Short Commentary
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Improvement and Enhancement of Enzyme Activity by Metal-Organic Framework (MOF) Adsorption

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Abstract

This short commentary mentions some reports of immobilization of enzymes by encapsulation into the structure of metal organic frameworks (MOFs) and adsorption on the surface of the MOFs. Improvements in thermal stability, storage stability, and reusability were also observed. The ability to improve the function of enzymes while maintaining their stability will lead to cost reduction. In addition, there are possible applications in the fields of biosensing and cancer treatment.

Keywords: Metal organic framework • Enzyme • Hybrid materials

Introduction

These articles report the results of immobilization of enzymes by encapsulation into the structure of metal organic frameworks (MOFs) and adsorption on the surface of the MOFs. Improvements in thermal stability, storage stability, and reusability were also observed. The ability to improve the function of enzymes while maintaining their stability will lead to cost reduction. In addition, there are possible applications in the fields of biosensing and cancer treatment.

Analysis of Docking MOF and Enzyme

Enzymes are proteins that acts as catalysts in chemical reactions in living organisms and are essential for these reactions. On the other hand, there are many cases where enzymes are unable to utilize the original functionality due to their fragile structure and low resistance to solvents and heat. Herein, we summarize the improvement of enzyme functionality by using MOFs as mediators of enzymes. First of all, we focus on the effect of encapsulation into MOFs. The protected the enzyme and improved its robustness, thermal stability, and chemical stability against changes in conditions such as pH change compared to the case of the enzyme alone. In addition, immobilization of the enzyme prevents aggregation of the enzyme and improves the functionality of the enzyme catalyst by improving the substrate selectivity [1]. In addition to these, the stability of the enzyme was ensured by docking. Similar results were obtained in the case of combining enzymes by adsorption to the surface through chemical bonding, and it was confirmed that this method has a significant impact on improving the function of enzymes. As an example of the method used for the docking of MOFs and enzymes other than those listed above, there is a method of one-pot synthesis of MOF-enzyme complexes by directly adding the enzyme to the reaction during the synthesis of the MOF complex. It was found that when the enzyme was trapped inside the MOF by this method, it showed higher activity than when the enzyme was encapsulated in the prepared MOF [2]. In addition, the improvement of substrate specificity enabled dynamic detection of cells and discrimination between normal cells and cancer cells, and other functional improvements were observed due to that increased the shelf life of the enzyme and improved its reusability, and it was found that even when the enzyme was used repeatedly, it could be used while maintaining higher catalytic activity than the enzyme alone [3], for chemistry and predicting the changes and results of reactions in advance. For this purpose, the most efficient policy would be to design molecules using data science that incorporates knowledge of chemistry and biochemistry. In the future, our goal is to predict the optimized structure of substances by using geometry, mathematics, data science, and to synthesize complexes of metal complexes the functionality of MOFs and enzymes is also affected by the structure of each material and the form of the binding. MOFs act as highly functional complexes when metal molecules and organic ligands are cross-linked in a uniform arrangement. If the orientation is disordered and the arrangement is non-uniform, the transfer of substances between MOFs does not take place properly and the original functions cannot be utilized. Similarly, in the case of enzymes, structural changes can lead to a decrease in enzyme function and inactivation. In addition, the molecular arrangement in a crystal has a significant impact on physical properties, such as changes in electrical conductivity due to differences in molecular arrangement, and changes in physical properties due to changes in electron spin and angular momentum. Therefore, efficient synthesis is possible by using big data such as crystal structure databases, handling the crystal structures and optimized structures of metal complexes and proteins from the viewpoint of computational and proteins with the optimized structure, leading to high activity (Figures 1 and 2).

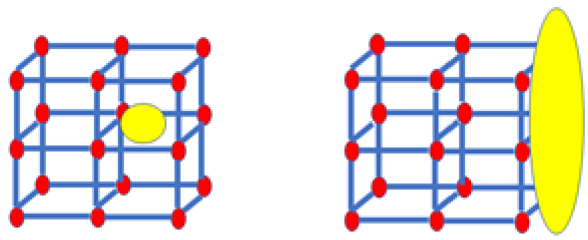

Figure 1. Encapsulation of enzyme by MOF (left) and adsorption of enzyme by MOF (right)

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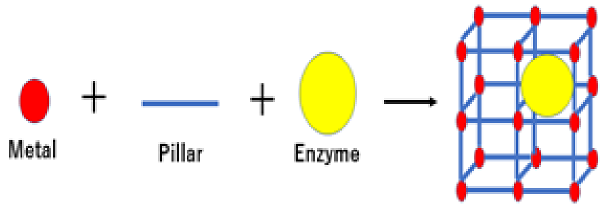

Figure 2. One-step packing by adding enzymes at the time of MOF fabrication

Conclusion

In summary, the docking of MOFs with enzymes protected the enzymes and enabled them to achieve high stability and activity. Since the docking improved the cell discrimination function, the results suggest that MOFs can be used not only in the material field, where they were originally designed to be used, but also in other fields such as the medical field.

This article reports the results of immobilization of enzymes by encapsulation into the structure of metal organic frameworks (MOFs) and adsorption on the surface of the MOFs. Improvements in thermal stability, storage stability, and reusability were also observed. The ability to improve the function of enzymes while maintaining their stability will lead to cost reduction. In addition, there are possible applications in the fields of biosensing and cancer treatment.

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