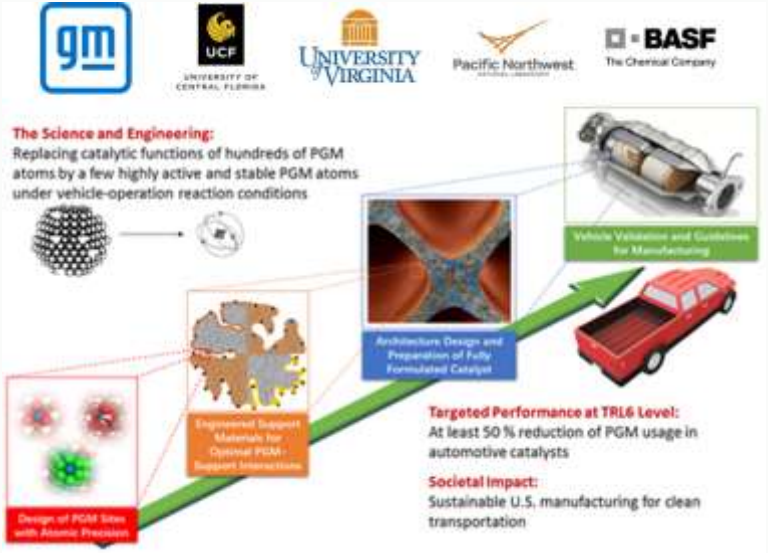

Slashing PGM in Catalytic Converters: An Atoms-to-Autos Approach

Wei Li, General Motors
Annual Merit Review (ACE 158)
6/23/2021

PGM: Platinum Group Metals

This presentation does not contain any proprietary, confidential, or otherwise restricted information

Overview

Timeline

- Start – 15 October 2020
- Finish – 30 December 2023
- 20% Complete

Funding

- Project Budget $3.35 million
  - $1.75M Federal Share
  - $1.60M Cost Share
- 2020 funds received $0
- 2021 funding planned $0.47M

Vehicle Technology Barriers

- Low temperature emission performance
- High PGM loadings
- PGM sintering

Project Team

- General Motors, LLC
- Pacific Northwest National Lab
- University of Central Florida
- University of Virginia
- BASF Corporation

general motors

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Relevance

- Global demand for PGM is outstripping supply, driven by
  - increasing global production of vehicles with internal combustion engines
  - increasingly stringent emissions standards
  - higher emission control system durability requirements

- Overall Project Objectives
  - Develop catalysts with predominantly single-atoms or small ensembles to identify the most promising Pd and Rh structures for TWC catalysts

This atoms-to-autos approach aims to reduce PGM use in the U.S. vehicle fleet by 50% while meeting future emission regulations (including SULEV30)

Technical Approach

- Overall Approach
  - Improve the utilization efficiency of PGMs in gasoline TWCs by engineering PGM sites and support materials with near 100% metal dispersion
  - *Uses PGM single atoms as building blocks, not necessarily as sole catalytic centers*
  - Material development effort will be supported by detailed kinetic studies and advanced characterization tools
  - Individual Pd and Rh catalysts with scalable preparation methods; rational washcoat structure design for integration and full-size validation
- 2021 Task Plan
  - Baseline catalyst technology definition (completed)
  - Design Pd and Rh Catalysts with Near 100% Material Efficiency and Optimal Catalytic Activities and Durability (on-going)
  - End-of-year Goal: Downselection of Technology Pathway for Individual Pd and Rh Catalysts

2021/2022 Milestones

Budget Period	Milestone	Description	Milestone or Go/No-Go Decision	Status
1	1.1	Definition of catalyst systems and experimental protocols	Milestone	Completed
	1.2	Evaluation of Pd and Rh species and support materials	Milestone	30% completed
	1.3	Desired optimal Pd, Rh species and supports identified and prepared	Milestone	Not started
	1.4	Proof of design concept to achieve performance measures	Go/No-Go Decision	N/A
2	2.1	Optimal supported Pd and Rh catalysts developed and prepared	Milestone	N/A
	2.2	Pd and Rh species optimized for aged performance	Milestone	N/A
	2.3	Optimized Pd and Rh catalysts after aging validated in core samples	Milestone	N/A
	2.4	Design concept optimized and aged performance validated	Go/No-Go Decision	N/A

Technical Accomplishments

Baseline Catalyst Technology Defined

- 2020 GM vehicle with turbo-charged 2L engine
  - *State-of-the-art catalyst technology*
- Baseline Pd and Rh Catalysts
  - *Powder and core samples*
  - *Degreened and Aged*
- Aging Conditions (LTAT protocols):
  - *Degreen: 700°C hydrothermal 2 hours*
  - *Aging: lean-rich 1025°C for 50 h*
  - *Powder samples degreened and aged at GM and distributed to team members: consistent baseline*

- Baseline Pd catalyst contains Pd nanoparticles in the fresh state and these particles grow significantly after aging.
- *This confirms the potential benefit of single-atom catalyst approach*
- Initial Pd and Rh catalyst concepts in preliminary screening stage

Collaborations

- **BASF** (*Y. Li, X. Zheng*)
  - Baseline catalysts (powder, core)
  - Catalyst scale-up and washcoat design; full-size part preparation
- **University of Central Florida** (*F. Liu*)
  - Support engineering
  - Single-atom catalyst development
- **University of Virginia** (*W. Epling*)
  - Catalyst aging study
  - Reaction kinetics and mechanism
- **Pacific Northwest National Lab** (*K. Rappe, N. Nelson*)
  - Catalyst characterization
- **General Motors** (*W. Li, K. Gu*)
  - Overall project management
  - Single-atom catalyst development; system level demonstration

Proposed Future Research

- *Budget Period One (10/2020 – 12/2021):*
  - Identify desired PGM species and anchor on engineered supports
  - Down select pathways to catalyst designs with potential for ≥60% PGM reduction
- *Budget Period Two (1/2022 – 12/2022):*
  - Concurrent optimization of the PGM species and the engineered supports
  - Demonstrate ≥60% PGM content reduction in core sample form
- *Budget Period Three (1/2023 – 12/2023):*
  - Transform powder and core samples to full-size, fully formulated catalysts
  - Provide pathway to 50% PGM cost savings

Summary

- Extensive collaboration among the team partners
- Test protocols established (aging, testing)
- Baseline catalyst technology defined and assessed
  - Fresh, degreened, and aged
  - Powder and core samples
- Initial Pd and Rh concepts in catalyst screening stage
  - Single atoms and small ensembles
  - Engineered supports