

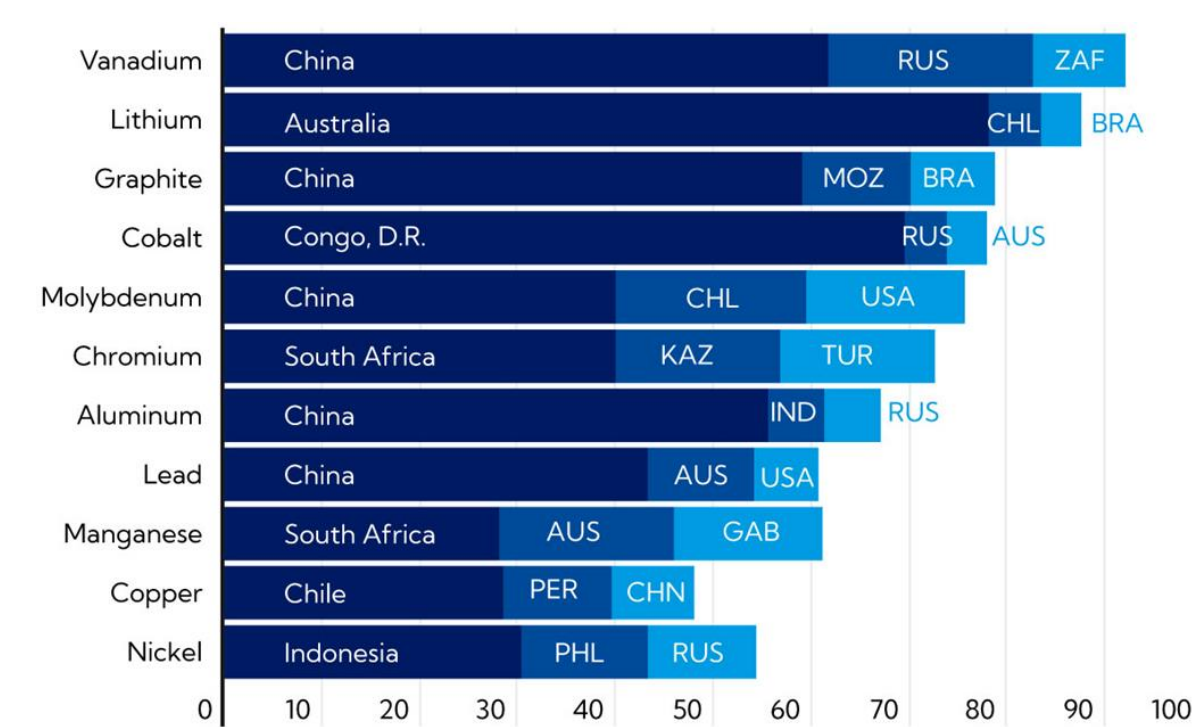
## Materials and Sensing Platforms for Luminescence-Based Sensing of Economically Critical Metals

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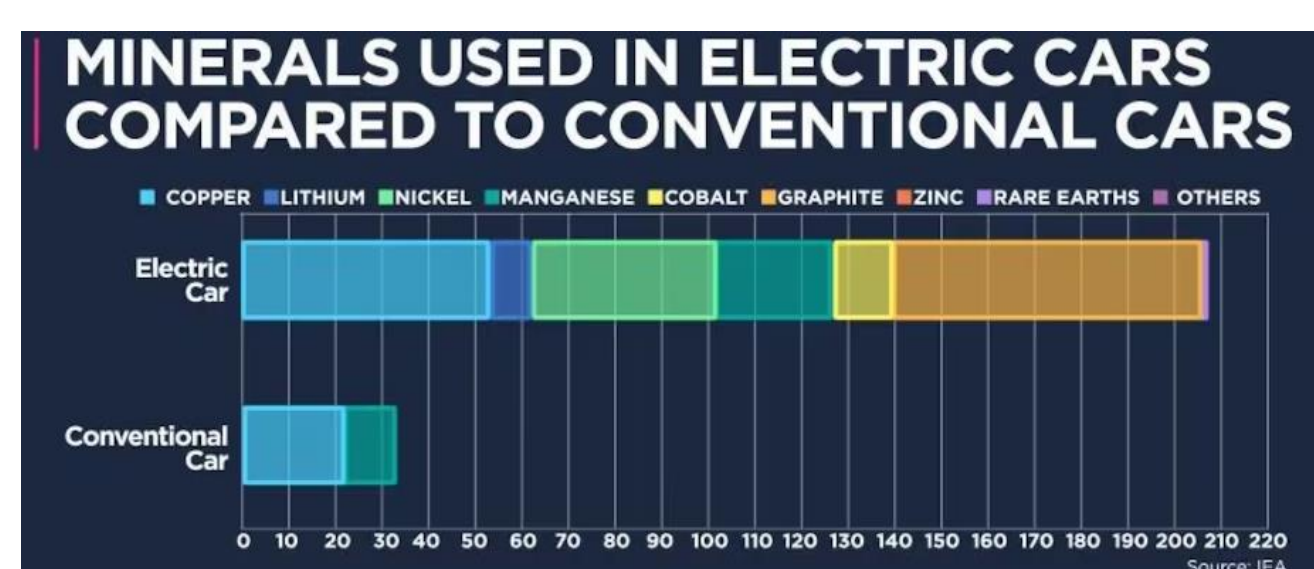
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### Critical Metals are Essential to Emerging Energy Technologies

Emerging technologies within the energy sector are creating significant increases in demand for the metals that power these technologies. In many cases, global production of these metals is controlled by a handful of countries, creating significant domestic supply chain vulnerabilities. This has spurred massive efforts to develop a robust domestic supply of these economically critical metals, both from conventional sources such as mining as well as unconventional sources such as coal waste. Slow and expensive characterization costs for metals are a critical barrier for domestic metals production. We relieve this pain point by developing low-cost, portable optical sensors for rapid metals analysis during prospecting and processing.



Sources: US Geological Survey - Mineral Commodity Summaries 2021; IMF staff calculations.

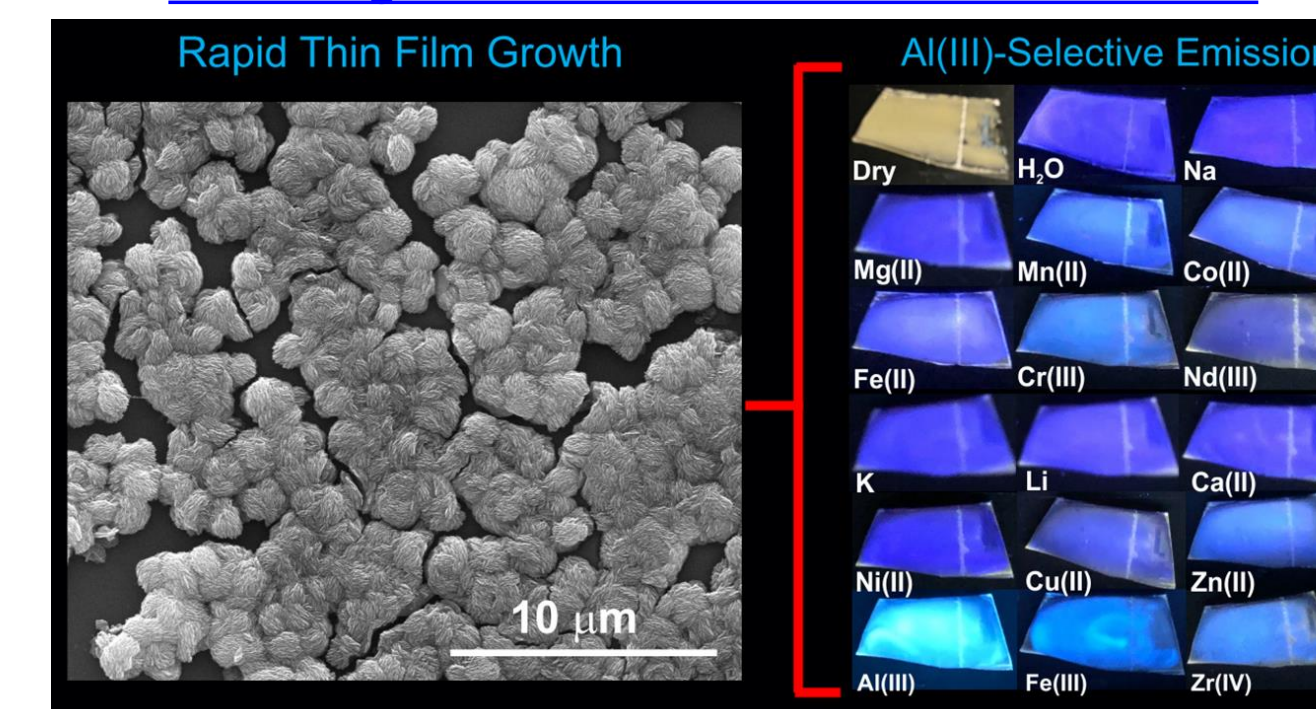


https://www.cheddar.com/media/evs-gobble-up-rare-earth-minerals-as-miners-struggle-to-keep-up/

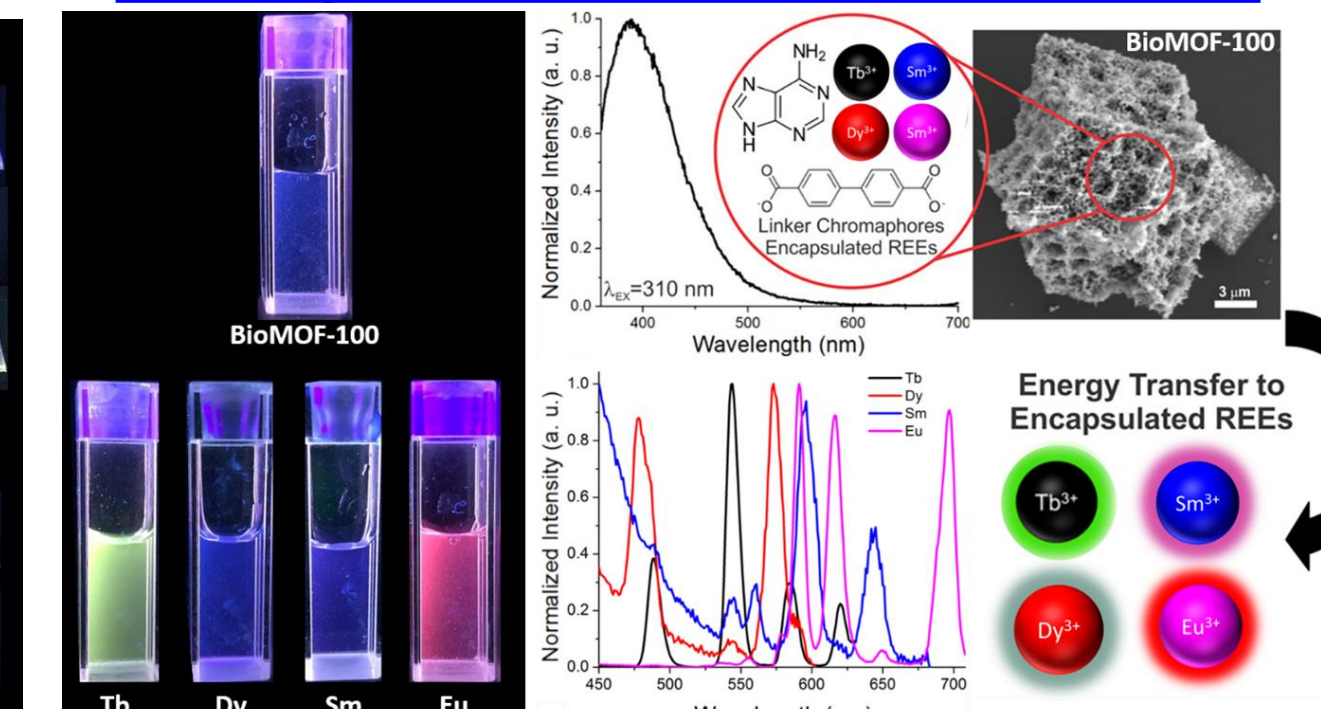
### Development of Luminescent, Responsive Sensor Materials

The detection of trace quantities of target metals in complex environments such as mining process streams or acid mine drainage poses a multitude of challenges, from low pH levels to high concentrations of potentially interfering non-target metals. *Overcoming these challenges requires the development of advanced materials that are not only very sensitive, but also highly selective.* Moreover, the sensing material must be able to operate in acidic conditions for practical deployment.

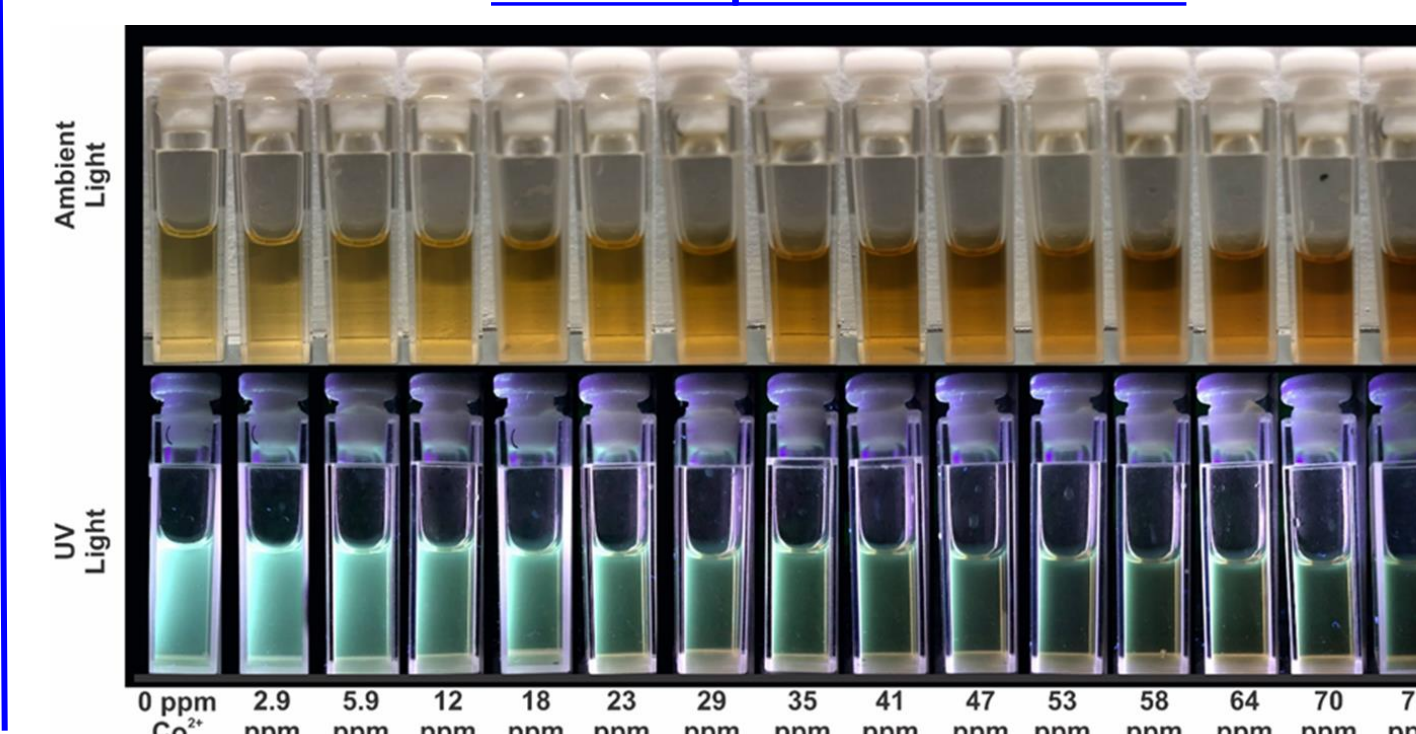
#### Metal-Organic Framework Film Aluminum Sensor



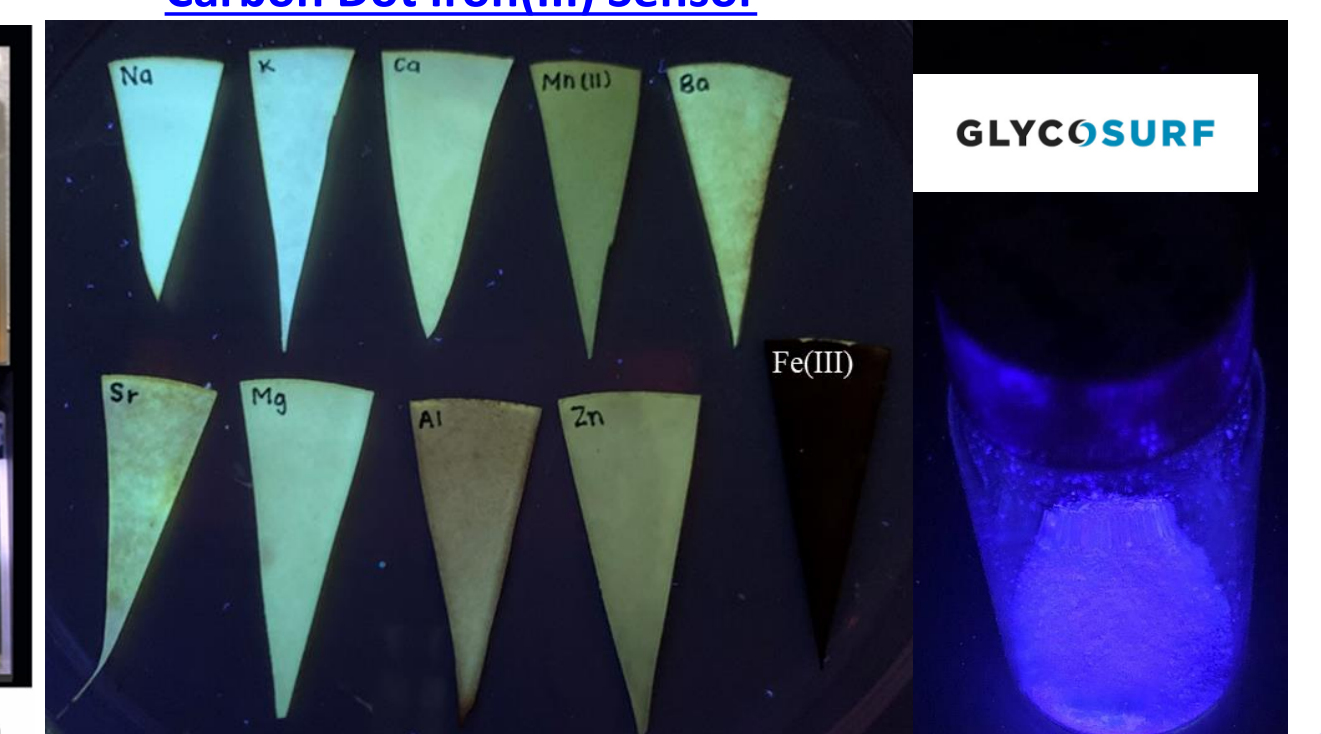
#### Metal-Organic Framework Sensitizer for Rare Earths



#### Cobalt-Responsive Carbon Dots

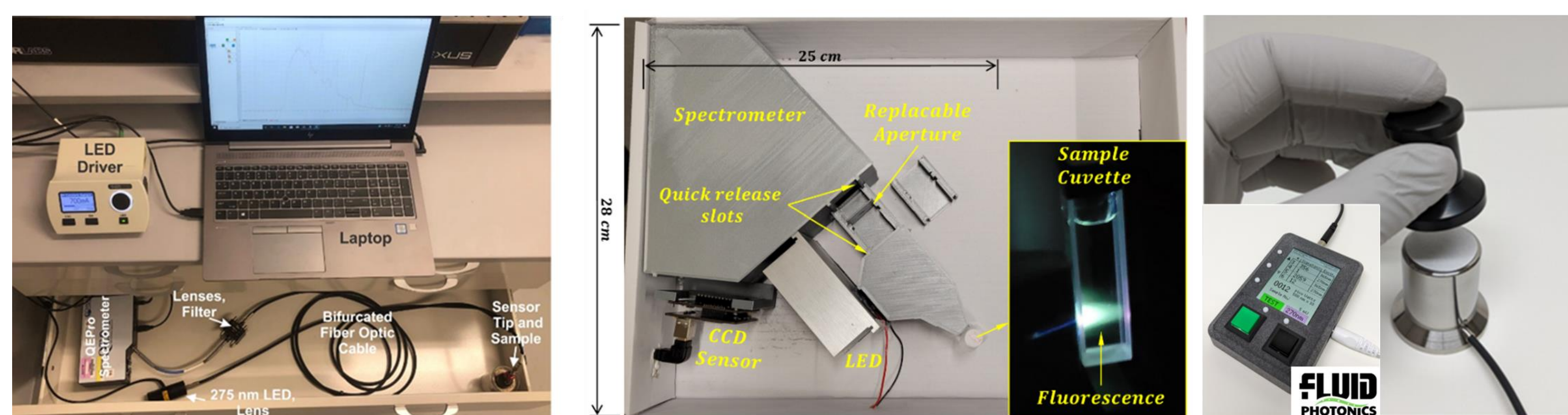


#### Carbon Dot Iron(III) Sensor



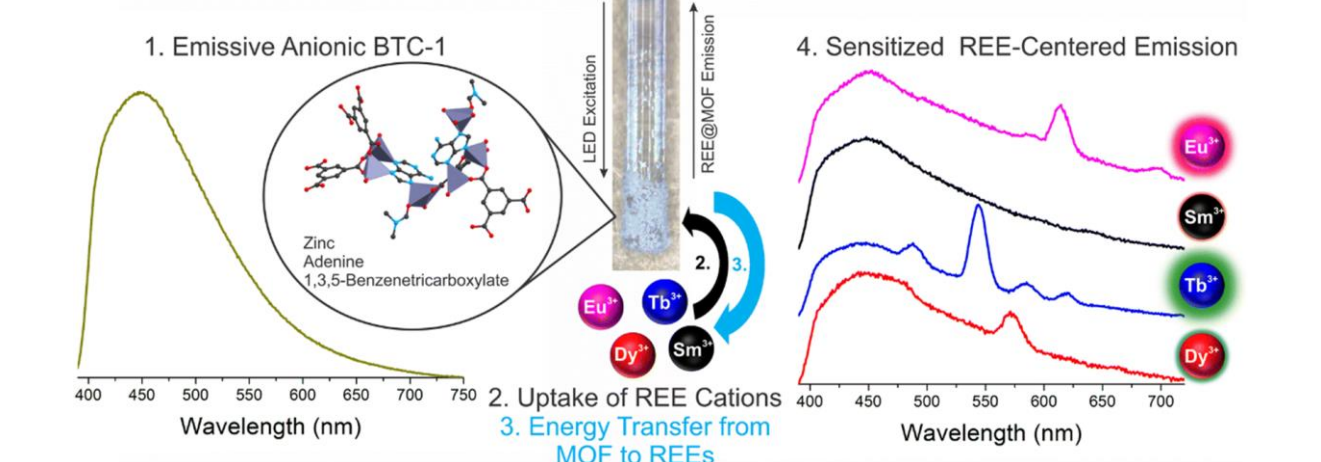
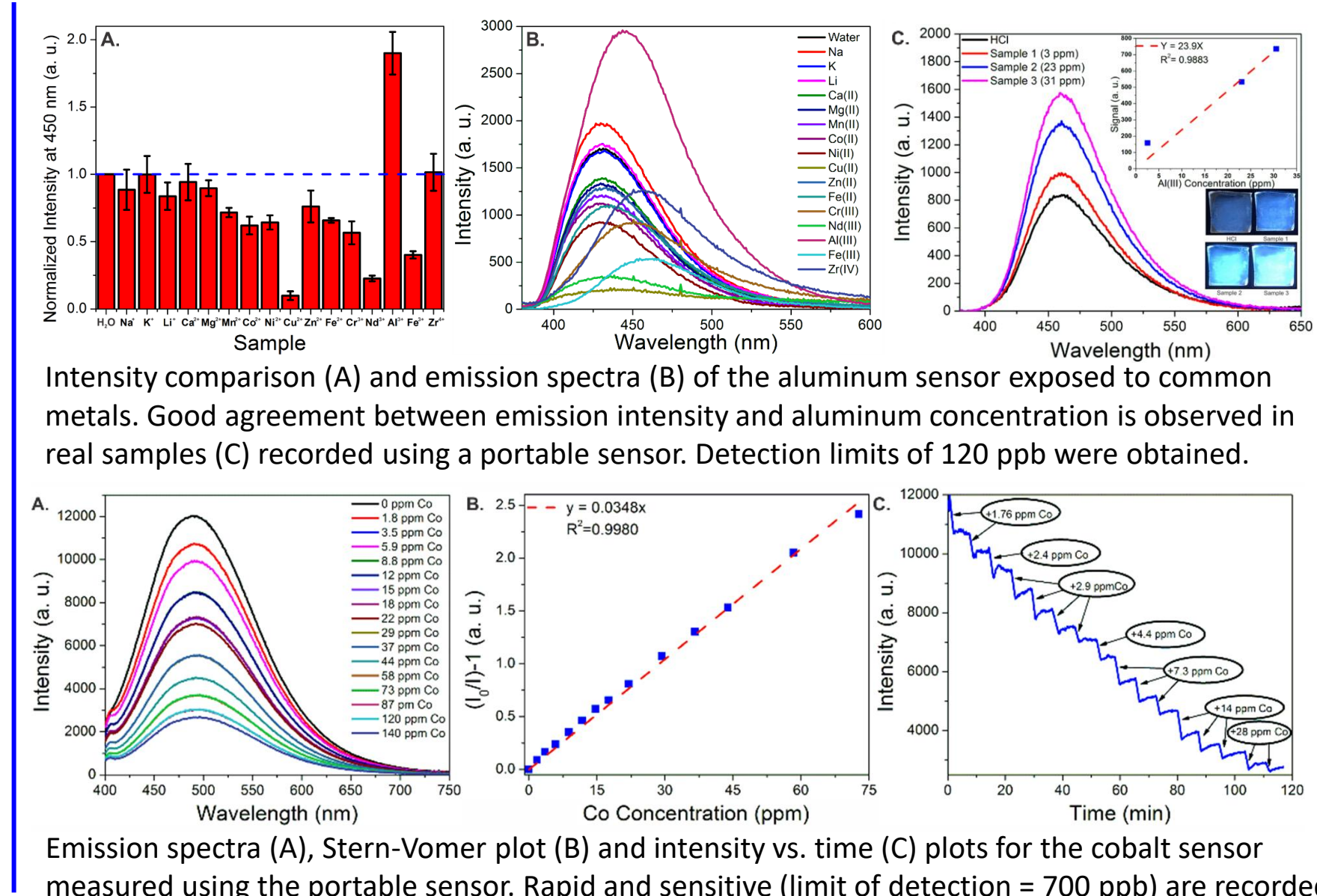
### Development of Compact, Low-Cost Sensor Platforms

Through both external collaborations and in-house development, we have produced a versatile suite of portable, low-cost sensor devices for analysis of liquid and test strip samples. These devices typically exhibit *similar performance to commercial systems at a significantly lower cost.*



With sensing materials and platforms in hand, key performance figures of merit including sensitivity and selectivity are evaluated in environmentally-relevant matrices. Detection limits within the part-per-billion range are detected.

### Detection of Trace Critical Mineral Concentrations



REE Sensitized	Limit of Detection (ppb)	Limit of Quantification (ppb)
Tb	5.7 ± 0.6	18 ± 2
Dy	170 ± 10	550 ± 30
Sm	184 ± 6	600 ± 100
Eu	18 ± 4	60 ± 10
Yb	260 ± 6	900 ± 20
Nd	100 ± 2	340 ± 7

Top: MOF immobilized on an optical fiber for enhanced rare earth detection. Bottom: limits of detection and quantification for the rare earths.