Improved Catalyst Selectivity and Longevity Using Atomic Layer Deposition

WBS 2.1.10.1

Argonne National Laboratory/ForgeNano/UOP

FY2018

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Project Overview

- ANL and its partners Honeywell UOP (UOP) and Forge Nano (FN) will apply one or more protective layers using atomic layer deposition (ALD) to inhibit metal sintering of commercial Pt-based PDH catalysts and extend usable lifetime.

Budget

	FY 18 Costs	FY 19 Costs	FY 20 Costs	Total Planned Funding (FY 18-Project End Date)
DOE Funded	$ 600K	$ 800K	$ 200K	$ 1.6M
Project Cost Share	$ 113K	$ 226K	$ 113K	$ 452K

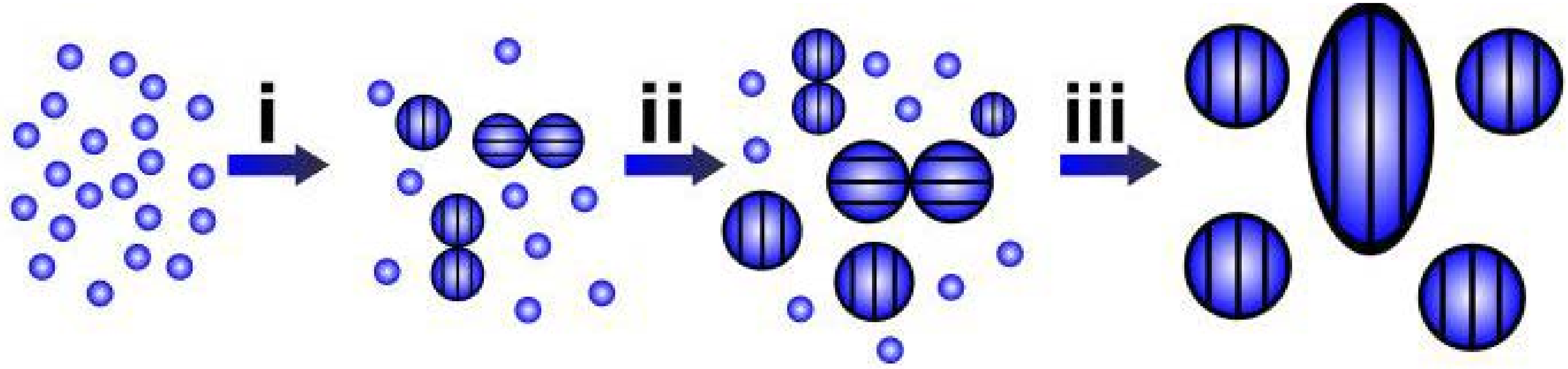
Timeline

- AMO Award issued March 2018
- Projected End date March 2020
- Project 5% complete

Problem

Sintering (Aging)

- Loss of active surface area from the prolonged exposure to high temperatures.
- Commercial catalysts lose surface area and hence activity via a process called sintering.
- In most cases the remedy for sintering is:
    - Increase reactor temperature **(energy inefficient)**
    - Remove spent catalyst and replace with new material. **(expensive and leads to loss in productivity)**



Project Objectives

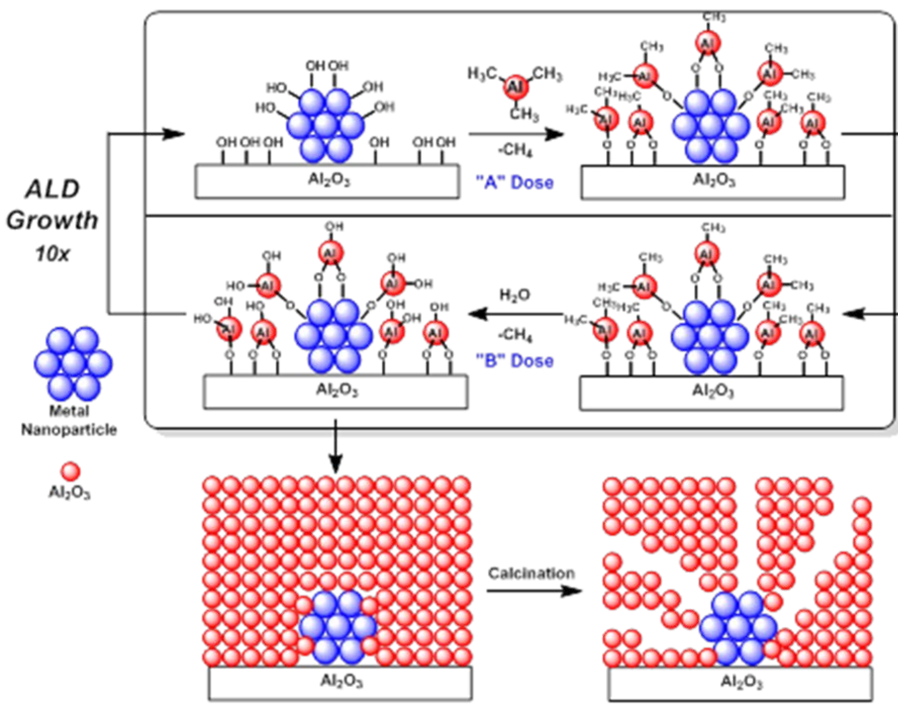
- *ANL and its partners Honeywell UOP (UOP) and Forge Nano (FN) are applying protective layers using ALD to inhibit metal sintering of commercial Pt-based PDH catalysts to extend its usable lifetime and demonstrate its performance during the catalysis of propane to propylene.*

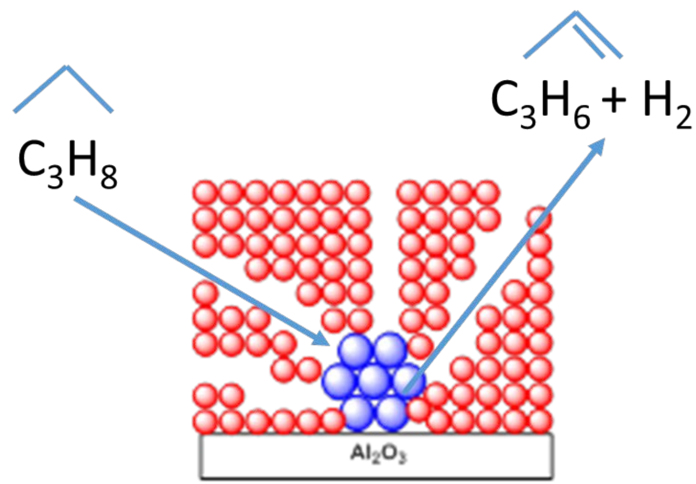
  - Improvement in the efficiency of the catalytic reaction to reduce the energy required for the process.
  - Larger energy savings would result from an improvement in selectivity.
    - Undesirable chemical byproducts that require high energy consumption processes for separation and removal from the product stream.
  - Activity and selectivity are both degraded by sintering.

Technical Innovation

Improved Catalyst Selectivity and Longevity :

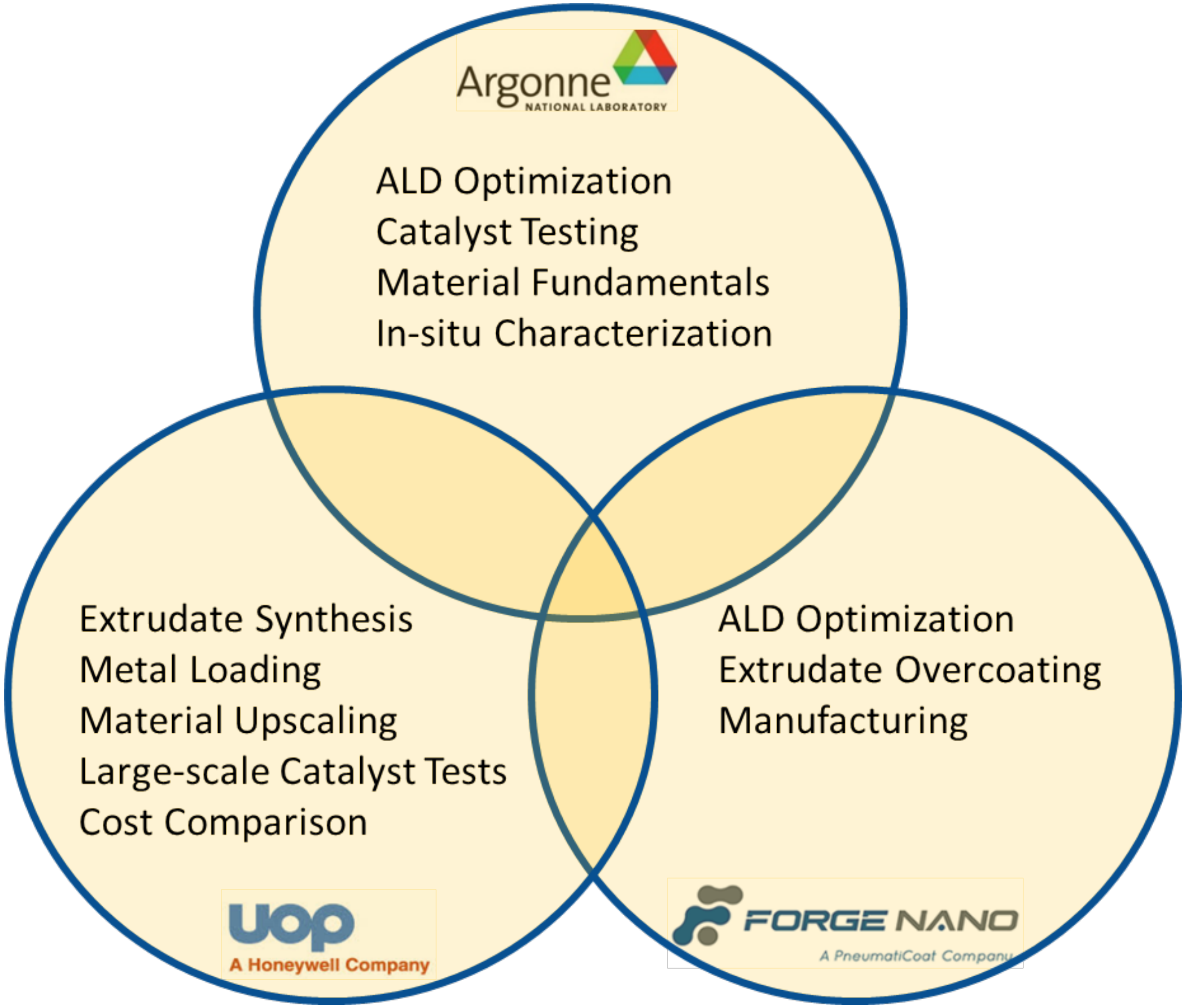
- ALD overcoating prevents sintering of the active catalytic metal.
- ALD overcoating improves the selectivity to olefin
  - avoiding coke formation.
- New technology from FN could make ALD useful for large volume applications such as catalyst manufacturing.



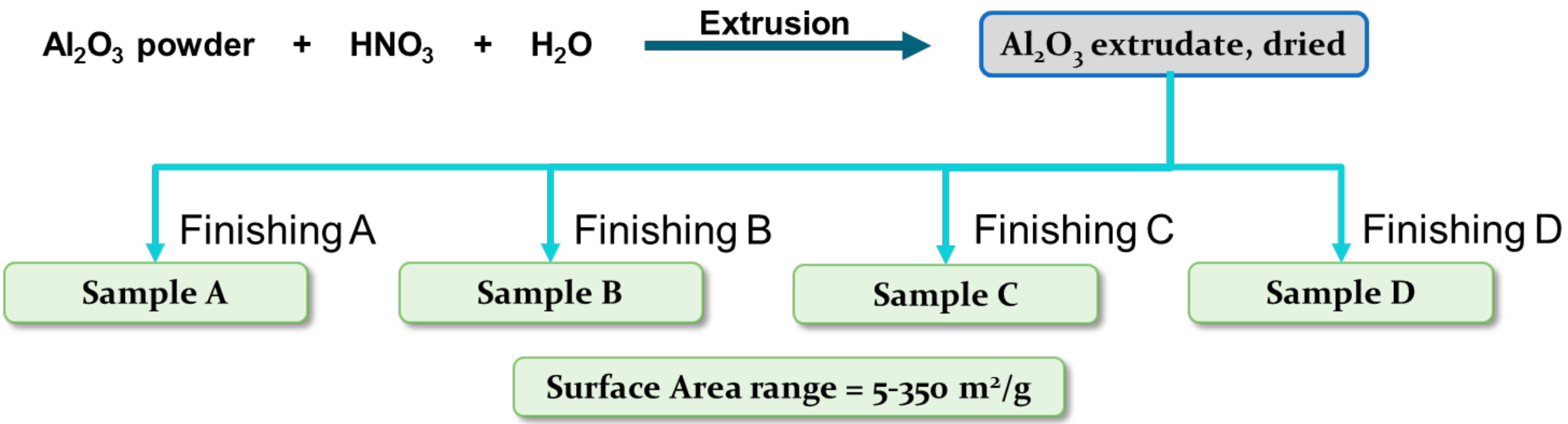


- Retain/Improve Productivity
- Reduced Metal Sintering

Technical Approach & Project Roles



Base catalyst preparation



For each sample A through D, platinum loading via impregnation at two levels:

X% Pt loading

Y% Pt loading

FN Objectives Overview

Develop infiltration strategies and optimize process conditions & coating loadings at the 1g scale

Make instrumentation modifications to enable chemistry on extrudates at scale

Scale to:
1 kg batches

Timeline

	FY18			FY19				FY20
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8
Task 1 – Project Management and StartUp Tasks								
1.0.0 Project Management and Meetings								▲M4.4
Task 2 – Extrudate Overcoating								
2.0.0 Fabrication of Extruded Catalyst Supports	▲M1.1							
2.1.0 Synthesis of TiO2 Overcoated Extrudates		▲M2.1						
2.1.0 Analysis of TiO2 Overcoated Extrudates								
2.3.0 Steaming Studies of TiO2 Overcoating Robustness								
Task 3 – Pt on Extrudate Overcoating								
3.0.0 Synthesis of Pt Impregnated Extruded Catalyst								
3.1.1 Al2O3 Overcoating			▲M3.1					
3.1.2 TiO2 Overcoating				▲M3.2				
3.2.0 Analysis of ALD Overcoated Materials								
3.2.2 Steaming studies of ALD Overcoating Robustness				▲M3.3	▲M3.4			
3.2.3 Reactor Testing of Down-selected Materials								
Task 4 – Commercialization								
4.0.0 Large Quantity Production, Validation and Modeling					▲M4.1	▲M4.2	▲M4.3	
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8
	Year 1				Year 2			

Go/No Go Decisions

Go/No-Go #1 *(May 2019)-- Demonstrate the ability to improve the productivity of a commercial dehydrogenation by Al_2O_3 and/or TiO_2 overcoating. Feedback the highest performing material formulations to FN for larger scale synthesis.* ***Materials delivered here will exhibit equal or improved catalyst performance along with improved catalyst longevity (≥125% lifetime increase) compared to baseline and have demonstrated reproducibility across multiple reactors/facilities.***

Go/No-Go #2 *(Nov 2020)-- Determine whether the optimized bench scale materials may be scaled up to the 1 kg level required for pilot plant testing.* ***The 1 kg batch must show equal catalyst properties to the lab scale materials.***

Transition (beyond DOE assistance)

- Forge Nano and Honeywell UOP are partners in the funded project.
- FN will further develop and demonstrate particle coating technologies at their Louisville, Colorado Facility that is currently employing 25 US workers and manufacturing state of the art Li-ion battery materials.
- Honeywell UOP is committed to the significant catalyst manufacturing presence it maintains on the US Gulf Coast since the 1950s, with current locations including Mobile, Alabama and Shreveport and Baton Rouge, Louisiana in addition to the plant located in McCook, Illinois.
- Sales avenues through typical UOP offerings

Questions?