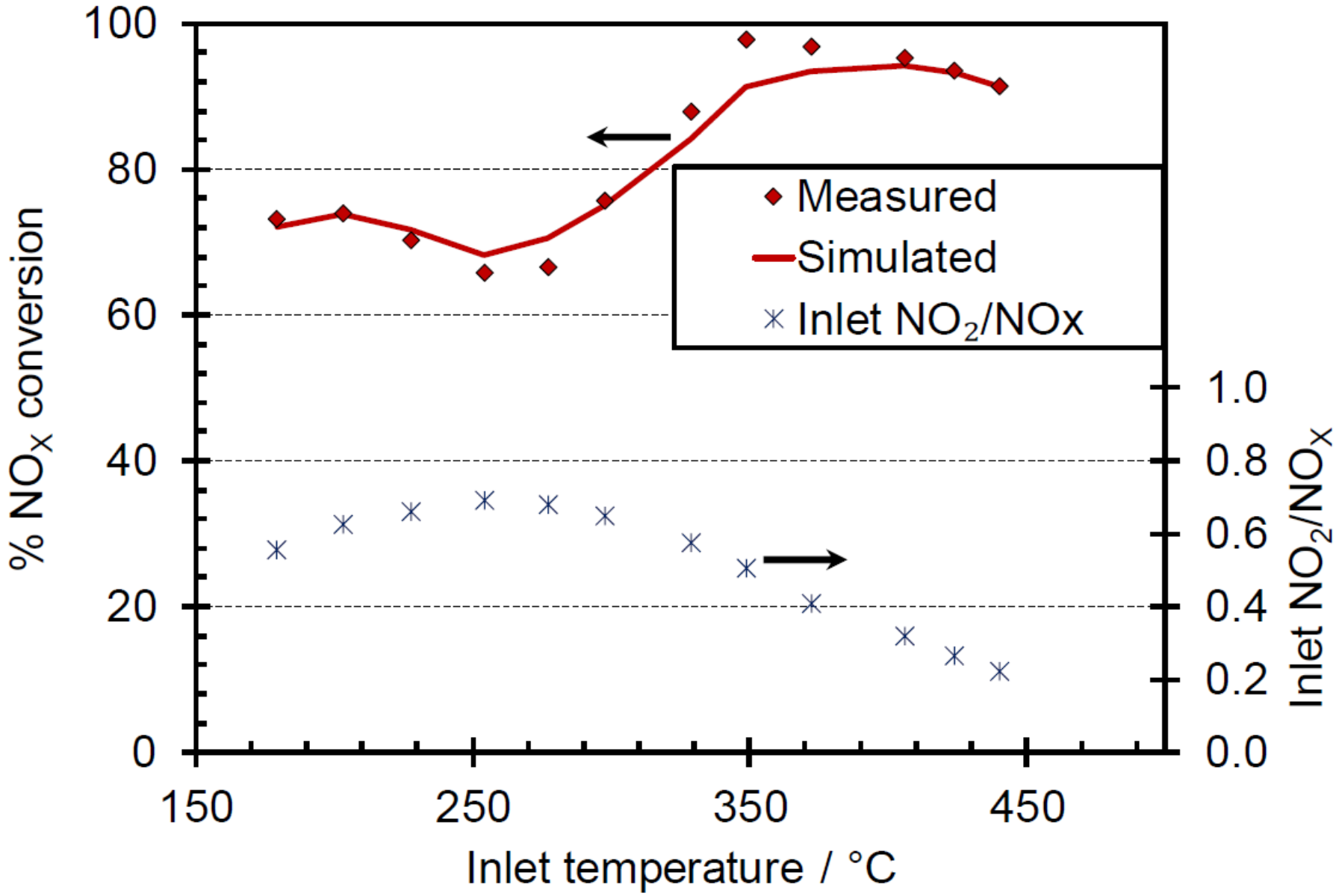
Numerical model development: wall permeability



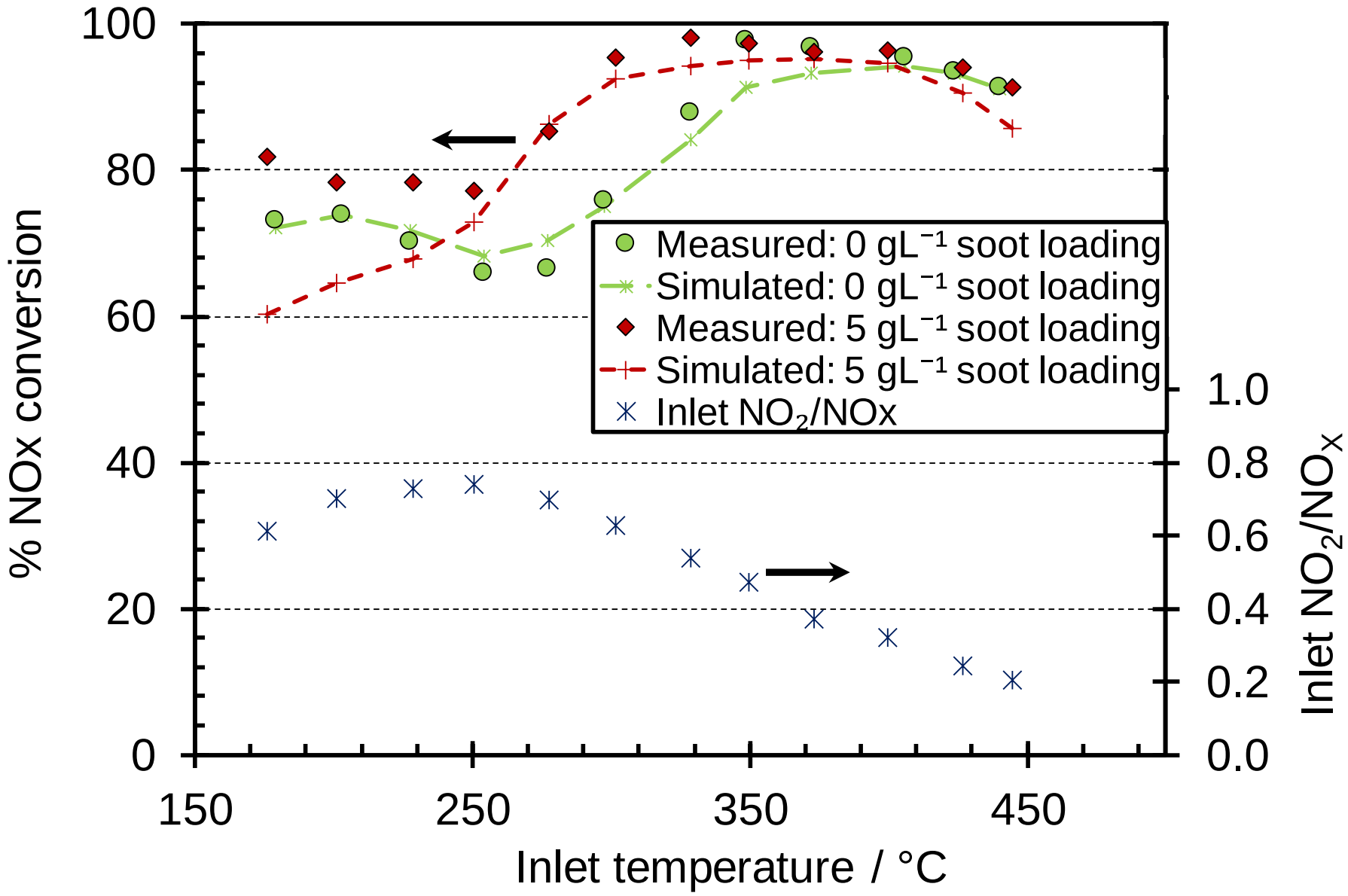
Numerical model development : Soot cake permeability



Development of SCR kinetic parameters: 0 gL^{-1} soot load

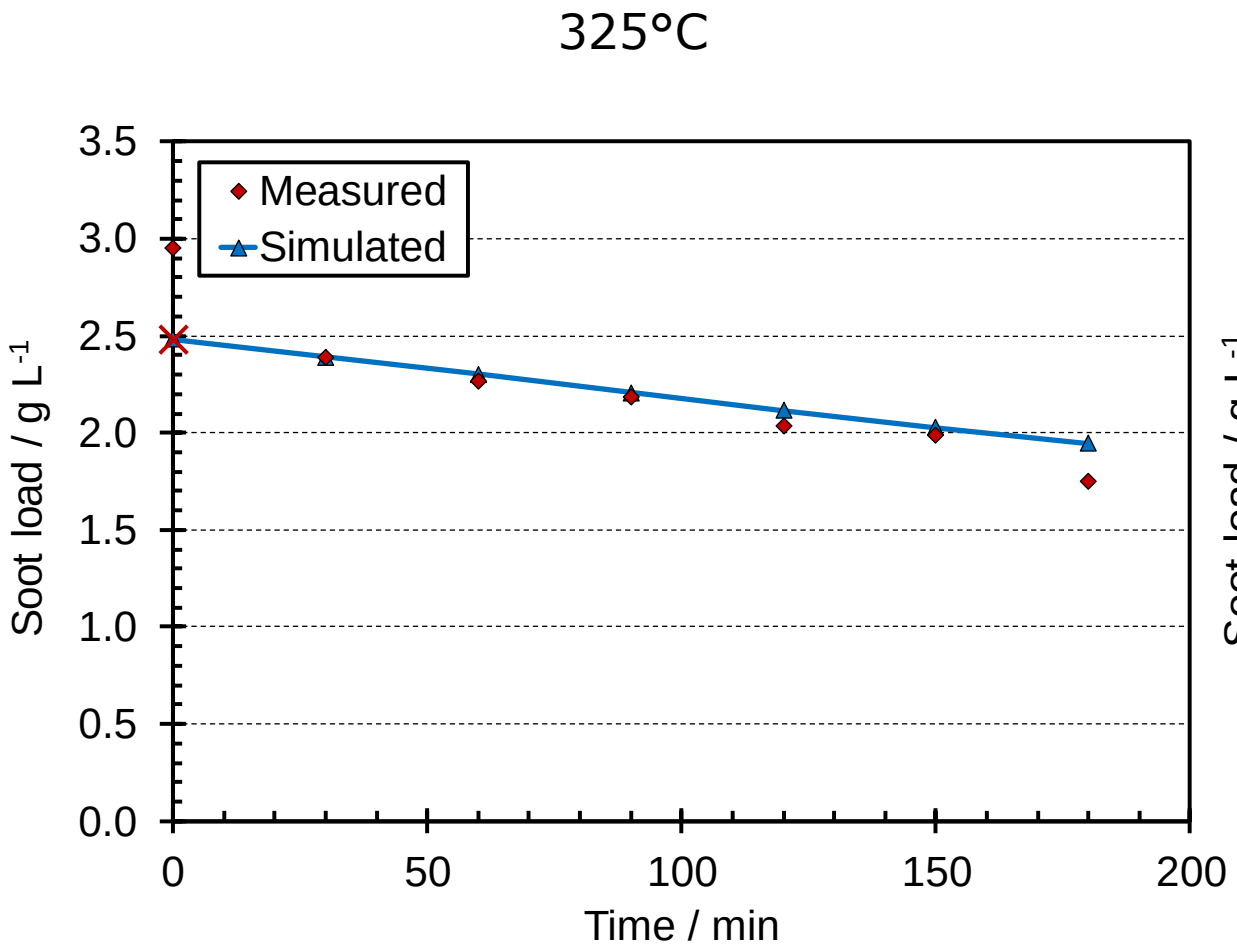


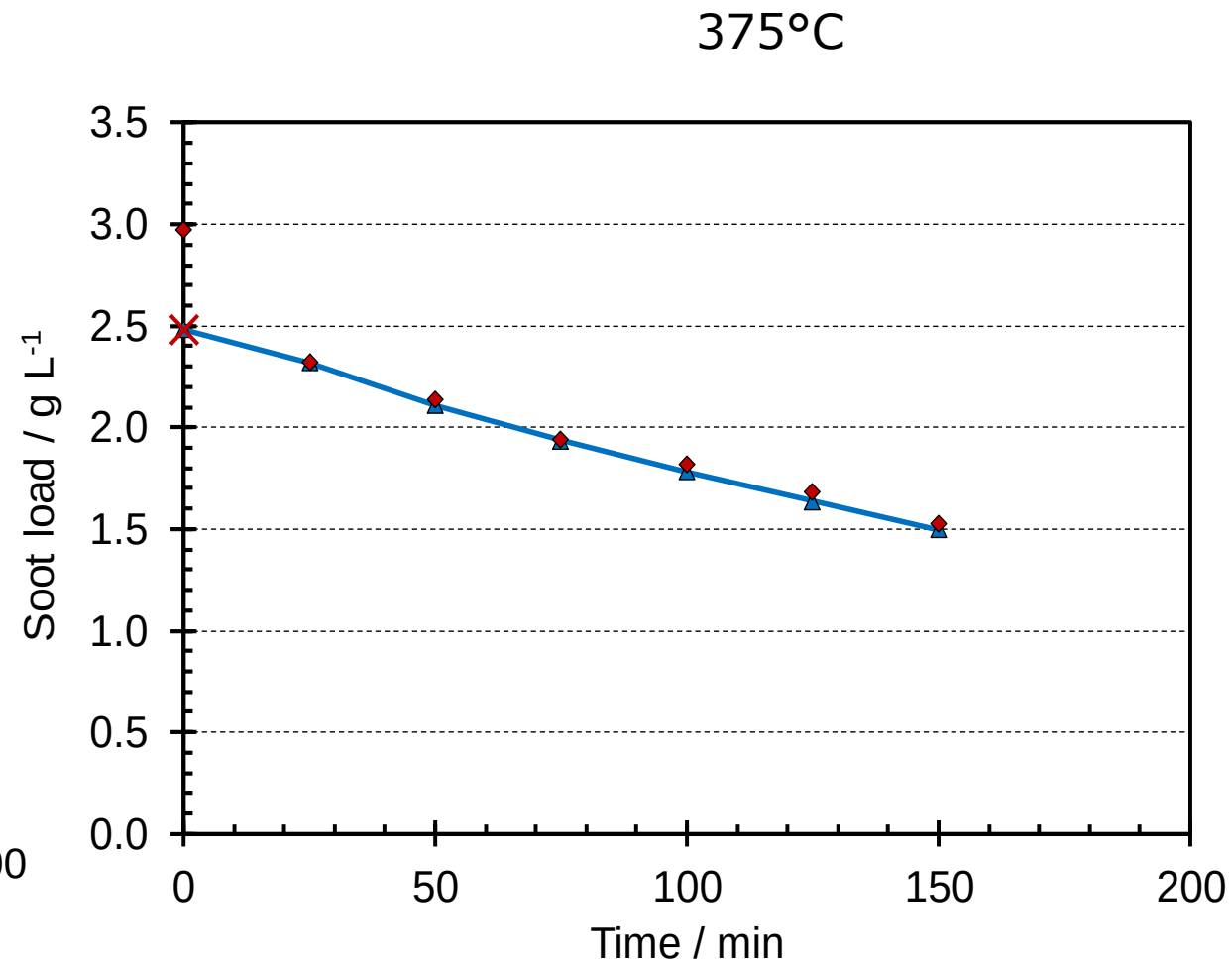
Impact of soot regeneration: 5 gL^{-1} initial soot load



- Soot inhibit formation of NH_4NO_3 or promotes its decomposition

Modelling soot regeneration with urea dosing





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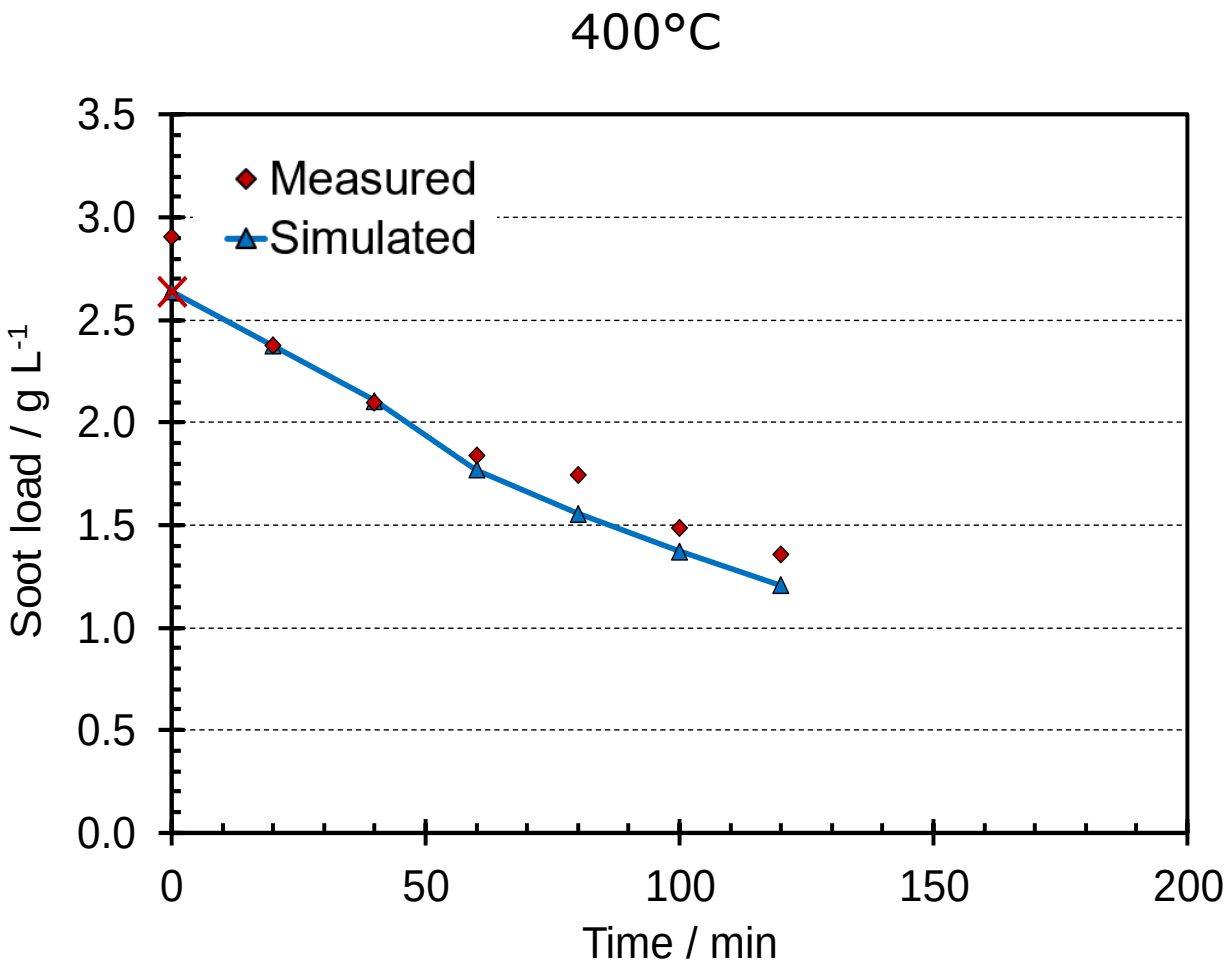
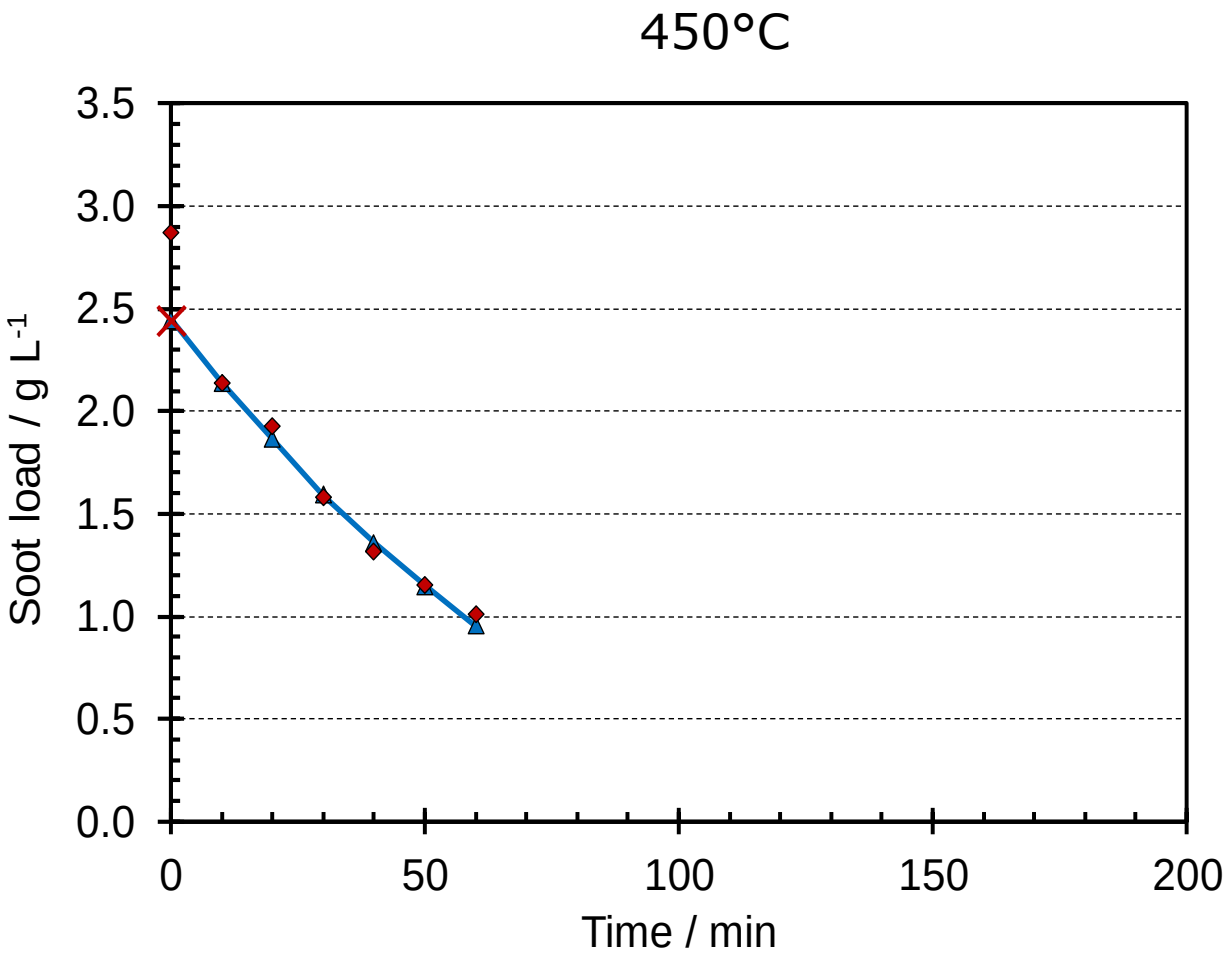
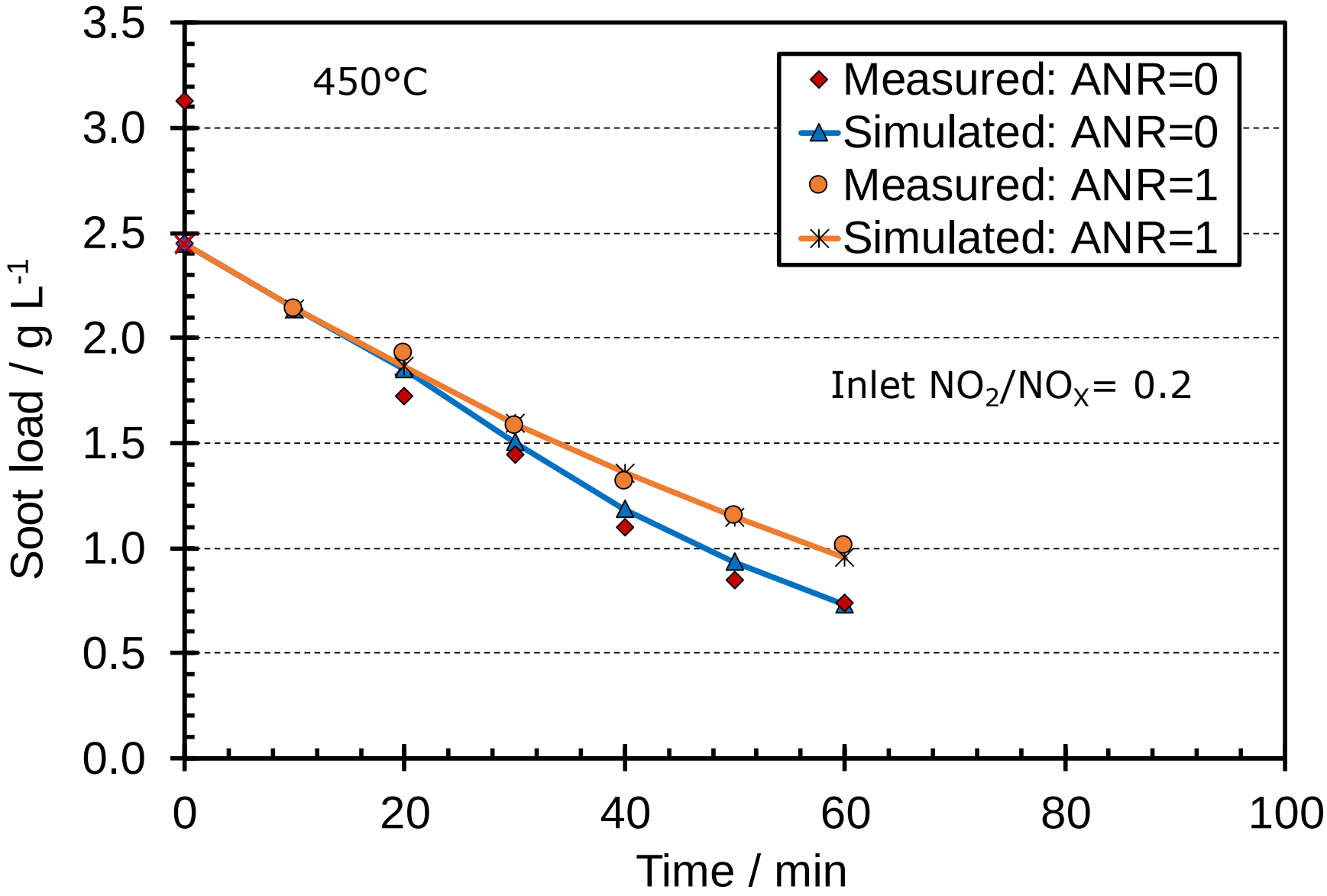
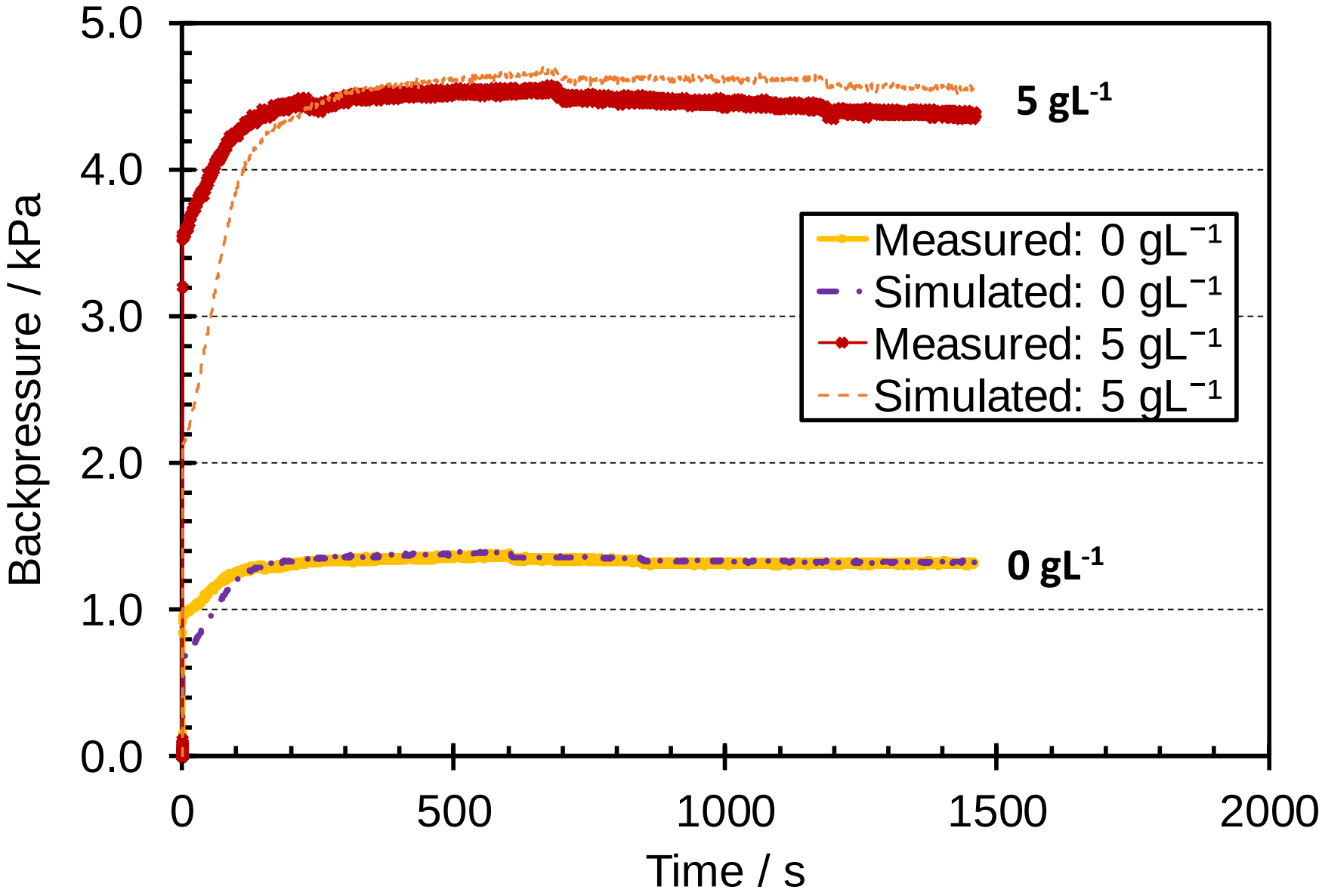




Modelling soot regeneration with and without urea dosing



Model backpressure predictions



Summary

- Characteristics of soot related to reactivity with O_2 and NO_2 are not significantly influenced by urea
- Rate of soot regeneration is reduced in the presence of SCR activity
- Soot loading on the SCRF® enhances SCR activity if inlet NO_2/NO_X is greater than 0.5
- At lower temperatures (<250°C), soot and ammonium nitrate interact favourably enhancing SCR activity
- Developed model yields predictions that are comparable to measured data for backpressure and soot regeneration with SCR activity