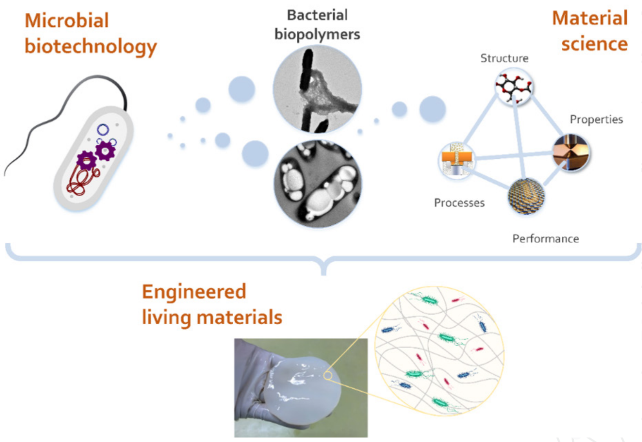
WHEN MICROBIAL BIOTECHNOLOGY MEETS MATERIAL ENGINEERING

Key message

This study highlights the enormous structural diversity of biopolymers, their production processes and how they can be modified, both biologically and chemically. It also explores the wide range of potential applications of these macromolecules in our daily lives, focusing on the rapidly growing field of engineered living materials (ELMs): bringing bacterial biopolymers to life.



Background

Bacterial biopolymers such as bacterial cellulose (BC), alginate or polyhydroxyalkanotes (PHAs) have aroused the interest of researchers in many fields, for instance, biomedicine and packaging, due to their being biodegradable, biocompatible and renewable. By employing microbial biotechnology strategies and materials science, the physicochemical, thermodynamic and mechanical properties of these biopolymers can be fine-tuned, giving rise to biopolymers with a wide range of non-native attributes.

Take-home messages

- This study emphasises the extraordinary diversity of bacterial biopolymers, which can be greatly expanded through the synergistic combination of microbial biotechnology, synthetic biology, metabolic engineering, and materials science.
- Bacteria are capable of naturally synthesising a wide range of biopolymers like polyamides, polysaccharides, polyesters and polyphosphates.
- Nonetheless, diversification thereof through metabolic engineering and chemical modification of their side chains or via crosslinking with other biopolymers/molecules, provides even more potential functionalities.
- The potential for bacterial biopolymers to be used as scaffolds for living organisms opens the door to creating ELMs capable of self-repair and responding to stimuli.

Source

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Results

- Bacteria naturally produce various polymers as part of their inherent physiology in the form of storage molecules, protective capsular layers surrounding cells, or as an extracellular matrix. Apart from natural proteins and nucleic acids, bacteria can produce polyamides, polyesters, polyphosphates (polyP), polysaccharides and extracellular recombinant proteins. These have applications in polymer biotechnology field. By manipulating the molecular weight, charge, monomer composition and specific 3D structure, a range of thermo-chemical and mechanical properties can be achieved.
- Chemical modification techniques such as blending, grafting/crosslinking and curing, further expand the potential uses of these biopolymers by introducing functional groups of interest, which would make them suitable for high value-added applications.
- The emergence of new technologies, such as synthetic biology, enables the creation of next-generation-advanced materials presenting smart functional properties, for example the ability to sense and respond to stimuli as well as the capacity for self-repair. These advances have led to the development of biohybrid materials, where synthetic components are combined with living organisms.
- Two different subfields have recently garnered particular attention: hybrid living materials (HLMs) and engineered living materials (ELMs). HLMs involve encapsulation or bioprinting, while ELMs are built from scratch using microbial biotechnology tools. Early studies showed the strong potential of alginate and PHAs as HLMs, whilst BC constituted the most currently promising material for the creation of ELMs.

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