Enzyme immobilization: rational basis for turning an enzyme into an efficient biocatalyst

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Immobilized biocatalysts have the potential of enabling continuous processing, lowering production costs and waste stream generation. Moreover, immobilization is mandatory for some enzyme applications as, for instance, in processes in organic phases where hydrophilic native proteins are prone to aggregate when hydrated or solvated by polar components. Prevention of protein contamination is one further motivation that induces pharma and cosmetic sectors to employ immobilized biocatalysts.

It has to be emphasised that enzyme immobilisation can help in the utilisation of the enzyme, but that this has to be proven separately for every case studied. Immobilisation of an enzyme entails the interaction of two species, the enzyme and the carrier. The surface properties of both are therefore important. While immobilisation of enzymes has been largely a trial and error approach, progress in the targeted immobilisation of enzymes is being made. Recent advances in the design of materials with tailorable pore sizes and surface functionality has enabled more precise control of the immobilization process with retention of catalytic activity and stability. While simulation of the surface characteristics of the target enzyme can be used to aid in the design of appropriate support materials, examples of the application of molecular simulation methods for the rational development of immobilization strategies are still limited. As the structure and mechanism of more enzymes become available, more controlled immobilization methods will be generated. Examples of immobilised enzymes indicate that the choice of the immobilization method cannot be guided simply by criteria that dictate the highest stabilisation and activity of the enzyme, but must also consider the specific configuration of the reaction that will be catalysed. In particular, successful applications of biocatalysts require systems that are not only stable and active, but are low in cost, sustainable and can undergo repeated re-use.

The lecture will discuss some general recommendations that are possible to draw from the research performed to date, which demonstrate how enzyme immobilisation is slowly turning into a well understood science where protocols are planned rationally.