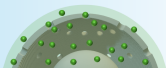
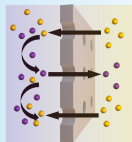
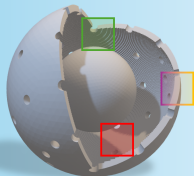


(a)

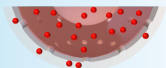


Phase 1: Surface Area Maximization



Phase 2: Mass Transport Engineering

Hollow Catalysts



Phase 3: Intermediate Densification

- Active site
- Reactant
- Product
- Intermediate

(b)

Conceptual Evolution



Simple
Hollow

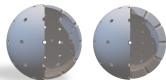


Yolk-shell



Shape
controlled

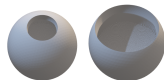
Structural Design Principle



Shell
thickness



Shell
multiplicity



Cavity size