Formation of Nanophase Catalyst Films on Metallic Substrates

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The Problem of Cold Start Emissions

- More than 60% of automobile hydrocarbon emissions arise when the catalytic converter is cold (<350ºC)

Approach to Reducing Cold Start Emissions

- Keep the converter hot
  - insulate the converter
- Decrease heat-up time
  - improve heat transfer to the converter
  - use a metallic substrate

Conventional Nanophase Material Formation

- Dispersion step
  - vapor formation
  - plasma (another ANL process)
- Condensation/Deposition Step
  - typically uses oxidizing conditions
  - often difficult to get particles to adhere to metallic substrate

A Novel Approach to Nanophase Material Formation

- Two step process
  - First step is a condensed phase dispersion
  - Several options for second step including an electrochemical step
- Both steps are performed at elevated temperatures under non-oxidizing conditions
  - particles will “weld” to metallic substrate
- Process is well-suited for
  - scale-up for rapid production
  - controlled and even surface coverage
  - production of films

State of Development

- Early stage of development
  - particles as small as 100 nm have been formed using this approach
- Additional feasibility experiments are planned and will include
  - SEM, TEM, and AFM analysis
  - evaluation of catalytic effects on hydrocarbon conversion

Staged Development of the Technology

- Phase I -- Proof-of-concept lab tests
  - 1 year, 0.5 FTE
- Phase 2 -- Optimize and Develop Prototype
  - 1 - 2 years, 5-10 FTE
- Phase 3 -- Package Engineering
  - 1 - 2 years, 5-10 FTE

Phase 1 -- Proof-of-Concept Tests

- Identify and rank candidate film systems
- Prepare condensed phase dispersions
- Evaluate options for second step
- Evaluate catalytic activity of film
- Microscopic examination of film
  - in-house evaluation
  - McCrone Associates

Phase 2: Optimize and Develop Prototype

- Optimize composition of catalyst
- Evaluate possibility of regenerating the catalyst
- Collaborate with a catalyst supplier to develop a prototype converter
  - conduct preliminary exhaust system testing
  - begin long-term testing
- Conceptual design of scaled-up production of nanophase film catalyst

Phase 3: Package Engineering

- Develop package for converter
  - insulation
  - pre-heating
- Evaluate long-term performance in exhaust system testing
  - poisoning
  - loss of catalyst
  - agglomeration of nanoparticles

Summary

- Technology is in the very early stage of development
- Production of a nanophase film is simple in concept
- If validated, the process is well-suited for scale-up
- This is a materials formation technology
  - broad range of applications
  - cold-start emissions converter is only one of many possible applications

There's Plenty of Room at the Bottom

"I would like to describe a field in which little has been done, but in which an enormous amount can be done in principle. This field is not quite the same as the others in that it will not tell us much of fundamental physics but . . . it would have an enormous amount of technical applications."

"What I want to talk about is the problem of manipulating and controlling things on a small scale"

Richard P. Feynman
December 1959