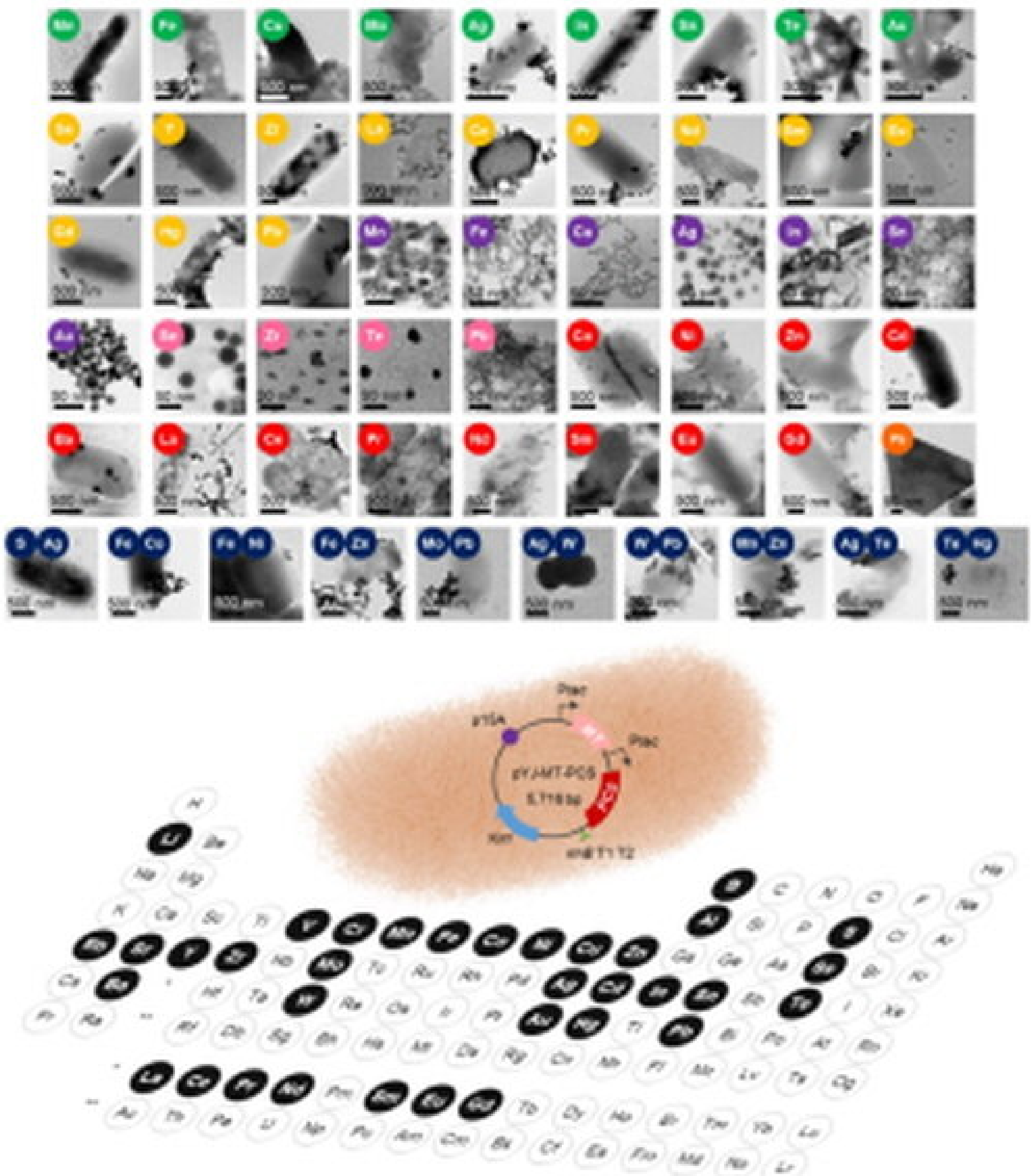
Recombinant E. coli as a biofactory for the biosynthesis of diverse nanomaterials

May 24 2018



The biosynthesis of diverse nanomaterials using recombinant *E. coli*. This schematic diagram shows the overall conceptualization of the biosynthesis of various single and multi-element nanomaterials using recombinant *E. coli* under incubation with corresponding elemental precursors. The 35 elements that were tested to biosynthesize nanomaterials are shown in black circles on the periodic table. Credit: KAIST

A metabolic research group at KAIST and Chung-Ang University in Korea has developed a recombinant E. coli strain that biosynthesizes 60 nanomaterials covering 35 elements on the periodic table. Among the elements, the team could biosynthesize 33 novel nanomaterials for the first time, advancing the design of nanomaterials through the biosynthesis of single and multiple elements.

The study analyzed the nanomaterial biosynthesis conditions using a Pourbaix diagram to predict the producibility and crystallinity. Researchers studied a Pourbaix diagram to predict the stable chemical species of each element for nanomaterial biosynthesis at varying levels of reduction potential (Eh) and pH. Based on the Pourbaix diagram analyses, the initial pH of the reaction was changed from 6.5 to 7.5, resulting in the biosynthesis of multiple crystalline nanomaterials that were previously amorphous or not synthesized.

This strategy was extended to biosynthesize multi-element nanomaterials. Various single- and multiple-element nanomaterials biosynthesized in this research can potentially serve as new and novel nanomaterials for industrial applications such as catalysts, chemical sensors, biosensors, bioimaging, drug delivery, and cancer therapy.

This study, titled "Recombinant Escherichia coli as a biofactory for various single- and multi-element nanomaterials," was published online in the *Proceedings of the National Academy of Sciences* (*PNAS*) on May

21.

A recent successful biosynthesis of nanomaterials under mild conditions without requiring physical and chemical treatments has triggered the exploration of the full biosynthesis capacity of a biological system for producing a diverse range of nanomaterials as well as for understanding biosynthesis mechanisms for crystalline versus amorphous nanomaterials.

There has been increased interest in synthesizing various nanomaterials that have not yet been synthesized for various applications including semiconducting materials, enhanced solar cells, biomedical materials, and many others. This research reports the construction of a recombinant E. coli strain that co-expresses metallothionein, a metal binding protein, and phytochelatin synthase that synthesizes the metal-binding peptide phytochelatin for the biosynthesis of various nanomaterials. Subsequently, an E. coli strain was engineered to produce a diverse range of nanomaterials, including those never biosynthesized before, by using 35 individual elements from the periodic table and also by combining multi-elements.

Distinguished Professor Doh Chang Lee said, "An environmentally-friendly and sustainable process is of much interest for producing nanomaterials by not only chemical and physical methods but biological synthesis. Moreover, there has been much attention paid to producing diverse and novel nanomaterials for new industrial applications. This is the first report to predict the biosynthesis of various nanomaterials, by far the largest number of various single- and multi-elements nanomaterials. The strategies used for nanomaterial biosynthesis in this research will be useful for further diversifying the portfolio of nanomaterials that can be manufactured."

More information: Yoojin Choi et al, RecombinantEscherichia colias a biofactory for various single- and multi-element nanomaterials, *Proceedings of the National Academy of Sciences* (2018). DOI: 10.1073/pnas.1804543115

Provided by The Korea Advanced Institute of Science and Technology (KAIST)