New separation process can efficiently mine rare earth metal europium from electronic waste

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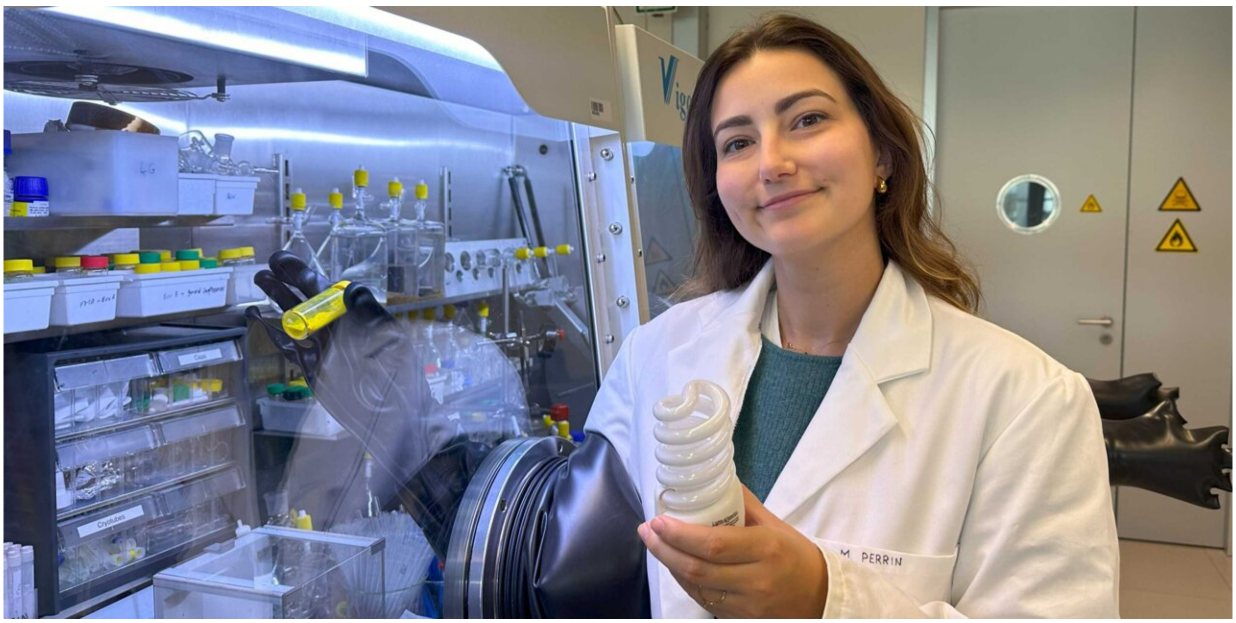


ETH doctoral student Marie Perrin presents the new recycling approach. In her left hand, she is holding the raw material in the form of a fluorescent lamp and, in her right, the yellow reagent that can separate rare earth metals. Credit: Fabio Masero / ETH Zurich

Rare earth metals are not as rare as their name suggests. However, they are indispensable for the modern economy. After all, these 17 metals are essential raw materials for digitalization and the energy transition.

They are found in smartphones, computers, screens and batteries—without them, no electric motor would run and no wind turbine would turn. Because Europe is almost entirely dependent on imports from China, these raw materials are considered to be critical.

However, rare earth metals are also critical because of their extraction. They always occur in compound form in natural ores—but as these elements are chemically very similar, they are difficult to separate.

Traditional separation processes are therefore very chemical- and energy-intensive and require several extraction steps. This makes the extraction and purification of these metals expensive, resource- and time-consuming and extremely harmful to the environment.

"Rare earth metals are hardly ever recycled in Europe," says Victor Mougel, Professor at the Laboratory of Inorganic Chemistry at ETH Zurich. A team of researchers led by Mougel wants to change this. "There is an urgent need for sustainable and uncomplicated methods for separating and recovering these strategic raw materials from various sources," says the chemist.

In a study published in *Nature Communications*, the team presents a surprisingly simple method for efficiently separating and recovering the rare earth metal europium from complex mixtures including other rare earth metals.

Inspired by nature

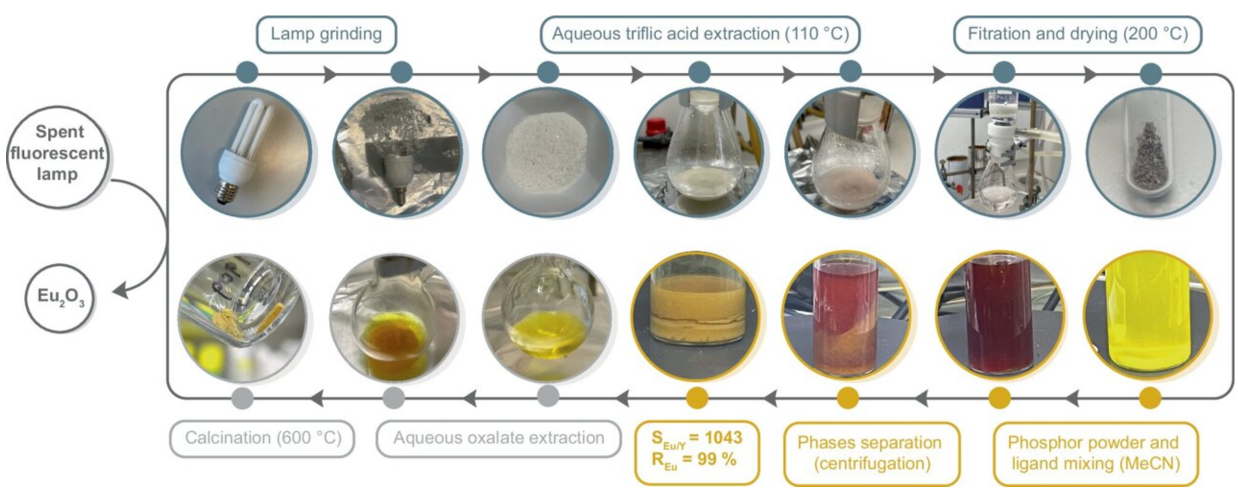
Marie Perrin, a doctoral student in Mougel's group and first author of the study, explains, "Existing separation methods are based on hundreds of liquid-liquid extraction steps and are inefficient—the recycling of europium has so far been impractical."

In their study, they show how a simple inorganic reagent can significantly improve separation. "This allows us to obtain europium in a few simple steps—and in quantities that are at least 50 times higher than with previous separation methods," says Perrin.

The key to this technique can be found in small inorganic molecules featuring four sulfur atoms around tungsten or molybdenum: tetrathiometallates. The researchers were inspired by the world of proteins. Tetrathiometallates are found as a binding site for metals in natural enzymes and are used as active substances against cancer and copper metabolism disorders.

For the first time, tetrathiometallates are now also being used as ligands for the separation of rare earth metals. Their unique redox properties come into play here, reducing europium to its unusual divalent state and thus simplifying separation from the other trivalent rare earth metals.

"The principle is so efficient and robust that we can apply it directly to used fluorescent lamps without the usual pre-treatment steps," says Mougel.



Illustrated circular process for europium recovery from a spent compact fluorescent lamp according to the process described in the present work. Credit: *Nature Communications* (2024). DOI: 10.1038/s41467-024-48733-z

Keeping europium in circulation

Electronic waste is an important but as yet underutilized source of rare earth metals. "If this source were tapped into, the lamp waste that Switzerland currently sends abroad to be disposed of in a landfill could be recycled here in Switzerland instead," says Mougels. In this way, lamp waste could serve as an urban mine for europium and make Switzerland less dependent on imports.

In the past, europium was mainly used as phosphor in fluorescent lamps and flat screens, which led to high market prices. As fluorescent lamps are now gradually being phased out, demand has fallen, so that the previous recycling methods for europium are no longer economically viable. More efficient separation strategies are nevertheless desirable and could help to utilize the vast quantities of cheap fluorescent lamp waste whose rare earth metal content is around 17 times higher than in natural ores.

Reduce demand

This makes it all the more urgent to recover rare metals at the end of a product's life and keep them in circulation—but the recovery rate of rare earth elements in the EU is still below one percent.

In principle, any separation process for rare earth metals can be used both for extraction from ore and for recovery from waste. With their method, however, the researchers are deliberately focusing on recycling the raw materials, as this makes much more ecological and economic sense.

"Our recycling approach is significantly more environmentally friendly than all conventional methods for extracting rare earth metals from mineral ores," says Mougel.

The researchers have patented their technology and are in the process of founding a start-up called REEcover to commercialize it in the future. They are currently working on adapting the separation process for other rare earth metals such as neodymium and dysprosium, which are found in magnets.

If this is successful, Marie Perrin wants to build up the start-up after her doctorate and establish the recycling of rare earth metals in practice.

More information: Marie A. Perrin et al, Recovery of europium from E-waste using redox active tetrathiotungstate ligands, *Nature Communications* (2024). DOI: 10.1038/s41467-024-48733-z

Provided by ETH Zurich