



Alvacat

# Synthesis of Core-Shell Catalysts

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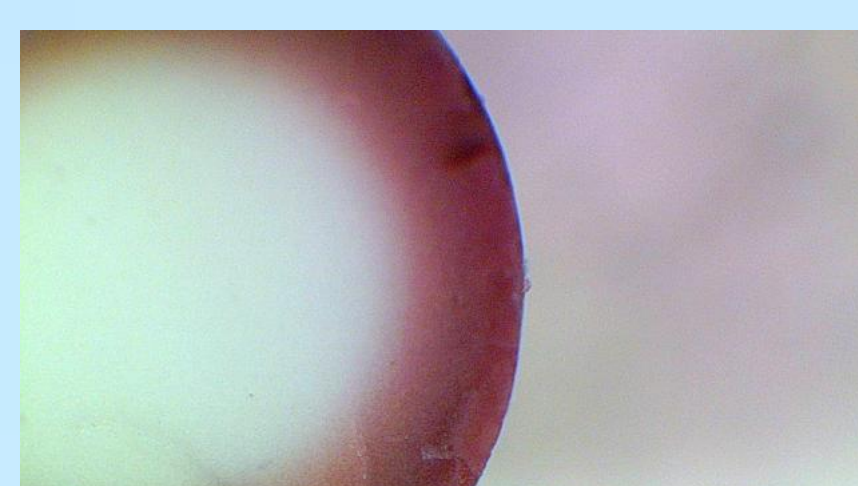
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## Company Profile

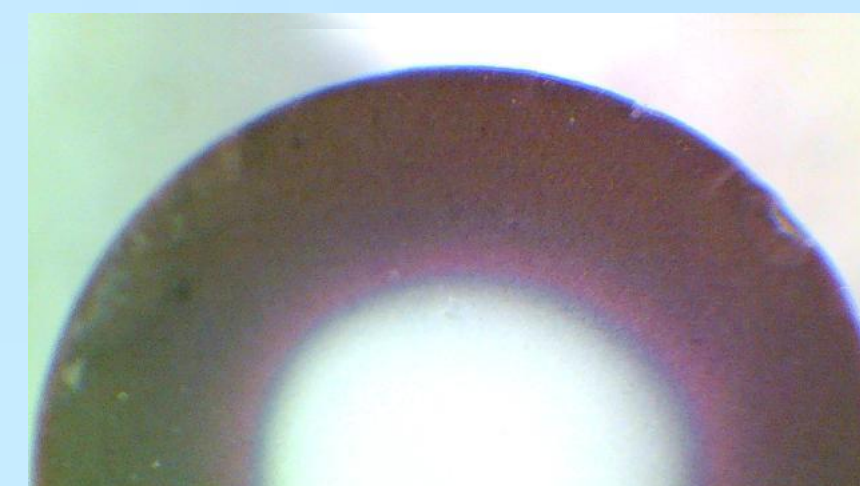
- Contract research
- Heterogeneous catalysis, Materials science
- Renewables
- Environmental catalysis
- Hydrogen storage catalysis
- Energy storage, Battery materials
- Custom catalyst and support development
- Lab scale, bench scale and scale up
- Catalyst carrier and solution inventory
- High throughput synthesis and screening
- Partnered with tollers for scaleup, piloting, manufacturing and metal recycling

## Novel & Scalable Shell Formation Recipes – PGM & Base Metals

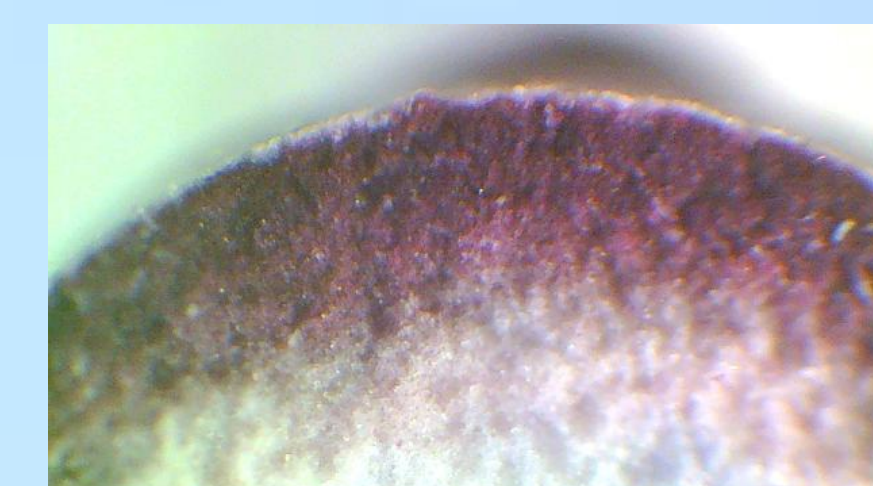
### Single-step wet chemical impregnation



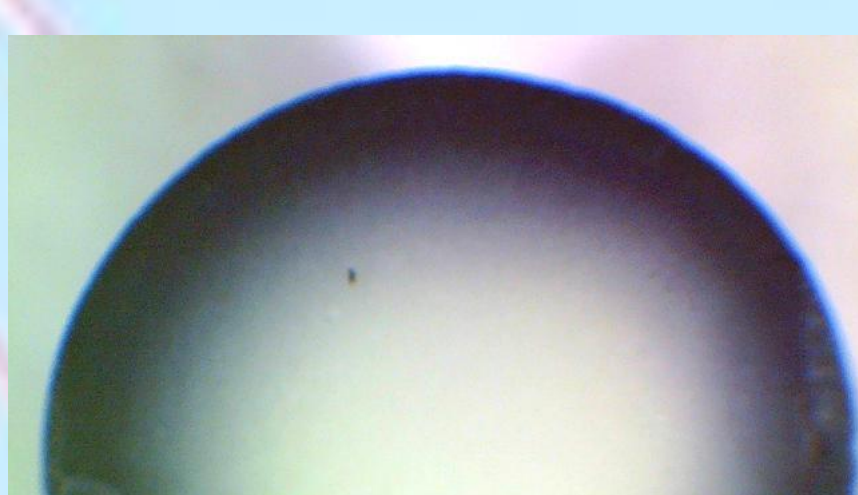
Au 230um  
1.8mm alumina microbeads



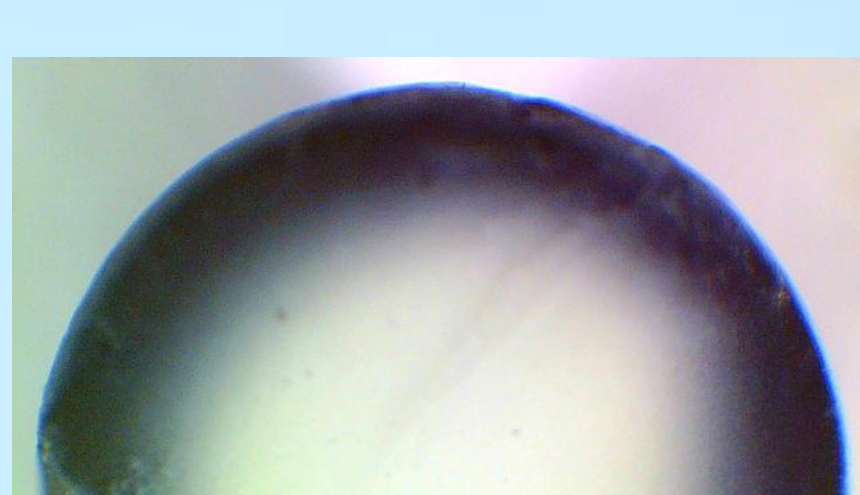
Au 390um  
1.8mm alumina microbeads



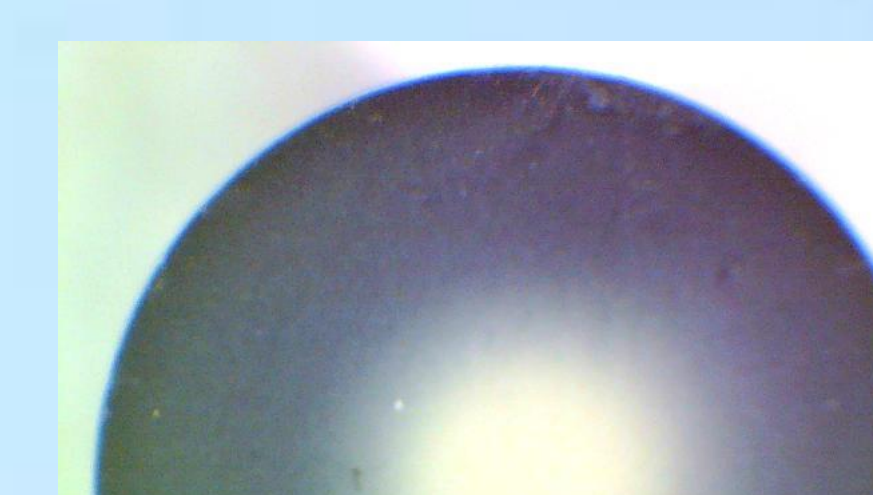
Au 400um  
3mm silica-alumina extrudates



Ir 210um  
1.8mm alumina microbeads



Ir 230um  
1.8mm alumina microbeads

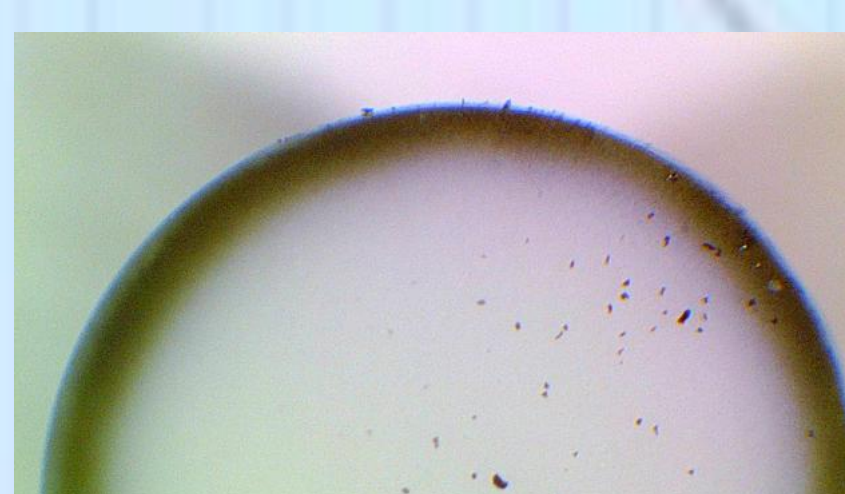


Ir 470um  
1.8mm alumina microbeads

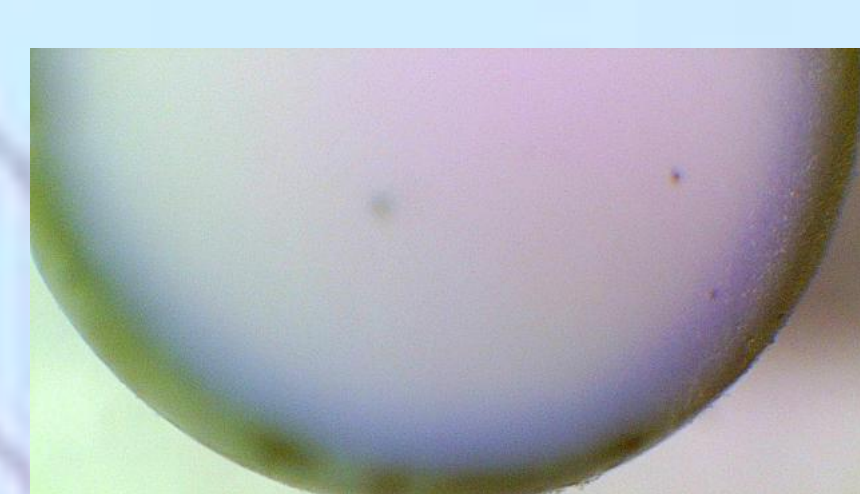
## Core-Shell Catalysts

- Widely used for commercial purposes
- Overcome mass transport limitations
- Enhance selectivity
- Experimental** space for recipe development:
  - Metal precursor selection
    - Chloride-free
    - Thermally decomposable
  - Support variation
    - Ceramic & Carbon
- Remarkable **Results**:
  - very thin 50um Pt shells
  - 200-400um Ni & 100-200um Co shells

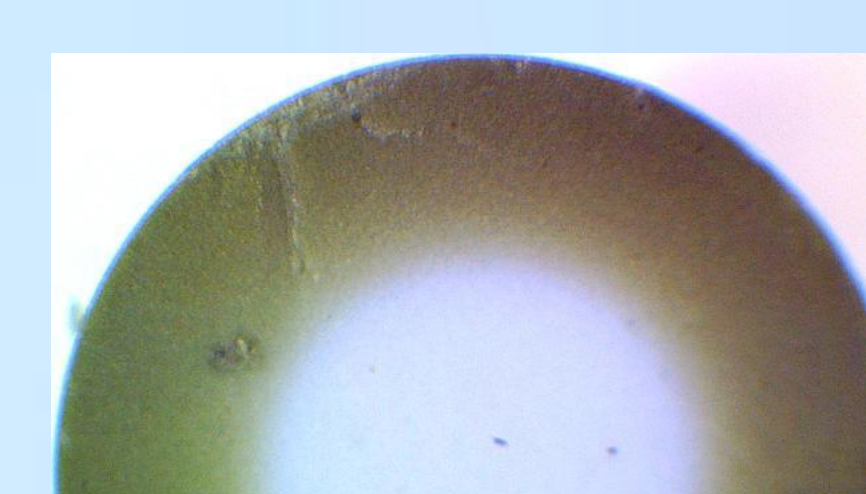
## Base Metal Shells on 1.8mm & 2.5mm alumina microbeads



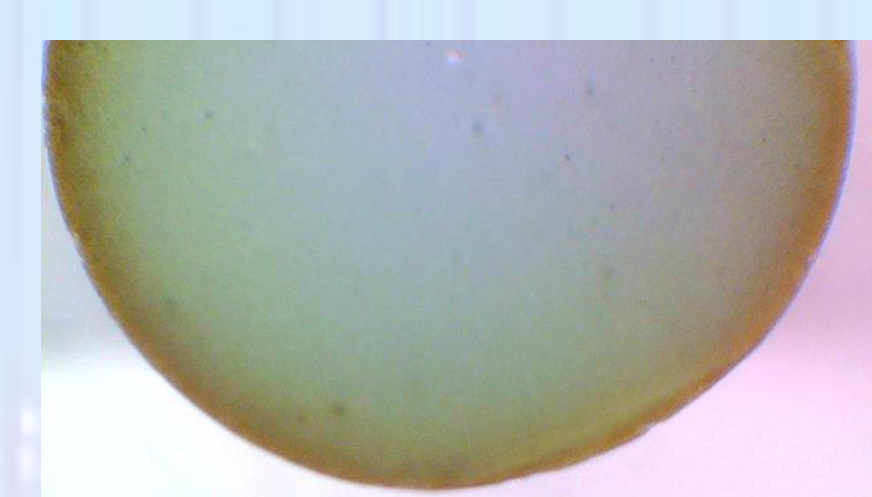
Co 100um



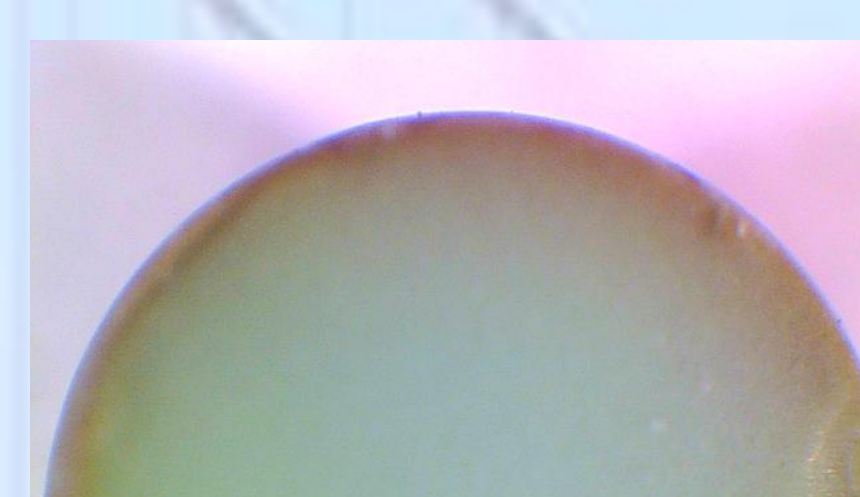
Co 120um



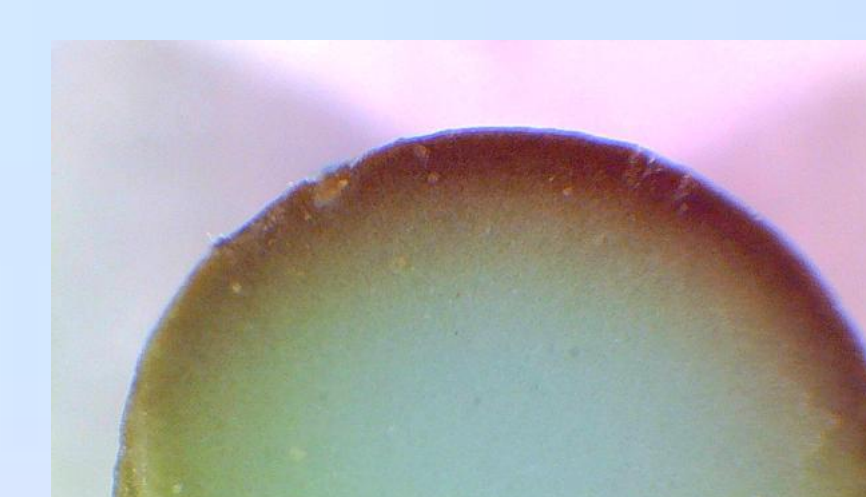
Co 350um



Cu 60um



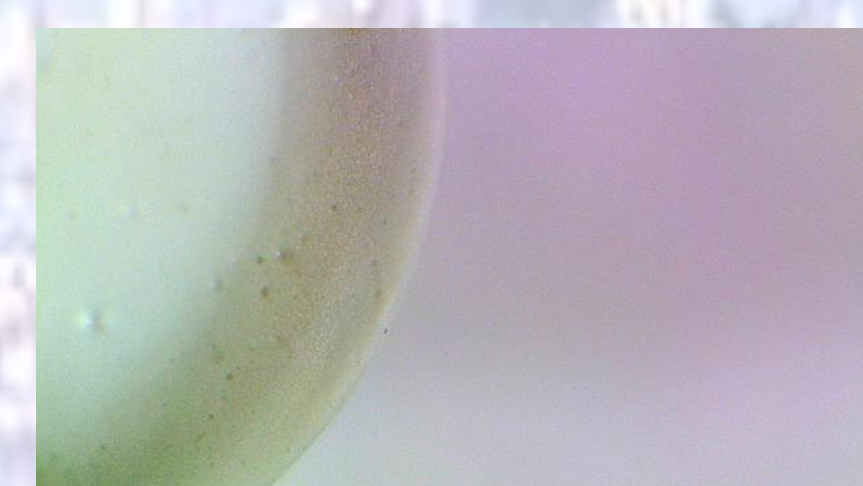
Cu 120um



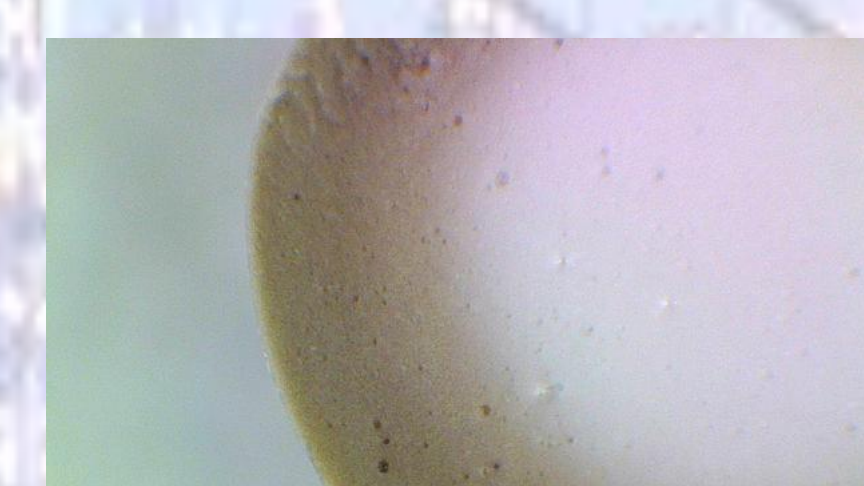
Cu 165um



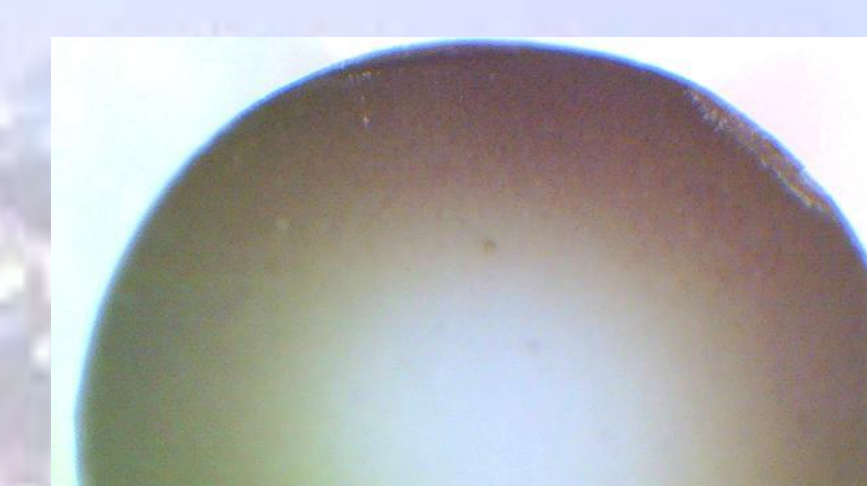
Ni 250um



Ni 290um



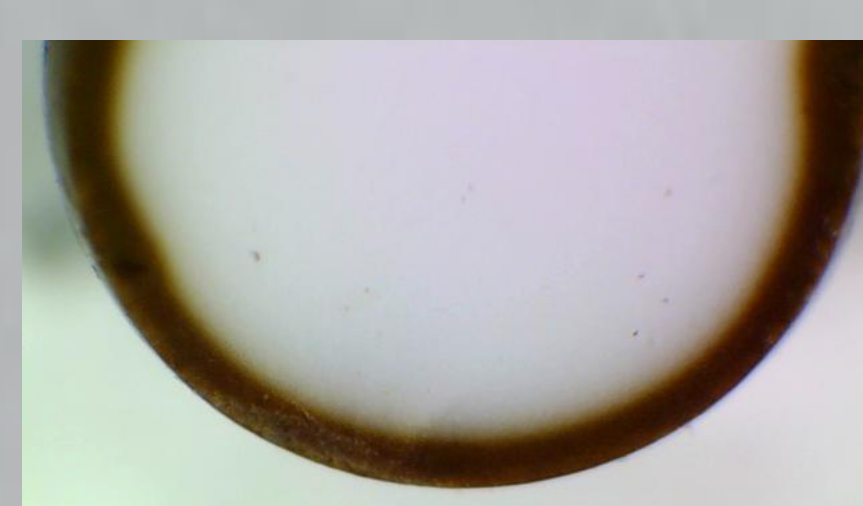
Ni 320um



Ni 350um

## PGM Shells on alumina microbeads & zirconia extrudates

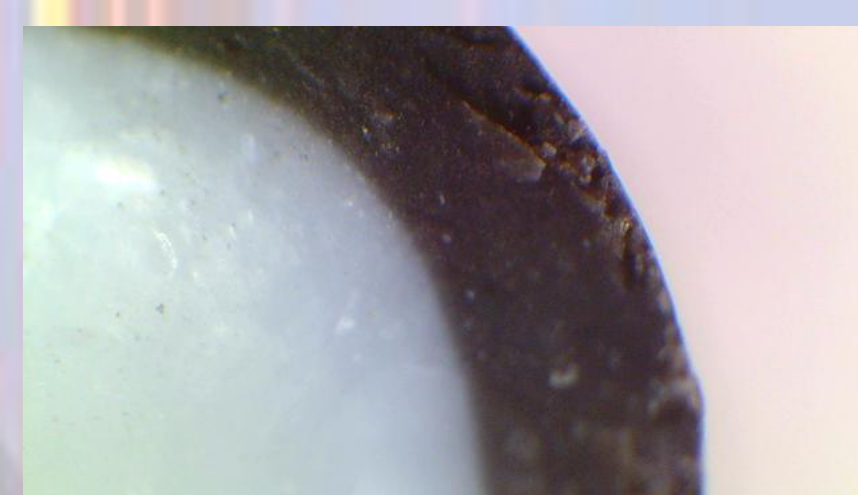
### 1-2 wt% PGM loading



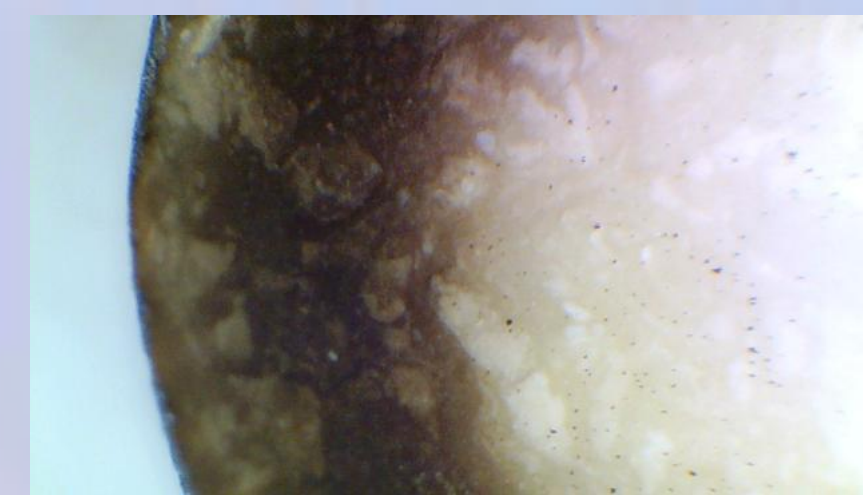
Pd 106um  
alumina



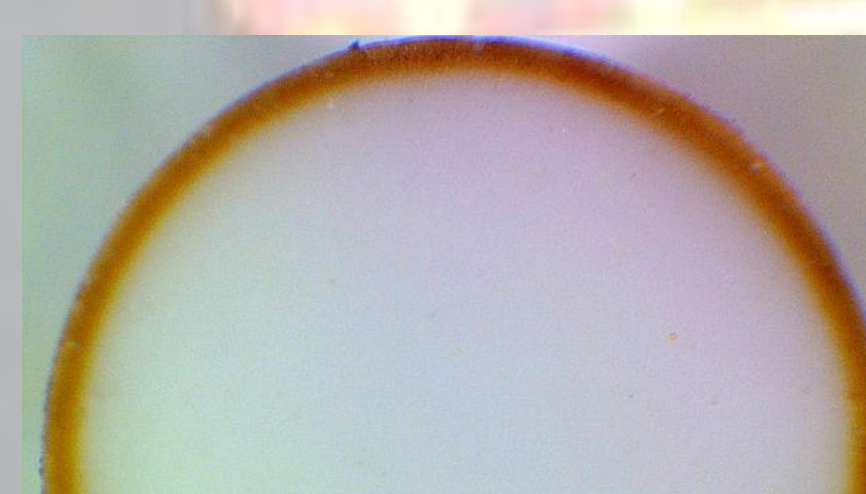
Ag 250um  
alumina



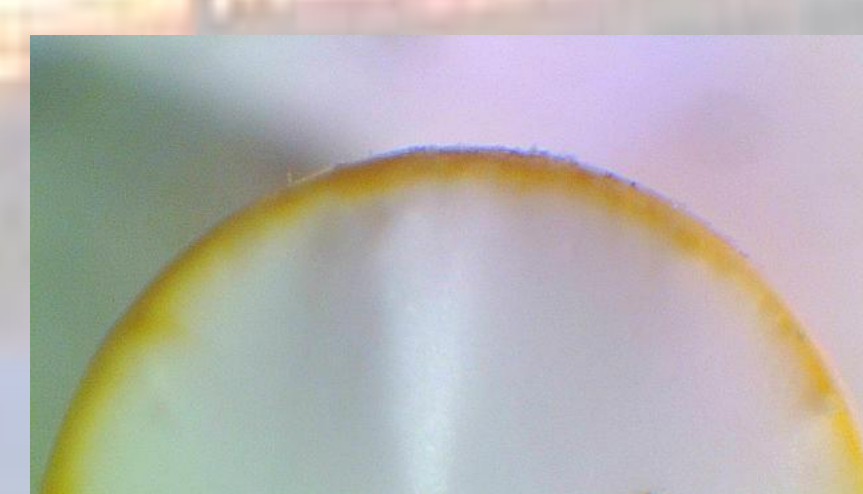
Pd 470um  
zirconia



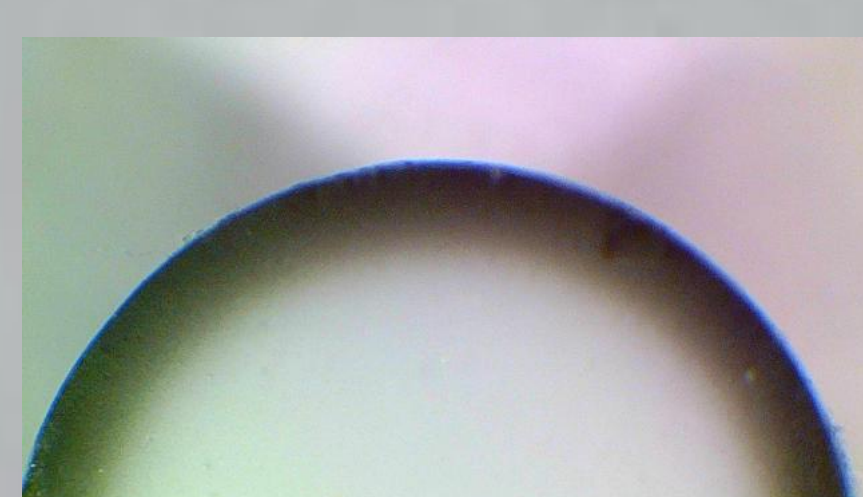
Pd 600um  
zirconia



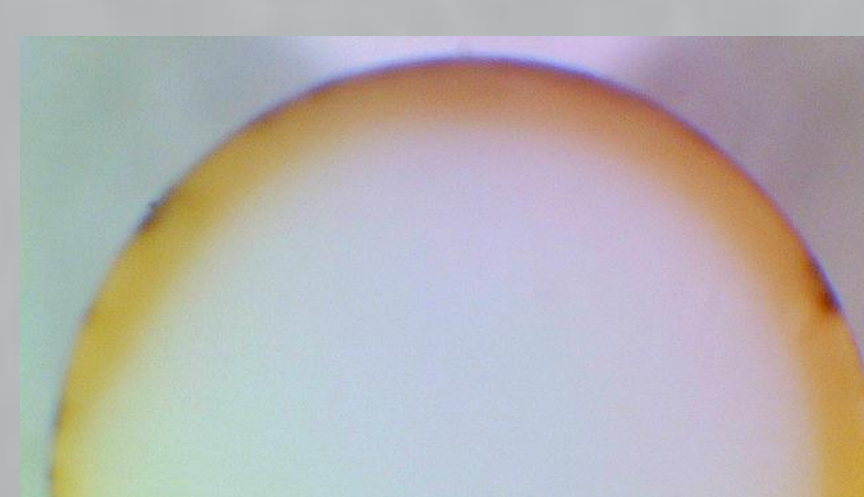
Pd 85um



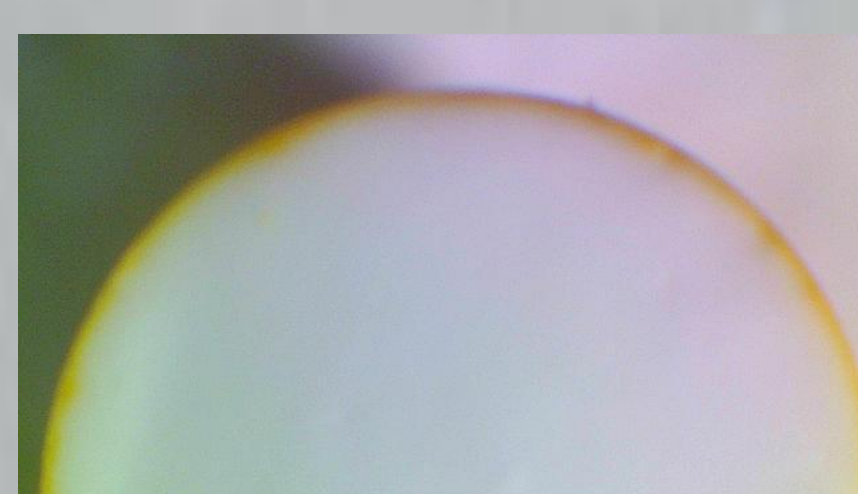
Pt 80um



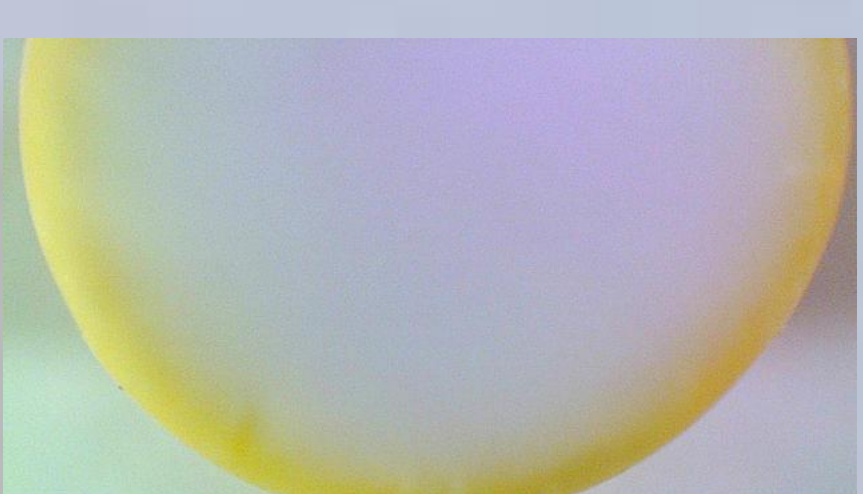
Ru 160um  
alumina



Rh 120um  
alumina



Pt 50um



Pt 105um

## Conclusions

### Novel Synthetic Recipes for Core-Shell Catalysts

- Single step wet chemical impregnation
- Adjustable shell thickness
- High plant productivity
  - de-bottlenecking wash and reduction steps
- Distinguishing features from traditional base fix/back diffusion/chloride wash recipe
  - chloride-free metal precursors
  - skip time-consuming wash step
  - no metal leaching
  - no capital investment in spray coaters
- Recipes available for base and precious metals
  - alumina microbeads
  - carbon pellets and extrudates