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Overcoming enzyme inactivation in biocatalysis by co-entrapment in ionic liquid gel materials

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PURPOSE OF THE ABSTRACT

A roadmap of biochemical routes lies at the heart of every living organism, enabled and maintained by nature's signature catalysts, enzymes. Enzymes embody the highest ideals of green chemical catalysts: They are derived from renewable sources and are biodegradable and biocompatible [1].

Although the use of these biocatalysts in industrial processes is not new, their widespread implementation can be expensive and thus severely limited [2]. Commercially available epoxy resins can be used to reduce costs by covalently immobilising enzymes onto their surface, enabling their recovery and reuse. However, these materials do not protect the enzyme from inhibitors present in the reaction mixture and could disrupt the protein structure as a result of the physical linkage to the support [3]. In this regard, entrapment methods offer a more sophisticated approach, creating a porous network that physically entraps the enzyme along with a solvent of choice.

Taking the well-studied polyacrylamide hydrogels as a starting point, the functional groups of the polymeric matrix can be altered and tuned through monomer co-polymerisation. Additionally, the use of ionic liquids as co-solvents in the entrapment process renders polymeric materials with superior mechanical properties [4], an important consideration in industrial operations. Ionic liquids are highly tuneable, non-volatile solvents that have been used in the past to assist biocatalysis in various ways [5].

Flexibility in both monomer and ionic liquid design provides a vast toolkit for microenvironment engineering. The ideal microenvironment would have minimum leach into the reaction solvent, would preserve enzymatic activity and would attract substrates into the matrix while allowing products to diffuse back into the bulk phase. Entrapment offers the benefits of biphasic reaction systems while keeping the biocatalyst in a conveniently retrievable solid form. At the end of its useful life, the ionic liquid can be extracted and re-used in further material syntheses, while the polymeric material can be degraded and disposed of [6].

In this work, co-entrapment of enzymes and green ionic liquids has been employed to assist in biocatalytic reactions, such as transesterification and hydrolysis; and the effects of altering the polymer matrix, and adding ionic liquids, assessed.

FIGURES

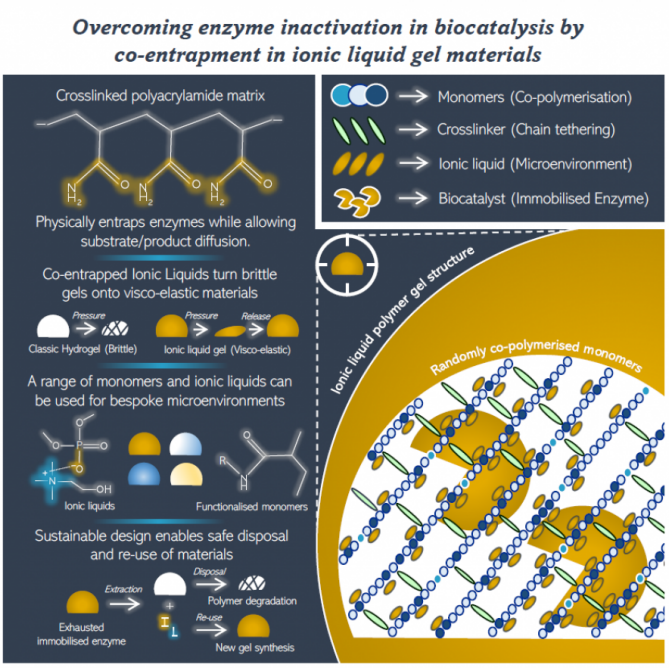

FIGURE 1

Graphical abstract

Visual description of ionic liquid polymer gel materials for enzyme entrapment: Structure, properties, versatility and degradation.

FIGURE 2

KEYWORDS

Ionic liquids | Entrapment | Polyacrylamide | Lipase

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