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Separating Trivalent Lanthanides: Enabling Nuclear Fuel Cycle  
or Recovery of Valuable Critical Materials?

Two reasons for being interested in separation of lanthanides have important energy implications, but  
in opposite ways. In working toward sustainable nuclear energy, lanthanide fission products are  
neutron poisons and so must be separated and discarded from actinides that we wish to recycle.  
However, in providing for sustainable energy, rare earths (which include the lanthanides, Y, and Sc)  
represent critical materials that feed the supply chains of clean energy technologies. Separation of  
minor actinides has been an active research area worldwide toward a closed nuclear fuel cycle that  
reduces the heat and radiotoxicity burden on geologic repositories, reduces the consequences of  
potential disruptive events involving repositories, and increases the utilization of nuclear fuel. Simple,  
efficient, and robust americium and curium separations, from lanthanides and from each other, are  
regarded as major technical challenges. These goals are pursued mainly within the paradigm of  
aqueous reprocessing of used oxide nuclear fuel dissolved in nitric acid. Principles of selectivity through  
various means have been developed based around two strategies: selective complexation of trivalent  
MAAs with soft-donor ligands, either as aqueous complexants or as extractants, and exploiting the  
higher oxidation states of Am. Ligand design for Am(III) extraction has started with the basic concepts  
of molecular recognition, namely complementarity and preorganization. A family of novel mixed N,O-  
donor compounds has led to astonishing affinities for Am(III), but interestingly, the same principles  
applied to lanthanide separation have led to astonishing selectivity for intra-lanthanide separation.  
Diglycolamide ligands (DGAs) have also provided a rich chemistry in the context of separations for both  
nuclear-fuel-cycle and critical-materials applications. They have enabled the development of the  
effective ALSEP process for MA separation from lanthanides, a promising technology with the potential  
to close the nuclear fuel cycle with full actinide recycle. Beyond actinide separations, DGA ligands have  
unusual selectivity across the lanthanide series with implications for more efficient recovery of critical  
materials. Looking deeply at the structure of the extraction complexes has provided insight into the  
interplay between the first- and second-shell coordination sphere and the role of co-extracted anions.

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**Required Graduate Student Seminar for ChE 5971**

Refreshments served before Seminar

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