National Aeronautics and Space Administration

NASA

TECHNOLOGY SOLUTION

Environment

Completely biodegradable filtration system for waste metal recovery from aqueous solution

Functionalizing biological substrates with bioengineered peptides to bind targeted molecules

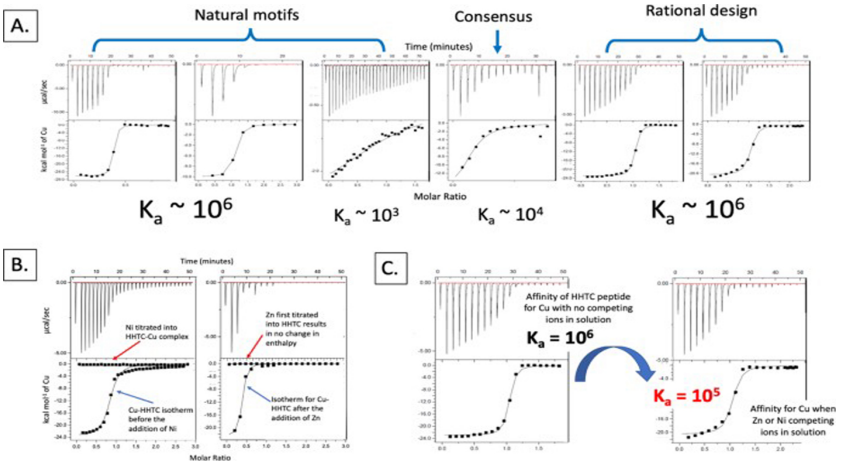
Rapid socio-economic development and technological advancement has made the hazardous chemical components of end-of-life electronics waste (e-waste) an imminent challenge. Conventional extraction methods rely on energy-intensive processes and are inefficient when applied to recycling e-waste or waste streams that contain mixed materials and small amounts of metals. NASA Ames Research Center has developed an inexpensive biological approach to removing or adsorbing a target substance or material, for example a metal, non-metal toxin, dye, or small molecule drug, from solution. Using a substrate such as fungal mycelium or chitin, with a peptide, the target substance is isolated and removed or recovered. This approach has a variety of useful applications, from cleaning water sources or recovering chemicals from aqueous solutions to minimize waste.

BENEFITS

- Cost-effective - Non-toxic way to recover metals and other materials in aqueous solution. The substrate, such as fungal mycelium, is extremely inexpensive to produce
- Scalable - Benefits of using mycelium material, as compared to flagella-based or cellulose filtration tools, is that it leverages the concept of economies of scale, and presents an entirely feasible option of scale-up of this technology
- Target-binding is selective when the target-binding domain exhibits a higher binding affinity for one target species than for a structurally or chemically related target species
- Can be employed to form mycelium into a variety for shapes and structures for use as substrates
- Disposal is non-toxic to the environment and could include decontamination with heating and or release of any toxic bound substances and use as a fertilizer or even building material

THE TECHNOLOGY

There is a significant need for an inexpensive biological approach to recover specific, targeted metals and other target materials in e-waste or other aqueous solutions that requires minimal input of resources, including energy. This invention is a method of removing or adsorbing a target substance or material, for example, a metal, non-metal toxin, dye, or small molecule drug, from solution, by functionalizing a substrate with a peptide configured to selectively bind to the target substance or material and to bind to the substrate. The substrate is fungal mycelium, and the naturally-occurring or bioengineered peptide is called a target-binding domain, which is chemically bonded to a selected solid substrate. The target chemical species binds to the target-binding domain and is removed from solution. The target can be any chemical species dissolved or suspended in the solution. Capture of the target by the substrate can isolate and allow removal of the target substance from solution, or for utilization in water filtration, or recovery of targeted chemical species from solution, particularly aqueous solution applications. The peptides used include (i) fusion peptides and/or proteins containing metal-binding domain sequence and optionally containing substrate-binding domain sequence; (ii) fusion peptides/proteins containing a metal-binding domain and a chitin-binding domain; and (iii) nucleic acids encoding fusion peptides and/or proteins containing metal-binding domain sequence. The technology enables simple scale up to a level that could be successfully implemented in an environment with limited resources, such as on a space mission or on earth in developing countries with poor access to clean water.



(A) Raw data and isotherms for tested peptides and Cu. (B) In this experiment, Cu was first titrated into HHTC and an isotherm was calculated based on changes in enthalpy. (C) Raw data and isotherm showing binding affinity of HHTC for Cu in the absence and presence of the competing ion, Zn.

APPLICATIONS

The technology has several potential applications:

- Water filtration applications and removal of other impurities from water including but not limited to antibodies, dyes, and other chemicals that can be directly or indirectly bound to a peptide domain
- Bioremediation and biomining applications in terrestrial and extra-terrestrial environments
- Electronics/computer industry
- Aerospace industry - Aircraft waste
- Mine tailings and industrial wastewater
- Development of chitin biosensors, conjugation with fluorophores
- Metal recovery: Removal of metals, for example, from wastewater, mine tailings and primary metal deposits on or off planet (e.g., asteroids, lunar and Martian materials)

PUBLICATIONS

Patent Pending

https://www.nature.com/articles/s41598-019-52778-2

technology.nasa.gov

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More Information

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Agency Licensing Concierge

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