Soot oxidation on manganese oxide catalysts in diesel and gasoline exhaust gas

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Strategies of DPF regeneration

- Passive regeneration (T=200…450°C)
  \[2 \text{NO} + \text{O}_2 \rightarrow 2 \text{NO}_2\]
  \[2 \text{NO}_2 + “C” \rightarrow \text{CO}_2 + 2 \text{NO}\]

- Active regeneration (fuel post-injection)
  \[“C” + \text{O}_2 \rightarrow \text{CO}_2 \quad T > 600°C\]

- Fuel Borne Catalyst: metal-organic compounds
  \[“C” + \text{O}_2 \rightarrow \text{CO}_2 \quad T > 300°C\]

- Catalytic DPF (CDPF): \(\text{CeO}_2\) and \(\text{Fe}_2\text{O}_3\) based catalysts
  \[“C” + \text{O}_2 \rightarrow \text{CO}_2 \quad T > 500°C\]

Evaluation of \(\text{Mn}_x\text{O}_y\) catalysts
**Evaluation of soot oxidation activity**

**Temperature Programmed Oxidation (TPO)**

**TPO conditions**
- $y(O_2)=10\%$, $y(N_2)=90\%$
- $F=500$ mL/min
- Intimate catalyst/soot blend
- $C_3H_6$-soot
- $m_{\text{blend}}=0.9$ g ($n_{\text{cat}}/n_{\text{soot}}=2$)

Plug flow reactor with packed bed

Laboratory test bench
Preparation and characterisation of the soot

- $\text{C}_3\text{H}_6/\text{O}_2$ diffusion flame

- Adsorbed species: 2.5 wt.%

- Chemical composition
  - 98.8 wt.% C
  - 0.7 wt.% O
  - 0.5 wt.% H
  - <0.1 wt.% N

- $S_{\text{BET}} = 65 \text{ m}^2/\text{g}$

- $d = 45 \text{ nm}$ (most frequent diameter)
Activity of manganese oxide catalysts in TPO

TPO conditions:
\( y(\text{O}_2) = 10\% \), \( \Delta T/\Delta t = 100 \text{ K/h} \)
\( m = 0.9 \text{ g} \)
\( n_{\text{cat}}/n_{\text{soot}} = 2 \)
Determining characteristics of the catalysts

Catalyst size

→ number of contact points

Number of acid sites of catalyst

→ transport of surface oxygen
Thermal stability of FSP-Mn₃O₄ catalyst

TPO conditions:
- y(O₂)=10%, N₂
- ΔT/Δt=100 K/h
- m=0.9 g
- n_{cat}/n_{soot}=2

after 16 h at 750°C (10% H₂O, 10% O₂)

after 4 h at 1050°C (air)

fresh
Test of catalytic particulate filters

Catalytic coating of DPF

Lab-DPF
300 cpsi, 1”x 2”
60% porosity

Coating device

Soot deposition on catalytic DPF

FSP bench

TPO conditions

- Catalyst loading: 22 g/L
- Soot loading: ca. 1.5 g/L
- y(O₂)=10%, y(H₂O)=2%, N₂ balance
- F=6500 mL/min (S.V.≈20’000/h)
Performance of lab-DPF coated with FSP-Mn$_3$O$_4$ under diesel conditions

TPO conditions:
Soot load: ca. 1.5 g/L
Catalyst load: 22 g/L
$y(O_2)=10\%$, $y(H_2O)=2\%$, $N_2$
$\Delta T/\Delta t=100$ K/h
S.V.$\approx20'000$/h
Performance of lab-DPF coated with FSP-Mn$_3$O$_4$ under diesel and lean gasoline conditions

TPO conditions:
Soot load: ca. 1.5 g/L
Catalyst load: 22 g/L
$y$(O$_2$)=1 or 10%, $y$(H$_2$O)=2%, N$_2$
$\Delta T/\Delta t$=100 K/h
S.V.$\approx$20'000/h
Manganese oxides are effective in soot oxidation and show high resistance towards thermal and hydrothermal aging.

Manganese oxide catalysts require intimate contact to soot.

FSP-Mn$_3$O$_4$ strongly supplies bulk oxygen to soot.

Beneficial effect of FSP-Mn$_3$O$_4$ also occurs onto particulate filters under diesel and lean gasoline conditions.

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