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Bacterial Adsorbent for Recovery of Rare Metals from Seawater

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Summary

Seawater contains a variety of valuable metal ions, the total amount of which far exceeds that of mine resources. However, existing adsorbents have issues with binding selectivity, and have not yet been put to practical use. On the other hand, there are proteins and peptides that show extremely high selectivity for certain metals. For example, the recently discovered "lanmodulin" specifically binds to lanthanides with 100 million times the selectivity as Ca(II), and is also useful for separating homologous elements.

We previously developed of a technology to present (display) any protein on the periplasmic space side via a membrane protein (General Grant Research 001, 2021). This E. coli is a "living adsorbent" that senses target metals in the periplasmic space while remaining alive and grows only when the target metal is present (only when there is work to do). It is also an "evolving adsorbent" whose metal-binding ability can be subject to evolutionary selection, using the most basic biological function of "growing" as an indicator. In this study, we constructed a system to present any protein on the periplasmic space using the E. coli membrane protein TetA. Using this TetA system, we created a library of randomly mutated parts of ranmodulin and expressed the mutants in E. coli. The transmembrane structure of TetA allows the mutant proteins to be presented on the periplasmic side, allowing us to screen for cells that selectively grow in the presence of metals. Metal binding, which requires evolutionary design, is governed by multi-body interactions with sub-Å precision and is a difficult area to rationally design, so optimization by screening is extremely effective. In fact, by repeatedly selecting while gradually decreasing the metal concentration and increasing the concentration of the chelating agent, we succeeded in obtaining high-affinity metal binding proteins.