Clean technologies for producing critical materials from wastes and mineral ores

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PURDUE UNIVERSITY | College of Engineering
Wang Research Group

Re ELEMENT TECHNOLOGIES

MARION ADVANCED TECHNOLOGY CENTER

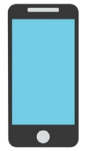
Rare earth elements (REEs) are “vitamins” for modern technology

Targeting and weapon

Communication

*	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu

Semiconductors, Magnets



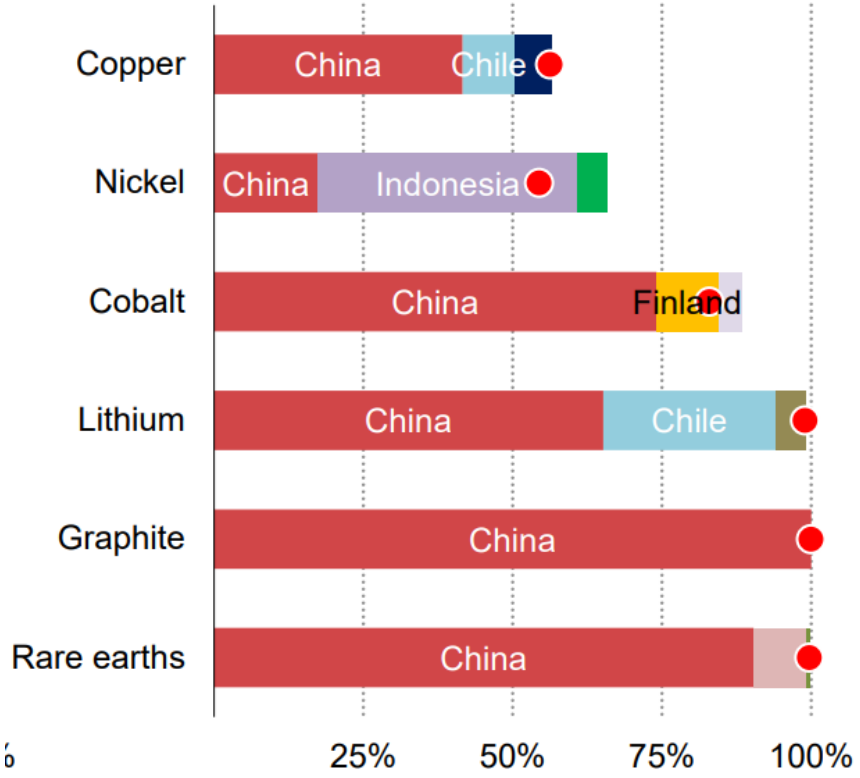
3,000 F-35 jets delivery delayed

Source: Congressional Research Service

Rising Demand and Chinese Refining Dominance

45,000 tons/yr REE concentrates currently sent from US to China for refining

China Controls Refining of Critical Materials



(EIA, *Critical Minerals Market Review 2023*)

USA: 7th largest REE reserve

- **1.8 million tons REO reserve in California**
- **1.5 million tons REO reserve in Greenland**

Challenges of REE Refining

Solvent extraction requires 1,000 mixer-settlers & produces toxic waste.

Waste

Lake in Inner Mongolia

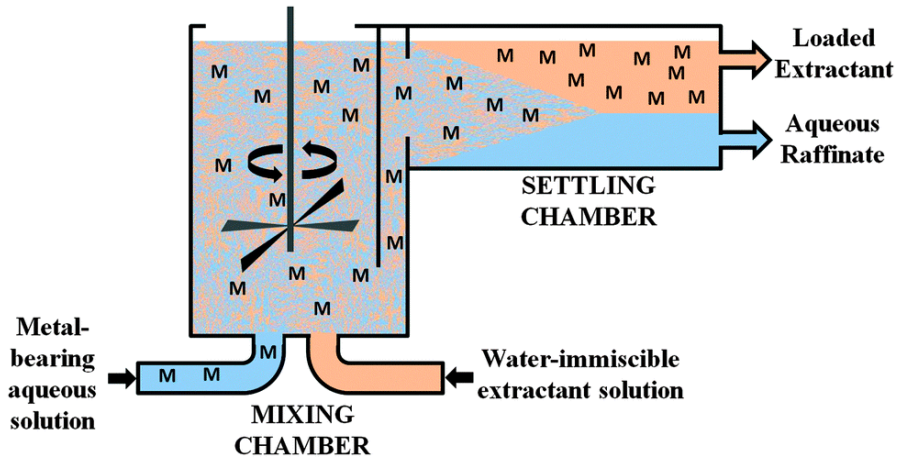
- US cannot use solvent extraction economically for REE refining.

Purdue Innovation

Conventional Refining vs Chromatography

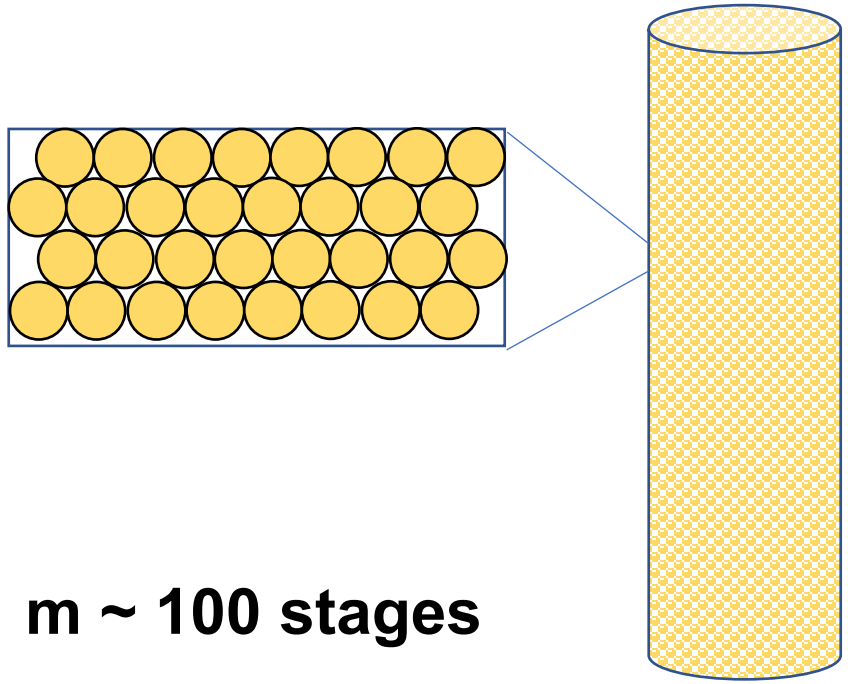
Chromatography: 500-1,000 m^2/g → a smaller separator volume

1 mixer-settler in solvent extraction



1 m ~ 1 stage

1 equilibrium stage in chromatography

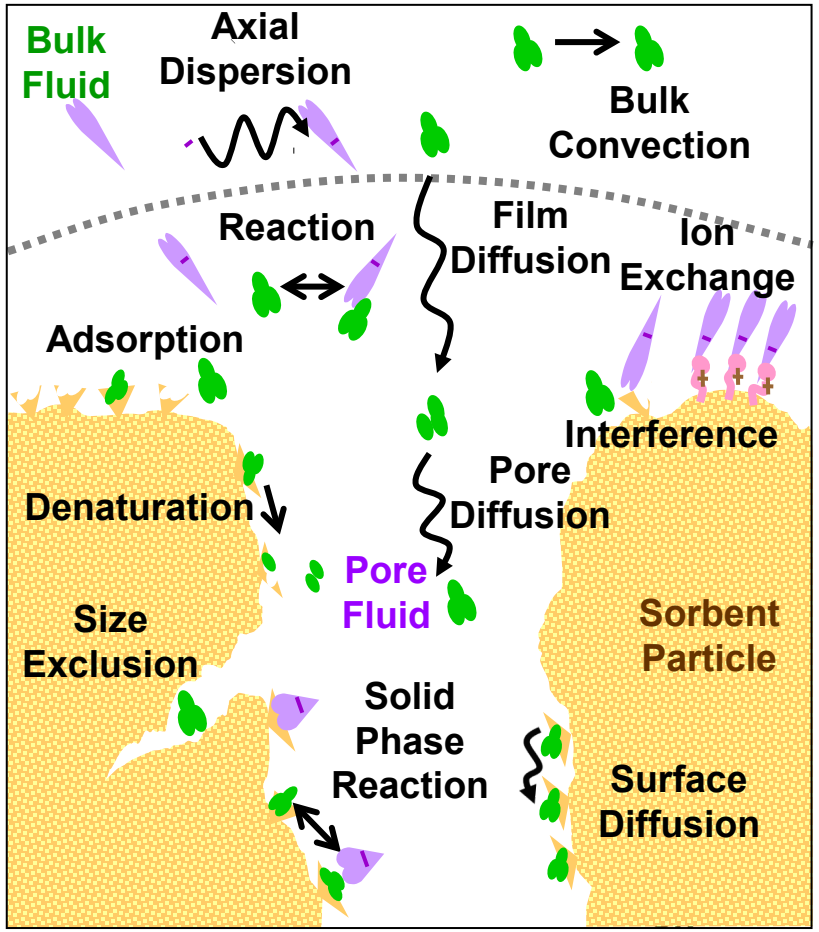


1 m ~ 100 stages

Purdue Chromatography Methods
Efficient and Scalable by Design

Standing Wave Design

18 factors
$3^{18} = 387 \times 10^6$



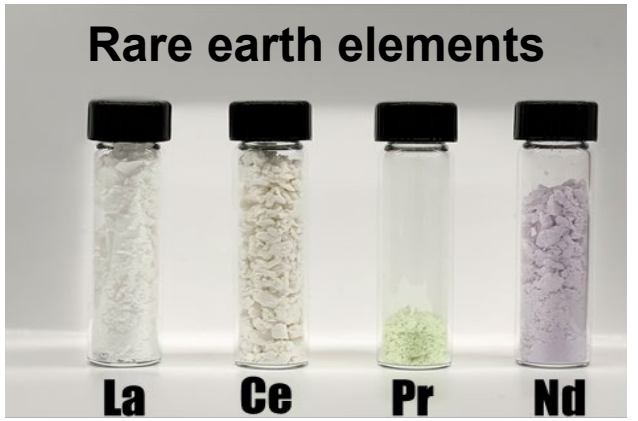
VErsatile
Reaction
SEparation
Simulation
Tool
(VERSE)
"Digital Process Twin"

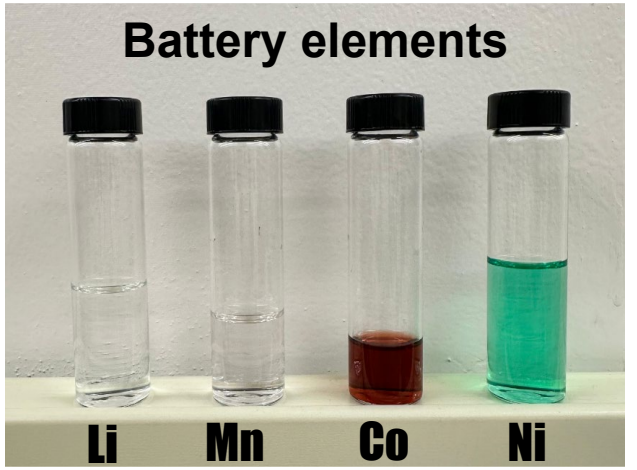
- SMB for fructose/glucose separation in 1998
- SMBs for insulin purification in 2003 & chiral drug separation in 2006

Purdue technology

Production of pure critical elements from ores and waste

Wang Research Lab

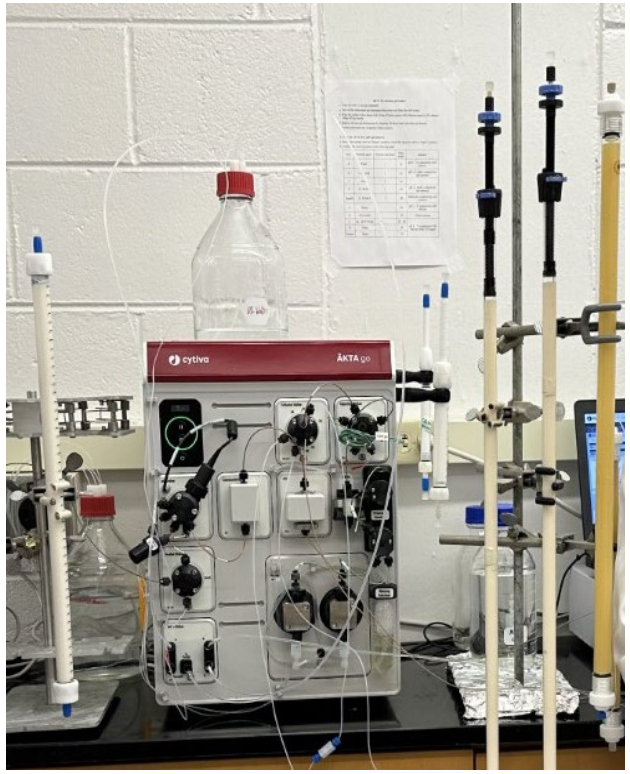




Scalability

Laboratory

Purdue



100 mL Column

1,500 X

Pilot

ReElement Pilot Plant
Noblesville, IN

150 L Column

200 X

Commercial

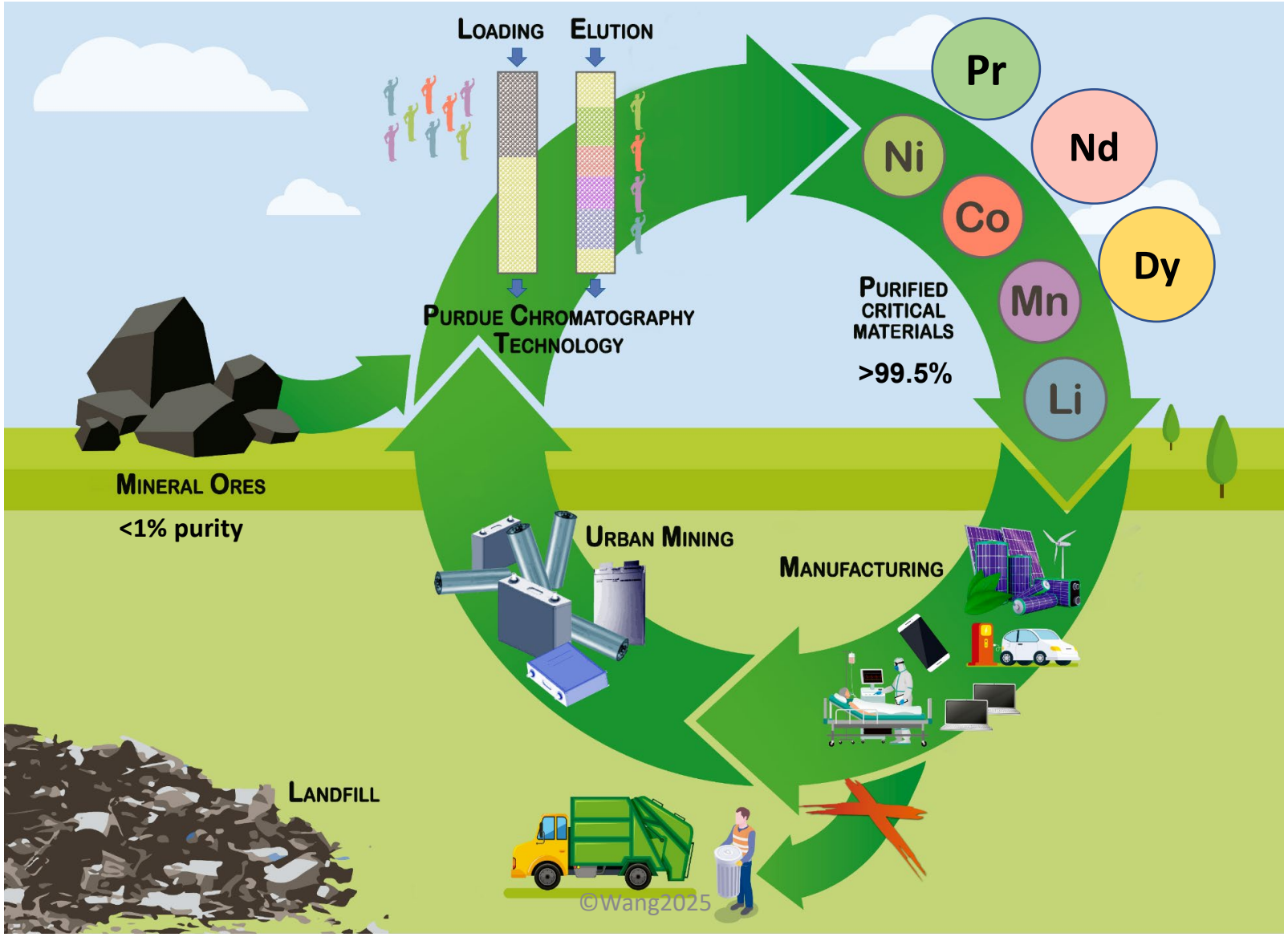
Marion Ad. Technology Center
Marion, IN

50 m^3 Column
1,000 tons REO/yr

Impact of Purdue Innovation

	Solvent Extraction	Purdue	Advantages
Safety	•Flammable solvents •Toxic extractants •Harsh chemicals	**•Aqueous solution •Dilute acid & base**	Safer
OPEX	1	**0.5**	Lower
Yield	88-90%	**>95%**	Higher
Productivity	1	**>10**	Higher
Environ. Footprints	1	**0.1**	Low environ. impact
Feedstocks and products	Specific	**Flexible**	More versatile
Separators	>1,000	**2**	Fewer
CAPEX	1	**0.1**	Lower
Waste	Acidic wastewater	**Almost zero waste**	Cleaner

Circular Economy for a Sustainable Clean Energy Future



Questions and Discussion