Extraction of precious metals from electronic waste by using supercritical fluid technology

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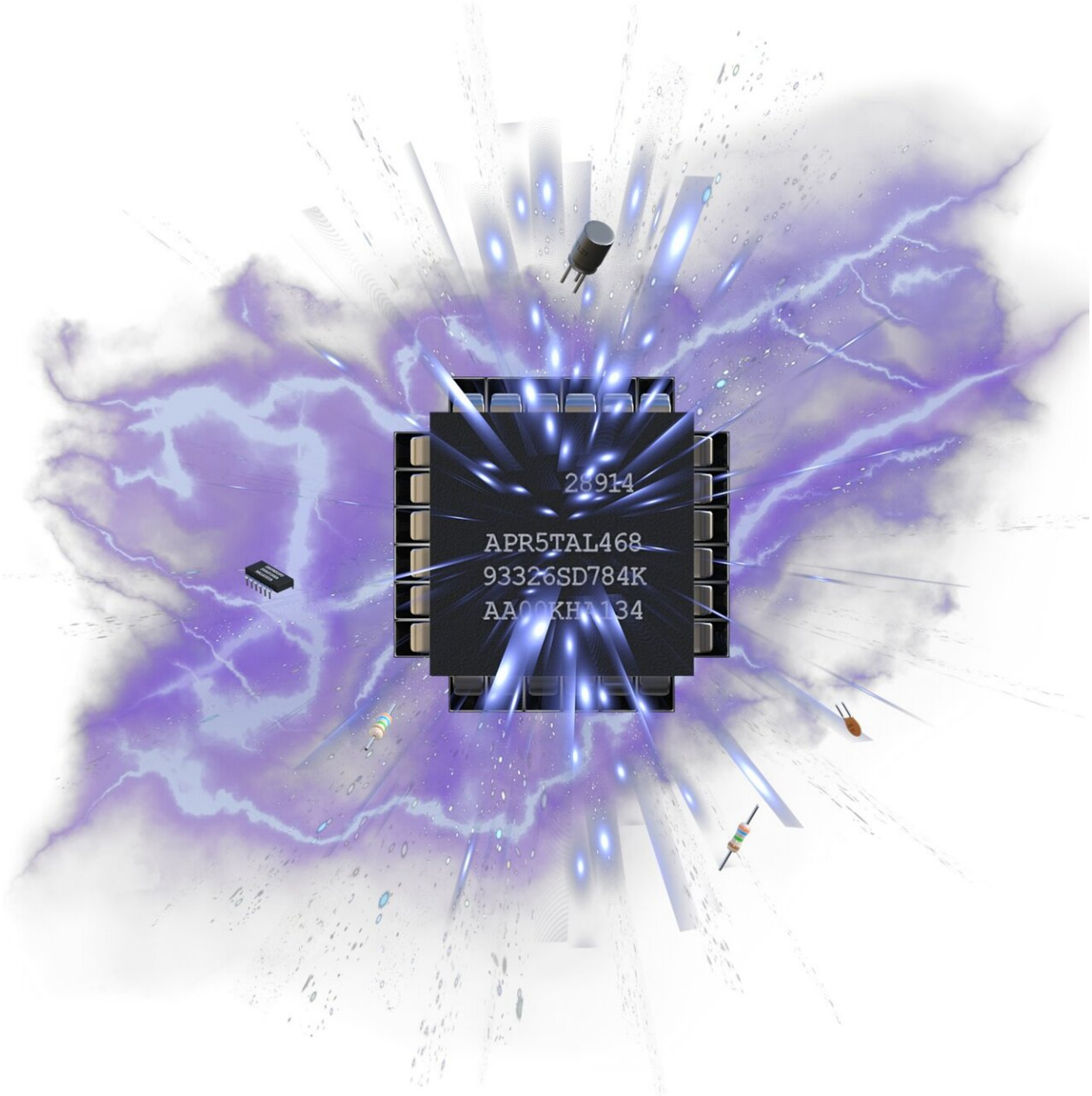
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The modern world relies on a small number of precious and rare metals that are vital for the components of our electronic devices. These elements are critical to the functioning of everything from mobile phones and tablet computers to the circuitry that underpins medical scanners and military installations. The design of current technology means they cannot be substituted with another metal, each component relies on the very specific electronic properties of each in the components from which it is built.

Unfortunately, access to sources of these elements is not only limited by geology and politics, but the rarest of the metals, which are often the ones on which we rely the most are present on earth in only limited quantities. As such, every electronic device that is discarded or abandoned represents metals wasted. If there were a simple and environmentally viable means to extract those metals so that they could be reused in the next tranche of devices, then at least some of the issues of accessibility and waste might be addressed.

At this point we must turn to the pre-electronic age and the discovery of a scientific phenomenon that could come to our rescue in the modern age—supercriticality. Supercriticality is a physical characteristic of substances that are heated while being compressed and give rise to properties in the substance that are very different from the substance under normal conditions. For instance, if we heat liquid water above its boiling point the liquid is converted into gas, steam, and this evaporates into the atmosphere.

However, seal the liquid water in a high-pressure vessel and heat it above its boiling point and the water vapor cannot escape. Indeed, the liquid cannot even undergo the transition from liquid to gas if the pressure is high enough. It becomes a supercritical fluid (SCF). As such, SCFs are fluids above their boiling point that remain liquid, they are liquids with more thermal energy than the gas, but neither true liquid nor gas. The nineteenth century scientists who first worked with SCFs recognized that these fluids had properties that allowed them to dissolve other substances that are not normally soluble in the liquid whether that was water or an organic solvent.

Water, organic solvents, even carbon dioxide can form SCFs if the temperature and pressure they are exposed to render them above the supercritical point. An important point about SCFs, however, is that if the pressure is released the substance will quickly convert to gas and evaporate from the now-open pressure vessel. This characteristic has led to numerous applications for SCFs where they can be used to dissolve seemingly intractable substances, which can then be separated from whatever else they might be bound to, the SCF pressure is released, the fluid evaporates, and the separated substance is left behind.

Writing in the *International Journal of Environment and Waste Management,* a team from Iran have shown how SCFs can be used to dissolve metals in electronic components and so separate those metals from the plastics and other materials of the circuitry. Different metals present can be dissolved in different SCFs and so extracted efficiently in what might be considered an environmentally benign way without recourse to toxic and corrosive solvents and acids. Additionally, the vented SCF can be easily trapped by additional equipment so that the fluid itself, now entirely free of any dissolved component, can be re-used. This would apply to water, organic solvents, or carbon dioxide used as SCFs in extracting metals from electronic waste.

Seyed Mohammad Fayaz, Mohammad Ali Abdoli, Majid Baghdadi, and Abdolreza Karbassi of the University of Tehran, point out that the primary aim of SCFs in this context might simply be to remove harmful metals from a waste stream containing electronic devices and components. However, the additional benefit is so obviously the possibility of recovering those metals for re-use in industry.

Where electronics have not been processed in any way before and simply dumped or buried in landfill, those sites might now represent a rich seam that could be "mined" and processed using SCFs. There are vast quantities of rare and precious metals locked up in waste sites that could one day be tapped and allow manufacturers of the electronics on which depend so much to access the metals they need without having to surmount geopolitical barriers.

More information: Seyed Mohammad Fayaz et al, Extraction of precious metals from electronic waste by using supercritical fluid technology, *International Journal of Environment and Waste Management* (2022). DOI: 10.1504/IJEWM.2022.120623

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