

Engineering FeCrAl Fibers Through Heat Treatment and Nano-Coating for High-Temperature Filtration and Diesel Emission Control

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Extended Abstract

FeCrAl sintered metal fibers are emerging as key materials for next-generation high-temperature filtration, catalytic conversion, and diesel emission control. Five coordinated studies establish how thermal oxidation, fiber diameter, nano-oxide coatings, and catalyst formulation interact to determine performance and durability in FeCrAl-based devices, providing a unified framework for designing robust Active Diesel Particulate Filters (ADPFs) and high-surface-area catalytic substrates. Multistage thermal oxidation (MSHT) experiments show that alumina-scale formation depends strongly on fiber size and thermal history. Large fibers (40 μm) form stable $\alpha\text{-Al}_2\text{O}_3$ but require several MSHT cycles for uniform coverage. Smaller fibers (12–17 μm) oxidize more rapidly, gain more mass, and experience faster aluminum depletion due to their higher surface-area-to-volume ratios. Microscopy confirms the presence of aluminum-rich interfacial layers in small fibers, indicating outward aluminum diffusion that exceeds oxide growth—an effect that limits lifetime in high-temperature filtration. To slow oxidation and improve durability, subsequent studies apply thin nano-oxide coatings of AlOOH and ZrO₂. These coatings remain adherent during repeated heating, reduce mass gain in thermogravimetric tests, suppress surface cracking, and prevent aluminum loss. High-surface-area boehmite and activated alumina layers further enhance catalytic compatibility, achieving BET areas above 130 m²/g after controlled heat treatment. A comparative Pt–Pd catalyst study using FeCrAl fibers as ADPF substrates shows that both catalysts disperse well on nano-coated fibers but yield distinct emission behaviors. Pt provides superior CO/HC oxidation and lower back pressure, whereas Pd minimizes NO₂ formation, enabling ultra-low-NO₂ operation. Together, these results demonstrate that controlled oxidation, engineered surface coatings, and tailored catalysts make FeCrAl fibers highly adaptable for next-generation high-temperature, low-emission filtration and catalytic systems.

References

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