Engineering Artificial Metalloenzymes for Lanthanide Photocatalysis

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Lanthanide photocatalysis is a powerful tool to activate organic molecules under mild conditions.[1,2] For instance, radical intermediates can be formed using visible light and simple complexes of the earth-abundant lanthanide cerium. However, it remains a major challenge to control the fate of these reactive intermediates to achieve regio- and stereoselectivity. We thus developed an artificial lanthanide-dependent photoenzyme (= *PhotoLanZyme*) enabling this chemistry in a protein environment.[3]

We utilized a de novo designed protein scaffold that we previously engineered to tightly bind lanthanide ions in its central cavity.[4] Upon visible-light irradiation, the cerium-bound enzyme catalyzes the radical C–C bond cleavage of 1,2-diols in aqueous solution.[3] We thoroughly characterized the molecular effects of photodamage and used protein engineering to improve the enzyme's photostability and metal binding properties. The photoenzyme cleaves a range of aromatic and aliphatic substrates, including lignin surrogates. It exhibits initial stereoselectivity for bulkier substrates. Surface display of the protein scaffold on *E. coli* and subsequent treatment of the cells with $CeCl_3$ facilitates whole-cell photobiocatalysis. Furthermore, we found that also natural lanthanide-binding proteins have promiscuous enzymatic activity towards cerium photoredox chemistry.

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