Chemical Challenges and Opportunities in Critical Materials

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Challenging Chemistry: Separations and Process

- **Rare earth element characteristics**
  - Difficulty of separating and extracting rare earth elements from ore bodies

- Separating/purifying rare earths from other rare earth elements

- General knowledge of rare earth element chemistry compared to other areas within chemistry

- Starting point for utilizing rare earths and a basis for future innovation
Chemistry Expertise for Critical Materials: Separations and Process

- Translate actinide (5f) element chemistry and experience expertise into rare earth (4f) separations, processes, and materials innovations

- New advanced chemistry for separations and processes
  
  Combinatorial
  
  Biomimetic

- Model of a novel rare earth complex. Four 1,2-HOPO building blocks coordinated to a Eu(III) metal center with a ninth cyano unit coordinated.

  K. N. Raymond et al. (LBNL/UC Berkeley)
A Separations Example for Thorium: Similar Approach for Rare Earths and Critical Materials?

- Novel molecule for thorium separation and sequestration
  - Waste prevention
  - Biotechnology
  - Nuclear energy

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Critical Materials Chemistry: Catalysis

- Development of substitutes from transition metals for platinum-group metal catalysts used in large-scale chemical processes.
  - Catalyst discovery based on first-row transition metals
  - Synthetic, mechanistic, and characterization efforts
- New rare earth catalysts for bond-cleavage and bond-formation for hydrocarbons
- New diesel exhaust catalysts
Critical Materials Chemistry: Sustainability

- Re-use and recycling infrastructure-manufacturing, re-manufacturing, reclamation, and efficient process chemistry
  - Green chemistry and environmental technologies for materials processing

- Development of new, more accurate unit value-based lifecycle models to guide industry and policy decision-makers
Summary: Opportunities and Challenges

• New revolutionary applications of rare earths and Critical Materials from improved chemistry knowledge and research
  - Examples in separations and process chemistry
  - Challenges in catalysis
  - Discover and develop new alternatives and substitutes
  - Sustainable chemistry

• Support of fundamental and targeted research to ensure both scientific and economic leadership in Critical Materials

• Imperative to educate and train the next generation of scientists