INEST

Institute for Nuclear Energy Science and Technology

Recovery of Precious Metals from Used Nuclear Fuel and Electronic Scrap using Sulfur-Impregnated Nanoscaffolds

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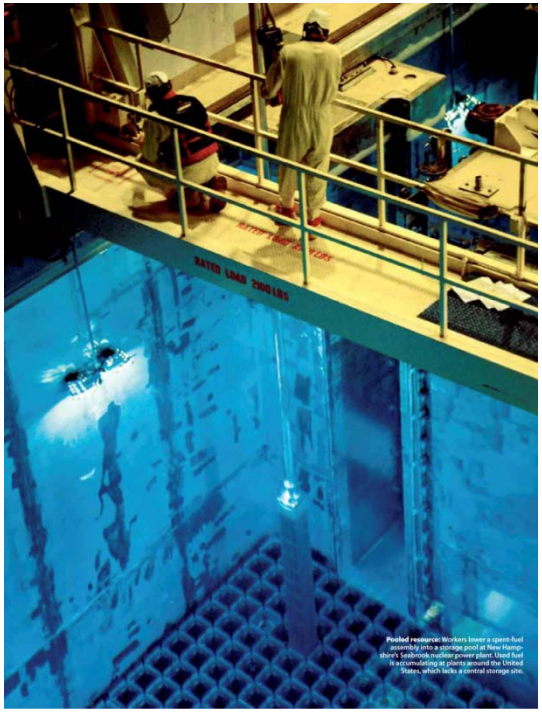
Outline

- Project premise
- Energy Critical Materials
- Research outline
- What are sulfur – impregnated nanoscaffolds?
- Preliminary results

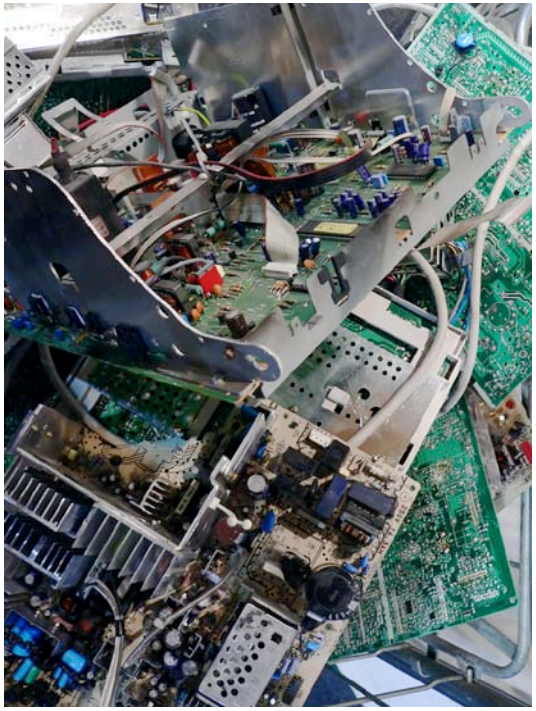
Building a bridge between advancements in material science and hydrometallurgical recovery of metals from extreme environments

- Used nuclear fuel

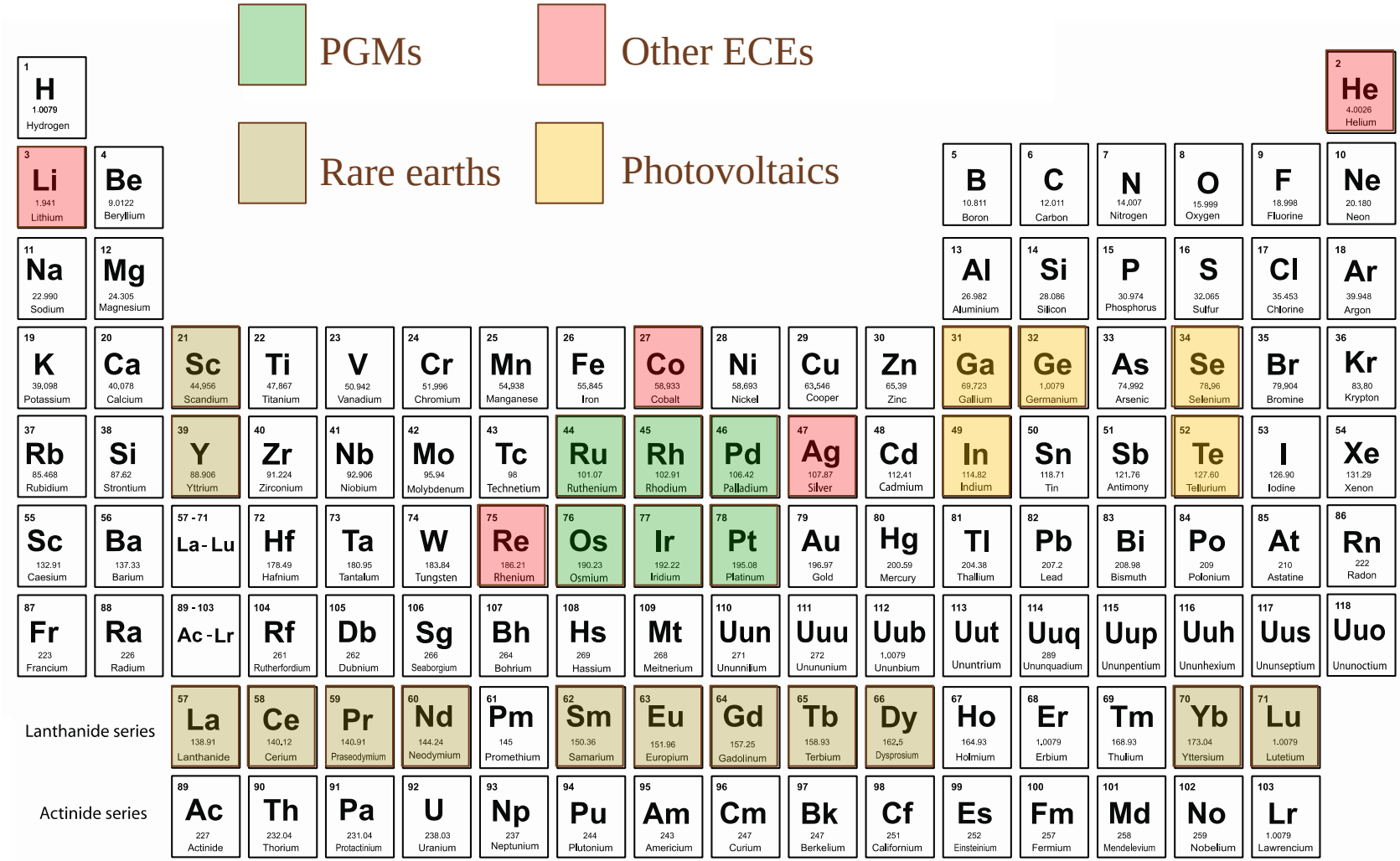


Pooled resource: Workers lower a spent-fuel assembly into a storage pool at New Hampshire's Seabrook nuclear power plant. Used fuel is accumulating at plants around the United States, which lacks a central storage site.

- Electronic scrap

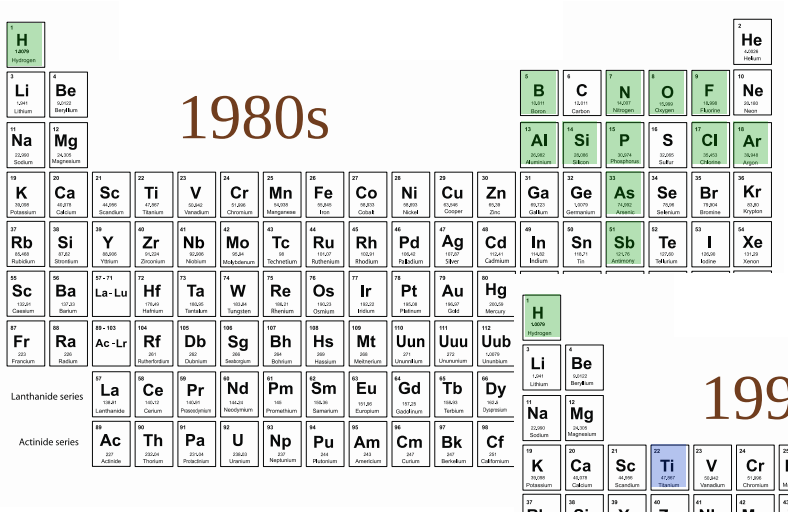


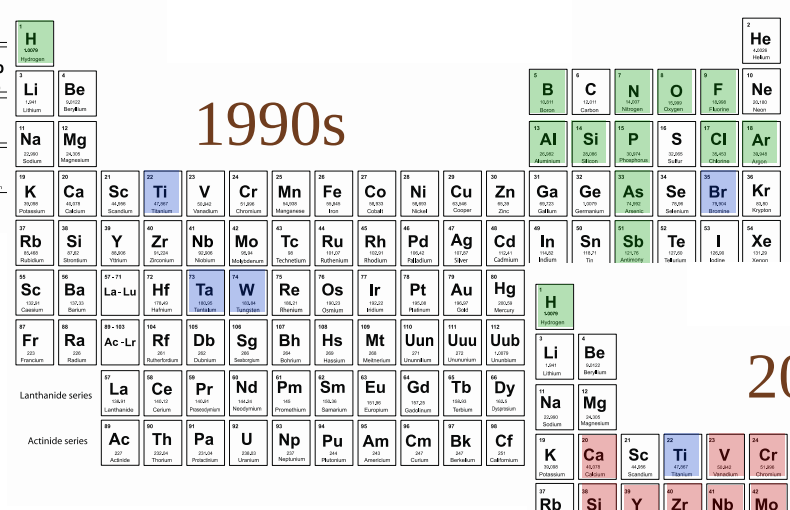
Energy critical elements

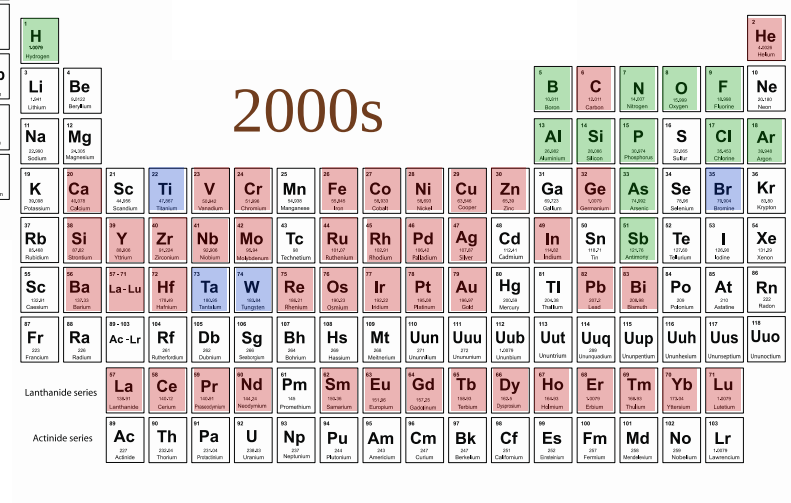


Source: Materials Research Society

Evolving diversity of used minerals



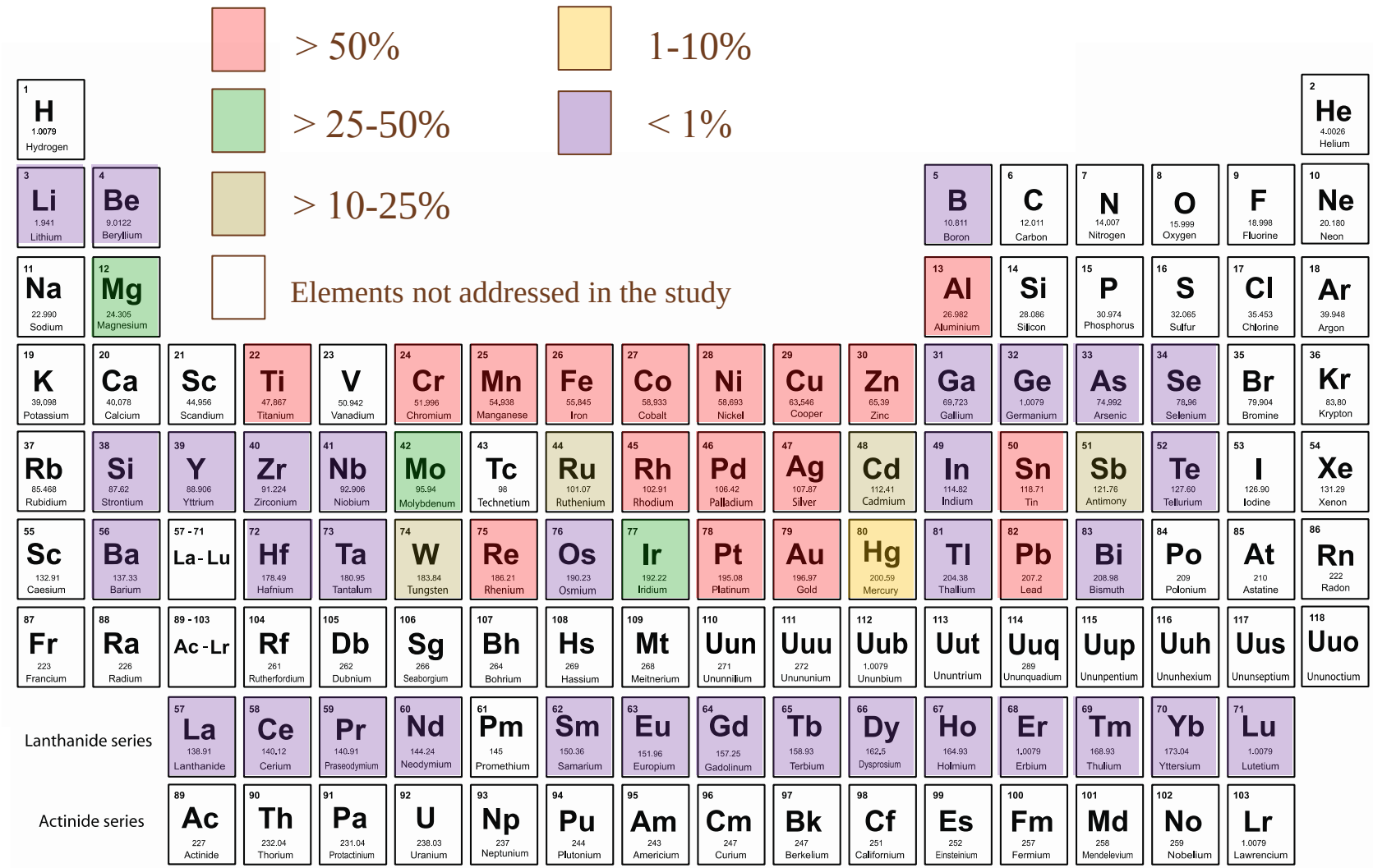




Elements involved in a two decade evolution of computer chip technology.

Source: Intel Corporation

Rates global post-consumer of recycling of metal resources



Source: UN Environment Program

A metric ton of the commercial light water reactor fuel (33 MWd/kg burn-up, 1 year cooling) contains approximately 1.3 kg of Pd and 0.5 kg of Rh.

A metric ton of used cell phones (~6000 units) contains roughly 1.4 kg of silver, 350 g of gold, 210 g of palladium and 130 kg of copper.

In perspective, a metric ton of an average gold ore affords 0.9 g of this precious material, which is more abundant than any element in the platinoid family.

Evaluating metal ion sorption properties for functionalized mesoporous carbons

Material science

SBA-15, CMK-3

Solution chemistry

Fundamental phase

- mechanism of solid/liquid adsorption
- modeling of sorption isotherms
- thermochemistry of adsorption
- hardness parameter correlations
- sorption competition studies

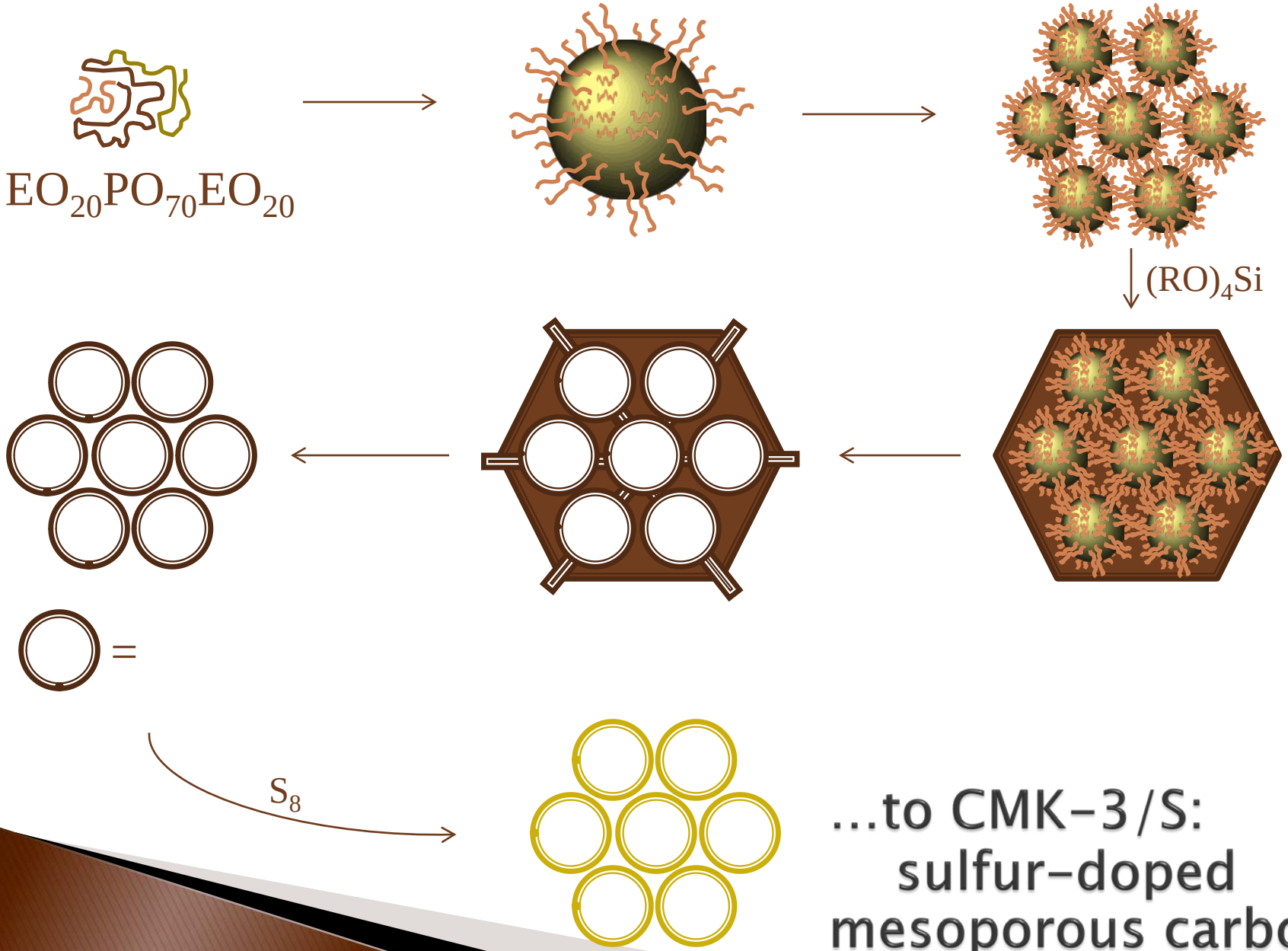
Applied phase

- extraction of Pt, Rh, Ag from simulated Purex raffinate
- recovery of metals from leached circuit boards
- engineered supports
- hydrolytic and radiolytic stability

Exploratory phase

- there are 60 economically important metals
- further application in nuclear nuclear fuel cycle

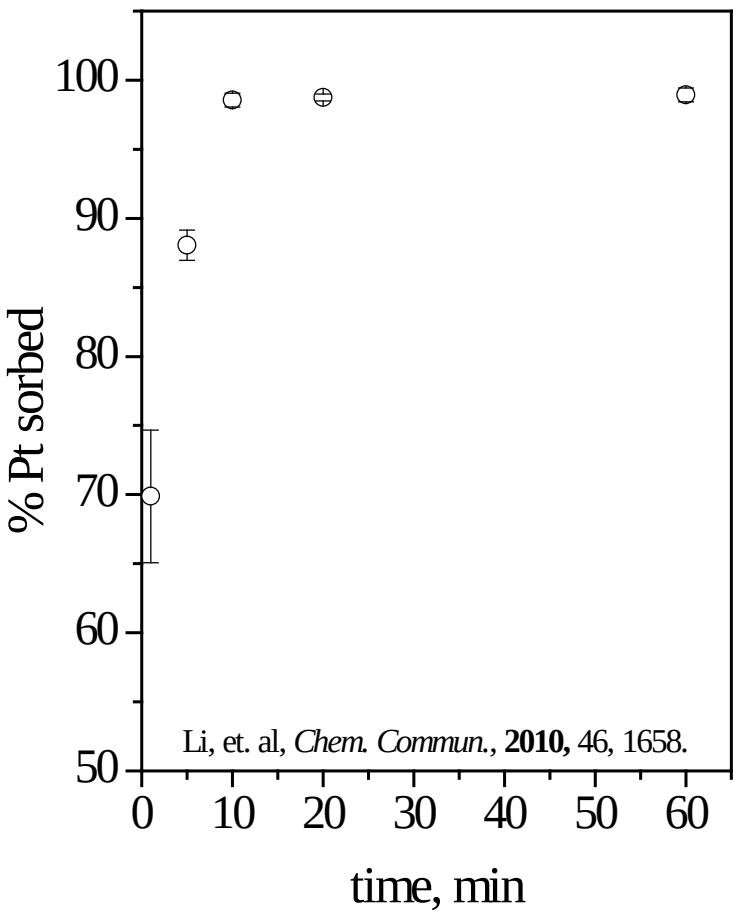
From polymeric surfactants….



…to CMK-3/S: sulfur-doped mesoporous carbon

Platinum sorption

- 10 mg CMK-3/S (10% S content) was dispersed in 100 mL of 5 mg/L Pt, pH 4, Cl^- media
- Loading capacity = 150 mg Pt / g CMK-3/S
- Thiol – SAMMS = 635 mg Hg / g sorbent
- 33% loading at end of experiment
- Matches up with 2:1 Pt:S mole ratio



Progress report

- 5 g of CMK-3/S synthesized at U. of Waterloo and shipped to INL
- Ag sorption isotherm pending ICPMS
- Pt sorption kinetics pending ICPMS
- Cd-109 traced isotherm shows no interaction with CMK-3/S
- UREX-type raffinate simulant solutions have been prepared
- PC circuit boards procured, obsolete cell phones at INL are re-directed for the project purposes
- Working on the implementation of appropriate work control

Thank you.