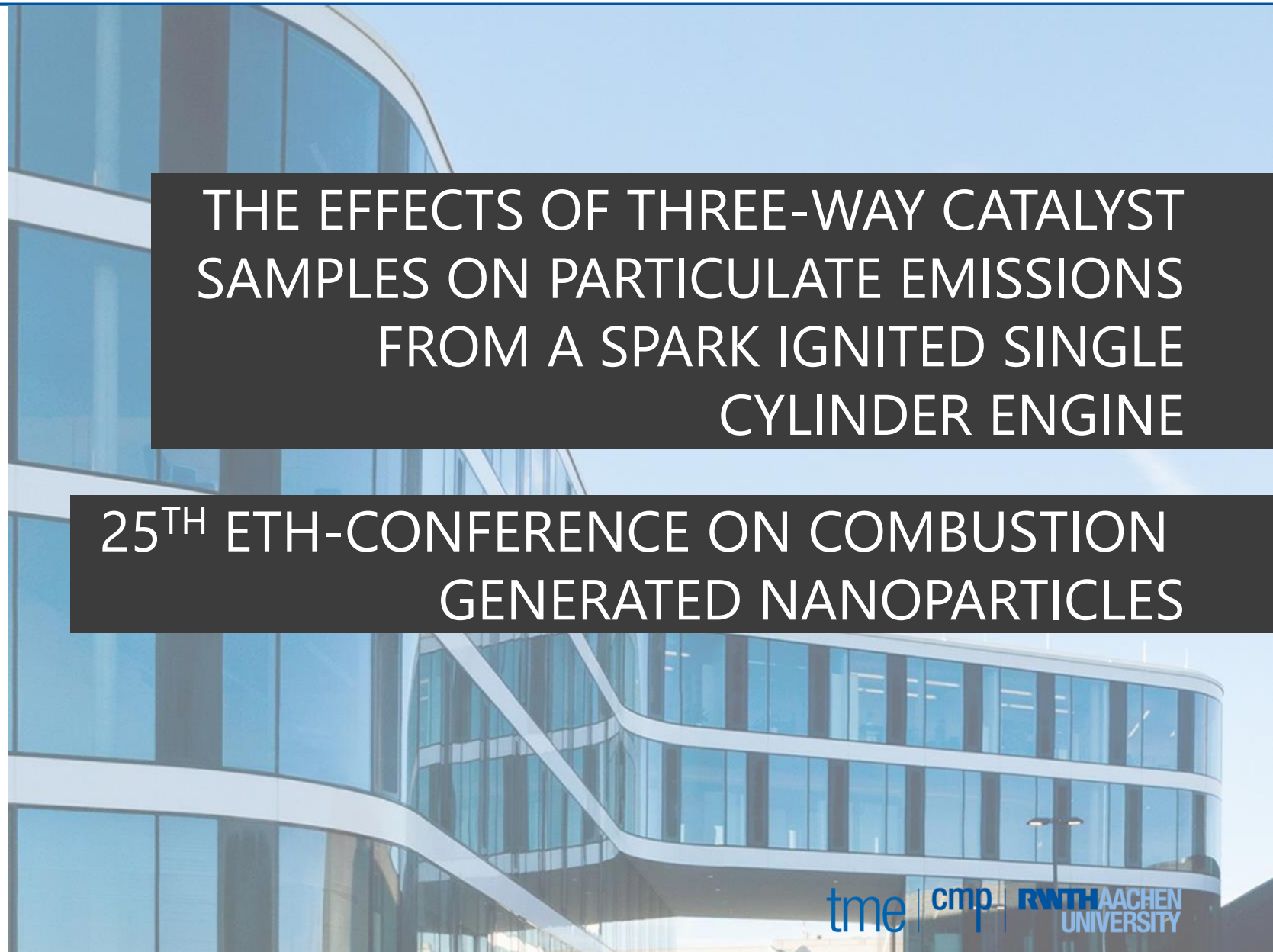
21.06.2022

SERAP KARAHANOGULLARI

INSTITUTE FOR THERMODYNAMICS OF MOBILE ENERGY CONVERSION SYSTEMS &
CENTER FOR MOBILE PROPULSION

THE EFFECTS OF THREE-WAY CATALYST SAMPLES ON PARTICULATE EMISSIONS FROM A SPARK IGNITED SINGLE CYLINDER ENGINE

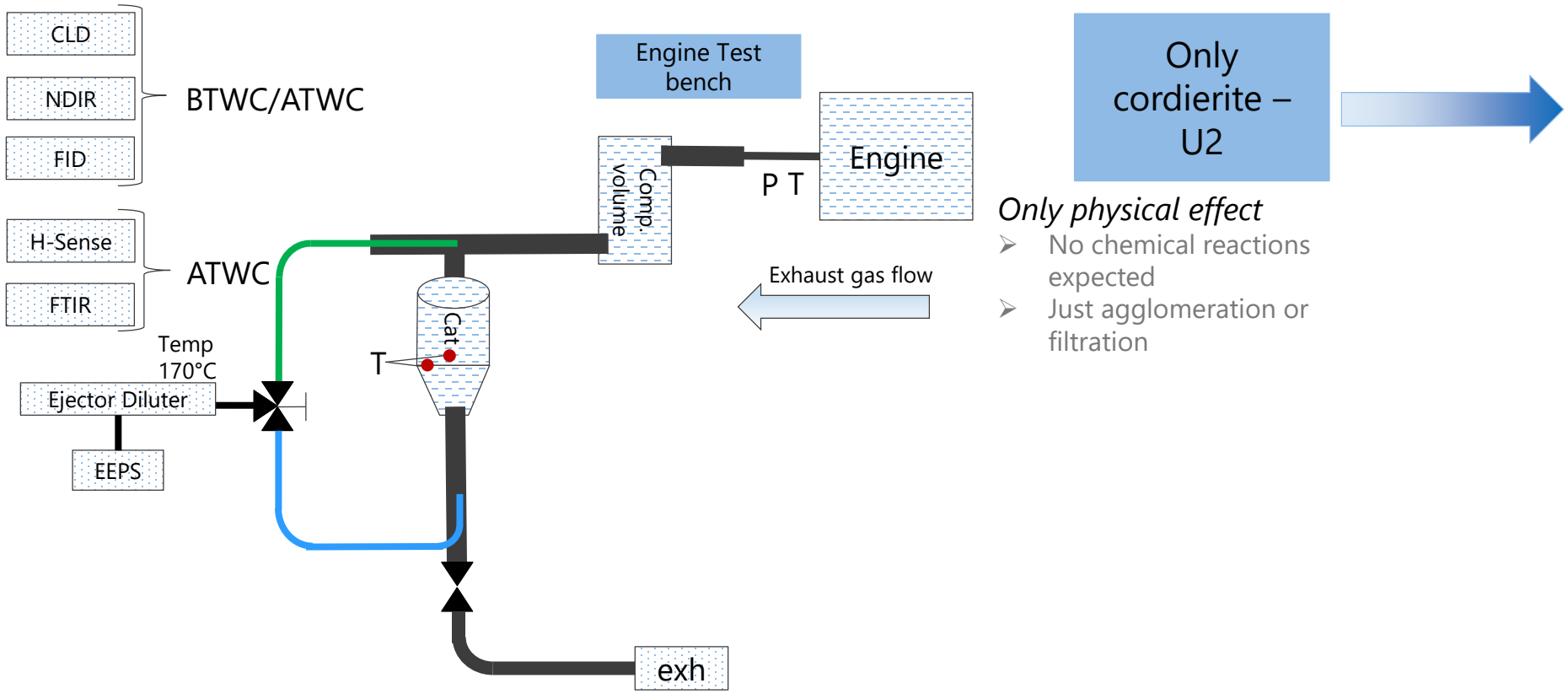
25TH ETH-CONFERENCE ON COMBUSTION GENERATED NANOPARTICLES



FVV PROJECT

4 different samples help differing the physical and chemical effects of catalyst materials on particle emissions

MEASUREMENT PROCEDURE / SAMPLES



Only cordierite – U2

Only physical effect

- No chemical reactions expected
- Just agglomeration or filtration

OSC: Oxygen storage capacity, exh: exhaust

TWC: three-way catalyst, Cell density [cpsi] / wall thickness : 400/4 mil
CLD (NO_x): chemiluminescence detector, NDIR (CO, CO_2): non-dispersive infrared detector, FID (HC): flame ionization detector, FTIR: Fourier-transform infrared spectroscopy, H-Sense (H_2), EEPS: Engine exhaust particle sizer

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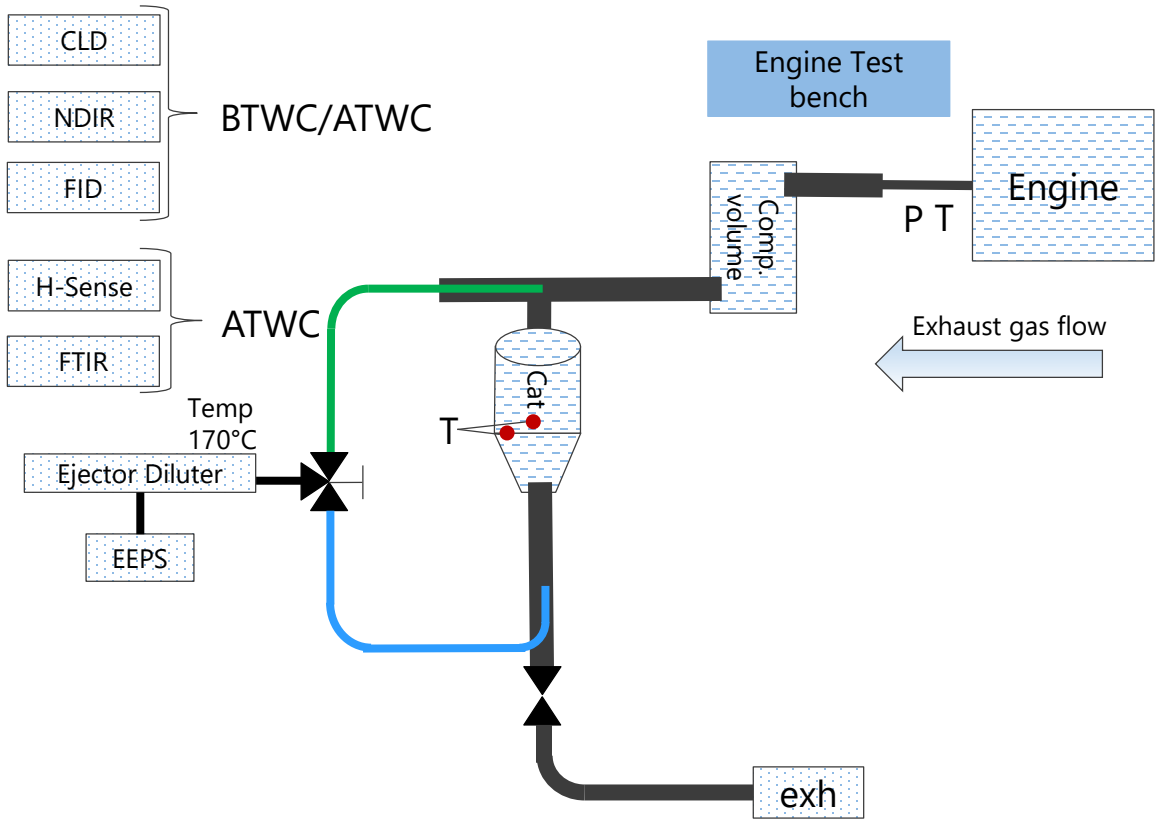

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Non-activated wash coat – N2

Only OSC effect

- 40% Al_2O_3+ 60% CeO_2 surface
- O_2 storage effect → soot reduction?

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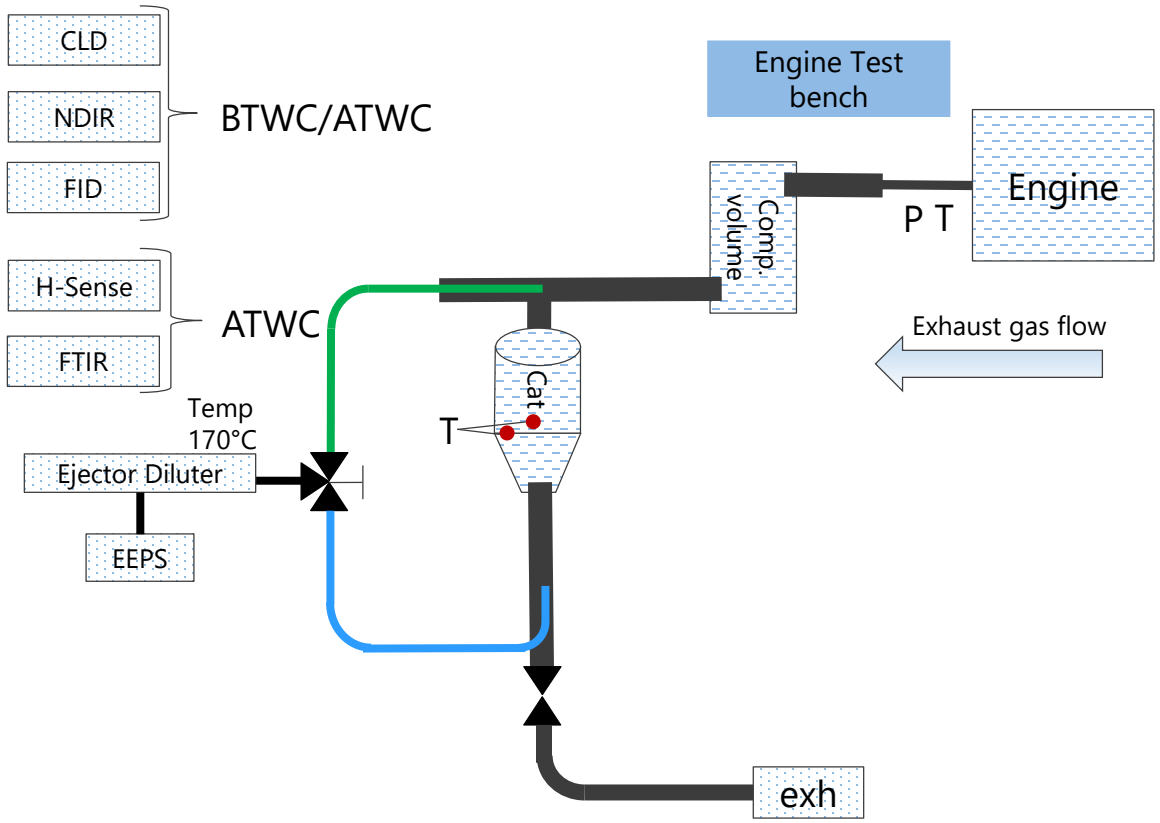

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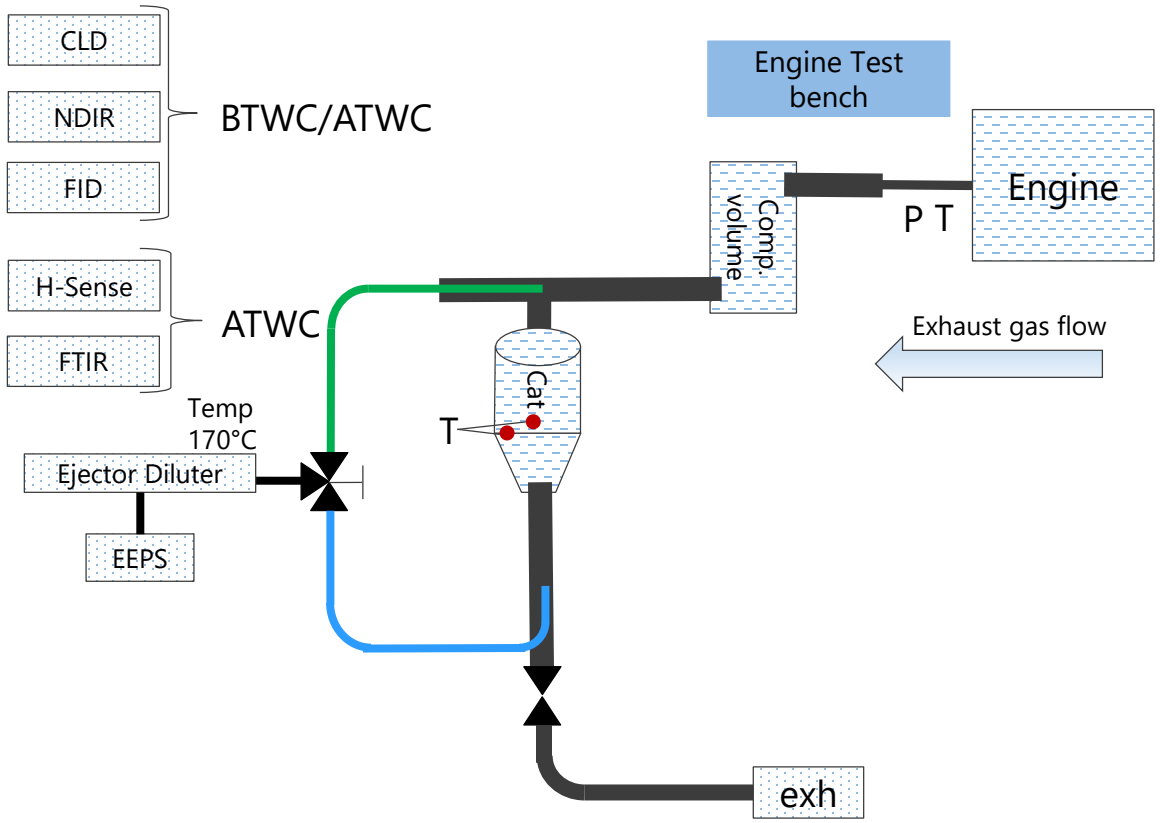

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Chemical effect

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High PGM loaded – H2

Chemical effect

- Pt:Pd:Rh → 0:300:10 g/ft³
- O_2 storage effect → soot reduction?

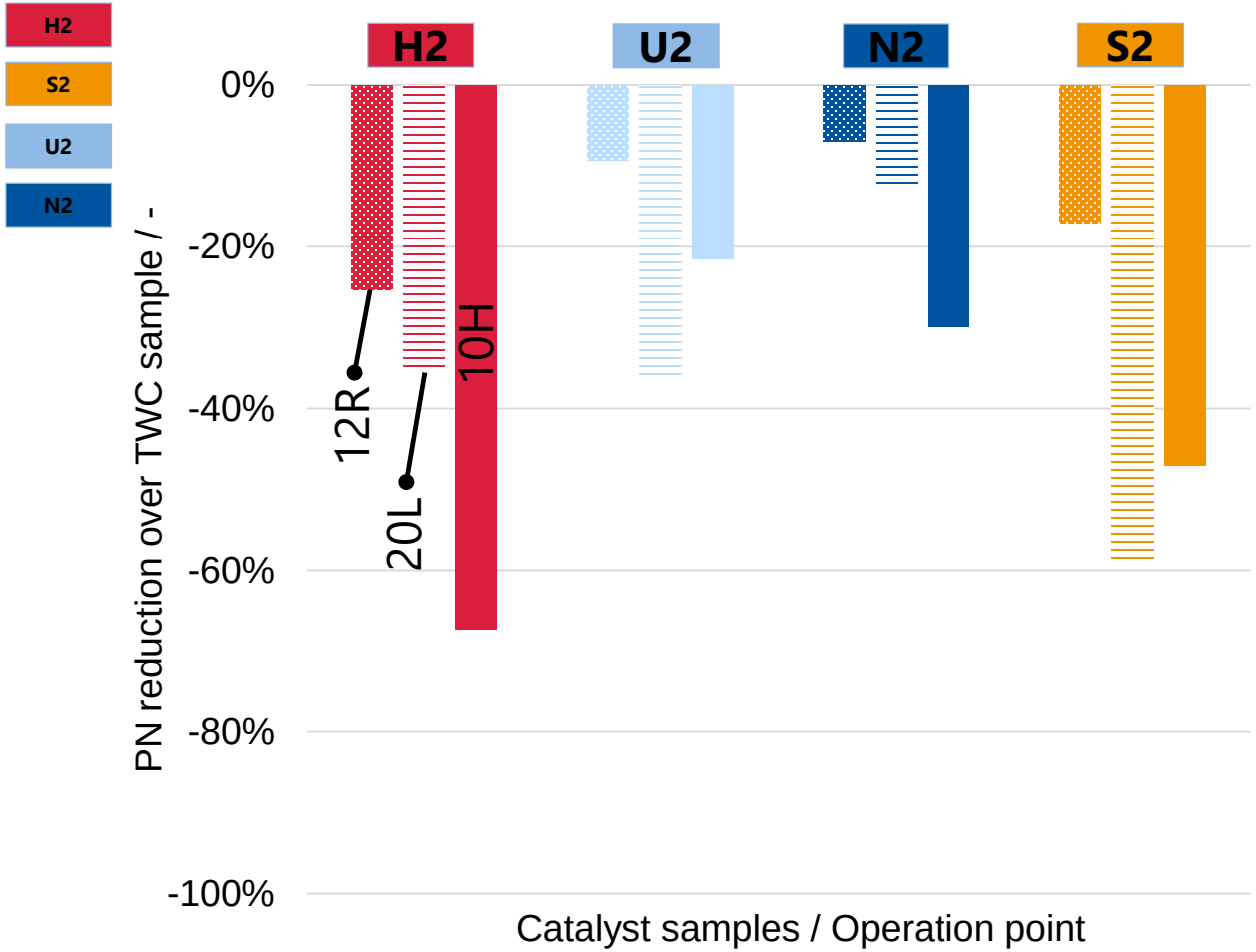
OSC: Oxygen storage capacity, exh: exhaust

Cell density [cpsi] / wall thickness : 400/4 mil

CLD (NO_x): chemiluminescence detector, NDIR (CO, CO_2): non-dispersive infrared detector, FID (HC): flame ionization detector, FTIR: Fourier-transform infrared spectroscopy, H-Sense (H_2), EEPS: Engine exhaust particle sizer

High load engine operation → higher mass flow → higher space velocity → more Pd-share of catalyst material increases the PN reduction

PN REDUCTION OVER THREE-WAY CATALYSTS



12R = catalyst heating engine operation 1200 1/min IMEP=3 bar, 20L = low load engine operation 2000 1/min IMEP=3 bar, 10H = high load engine operation 1000 1/min IMEP=12 bar, for all engine operations compression ratio=12,2, Fuel: RON95E10

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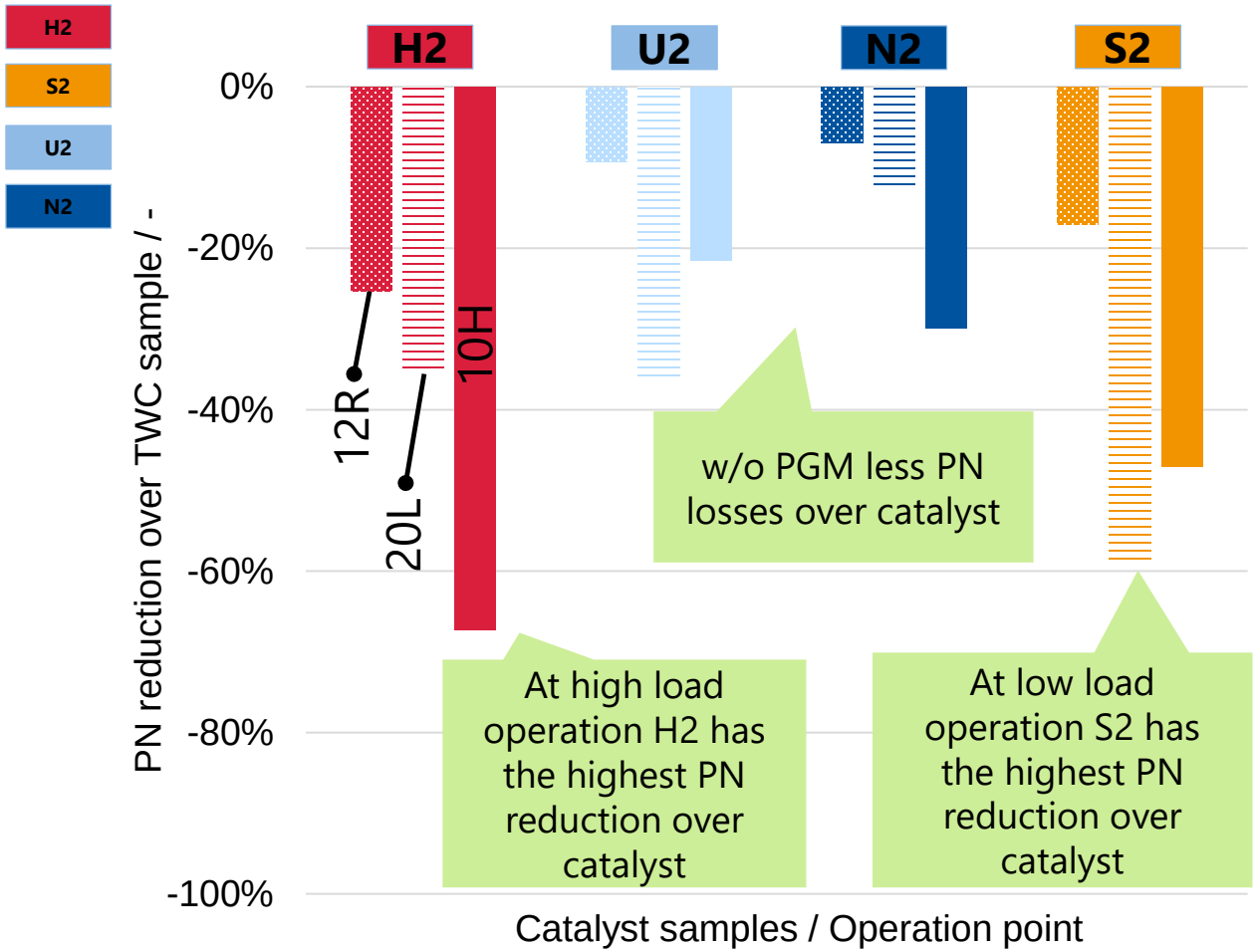

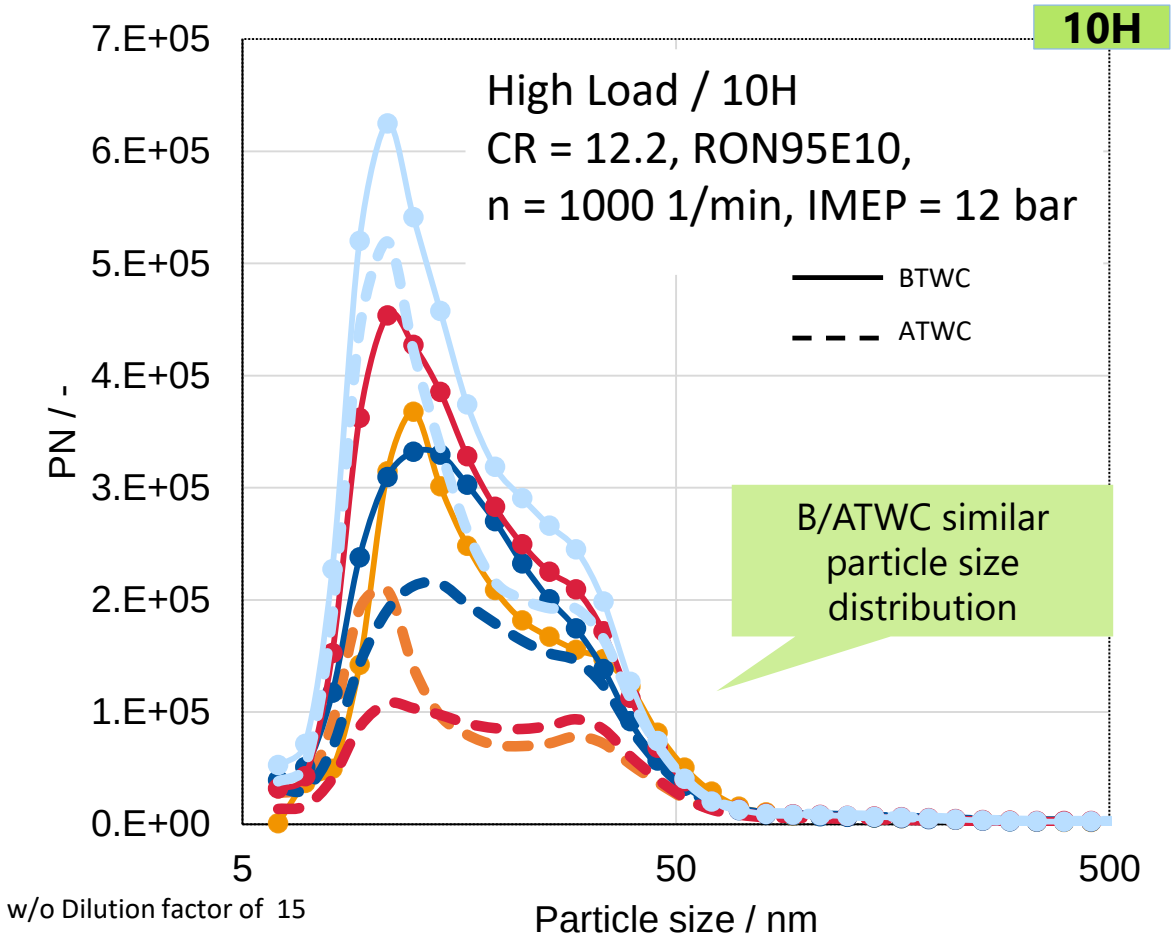

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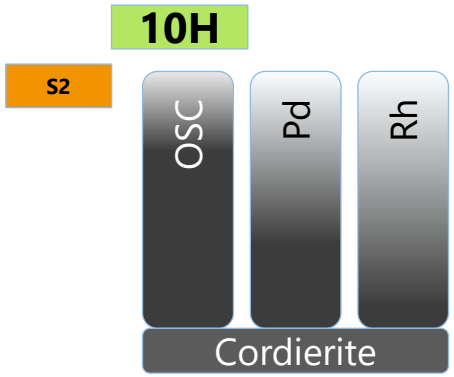
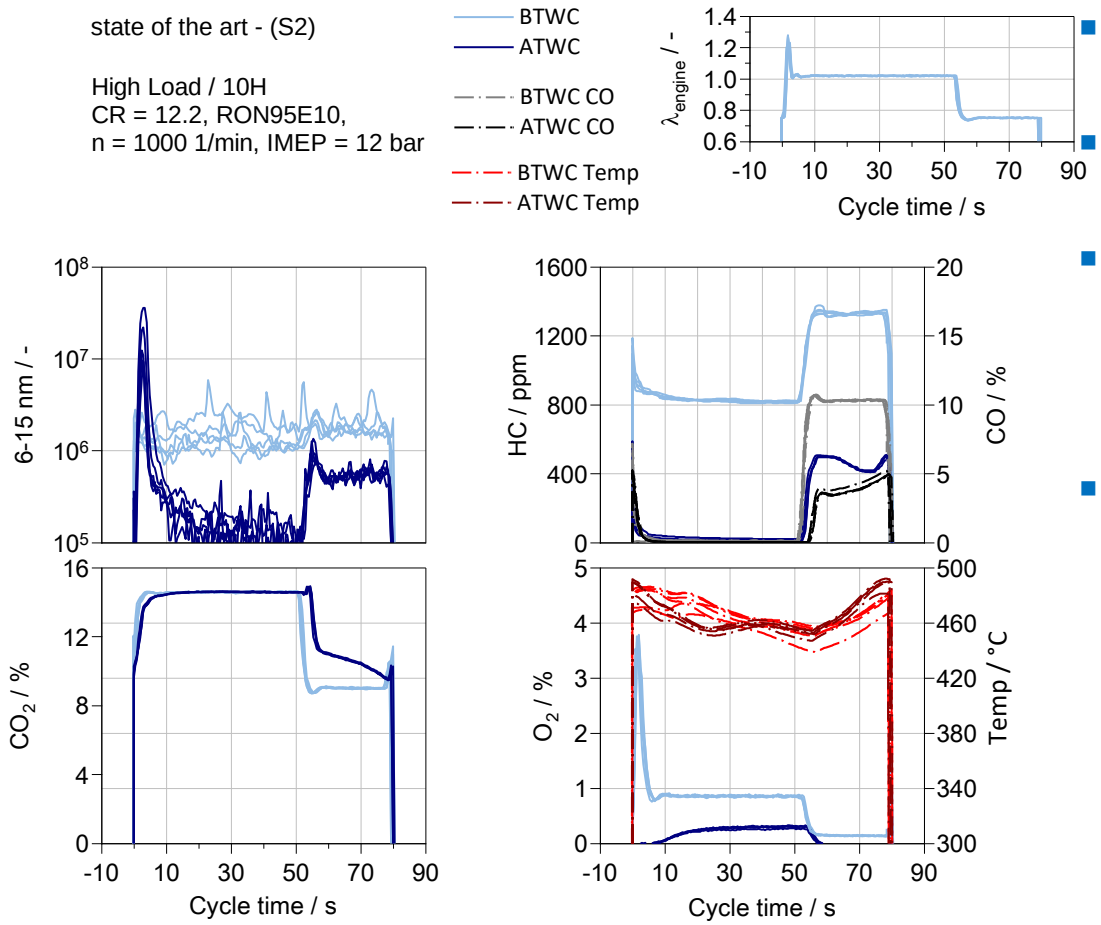
Sub-15 nm particles → remarkable reduction through state of the art catalyst with higher OSC and lower PGM

SAMPLE - STATE OF THE ART





- Highest O_2 usage in comparison to other catalyst samples
- During lean → almost all HC are oxidized
- During rich → highest CO usage through catalyst, higher HC oxidation → OSC and PGM effect
- Temperature of catalyst is the highest → at ~480°C
  - during lean endothermic reactions
  - during rich exothermic

PGM : platinum group metals OSC: Oxygen storage capacity, CR: compression ratio

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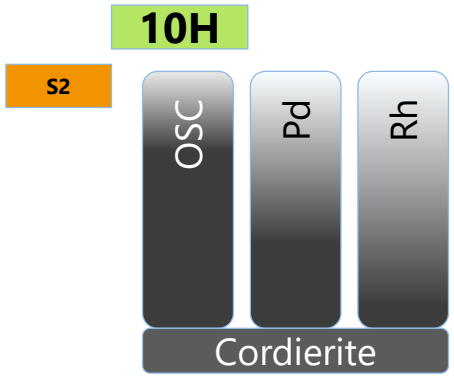

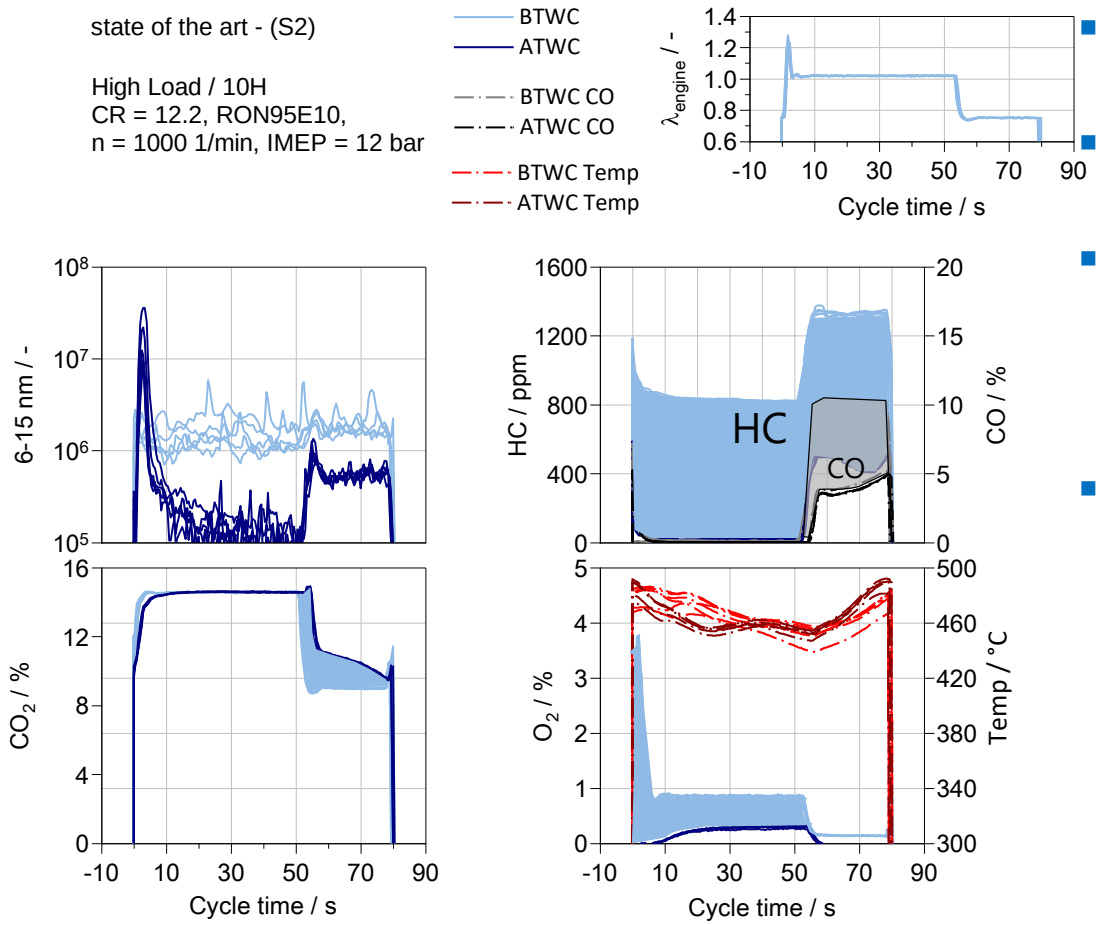

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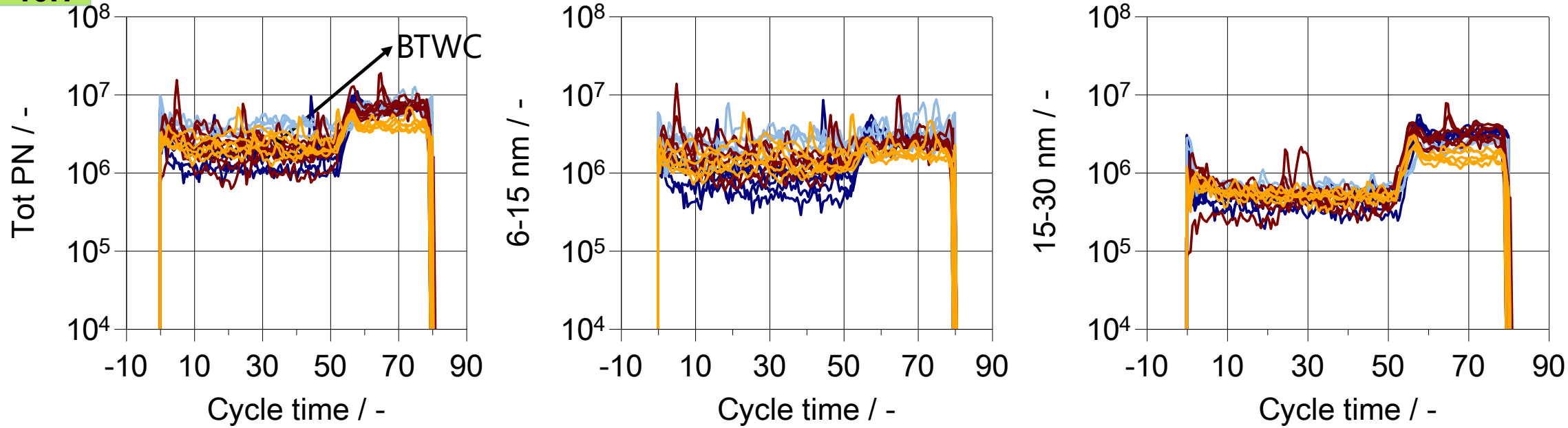
BTWC - 1
ATWC - 1

PGM : platinum group metals OSC: Oxygen storage capacity

PGM loaded samples (orange and red) reduces more particles than just OSC and only cordierite sample

BTWC / ATWC COMPARISON

H2 **10H**
S2
U2
N2



- The highest effect on particle emissions are on

sub-30 nm particles → by high PGM loaded sample – H2

- PGM loaded samples are better than w/o PGM loaded samples
- OSC enhanced PN reduction/oxidation

➢ The consideration of the mean values is not conclusive, therefore we observed the size classes in a time-resolved manner to see the behavior precisely

PGM : platinum group metals OSC: Oxygen storage capacity, BTWC: before TWC

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H2 **10H**

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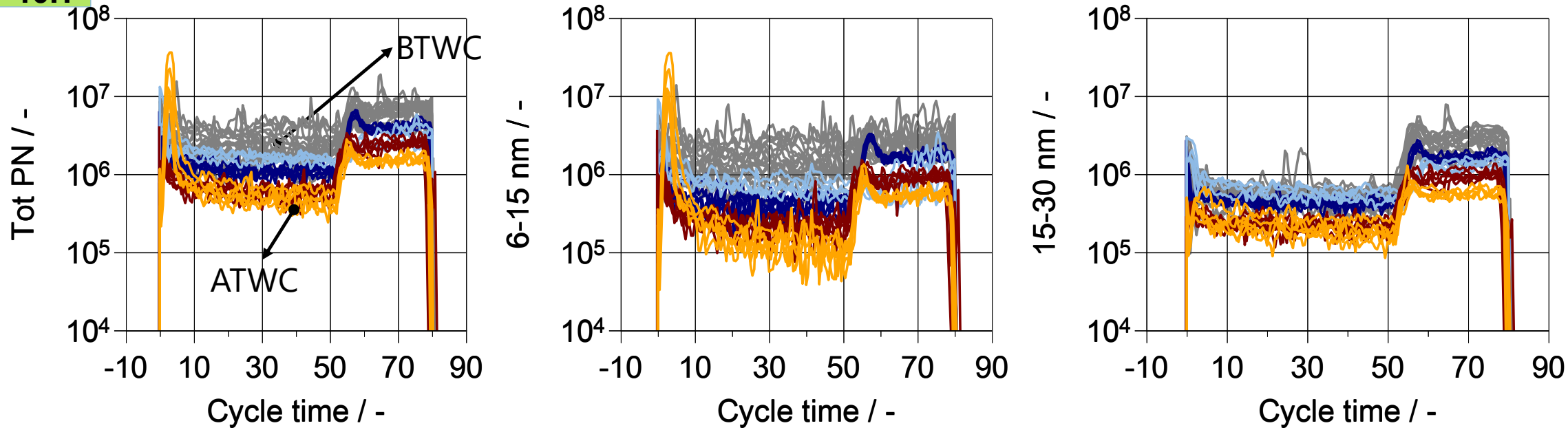
U2

N2



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Thank you for your attention!
Open for discussion!

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