HYDROCELL

A GMO Proposal: The growth of hydrophobic and self-cleaning bacterial cellulose introducing surface related genes from Nelumbo Lucifera.

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Introduction

Petroleum-based plastics are the predominant materials for food packaging. In fact, of 368 million tons of plastics produced in 2019, the 40% was used to fabricate food packaging materials (PlasticsEurope, 2020). Petroleum-based plastics offer good physical properties, chemical inertness, easy processing, high versatility, and low weight together with very attractive production costs, but are highly contaminant in ecosystems (Guzmán-Puyol, Heredia, Heredia-Guerrero, & Benítez, 2021).

Bacterial cellulose has several characteristics that make it interesting for an alternative of petroleum-based plastics:

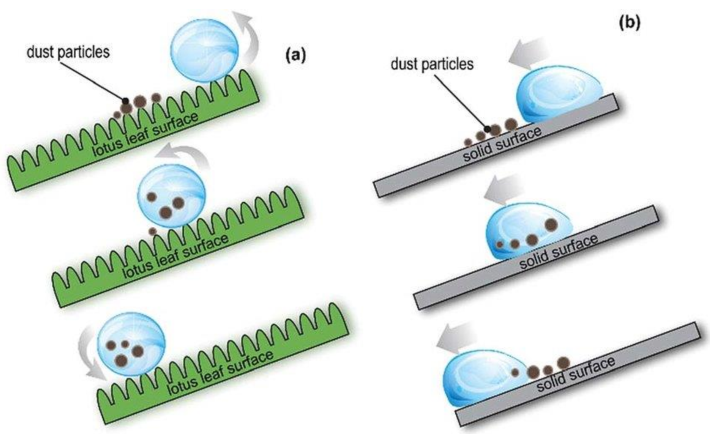
Biodegradability.
Renewable: It is derived from the fermentation of sugars, which can be sourced from renewable biomass.
Biocompatibility: Bacterial cellulose has good biocompatibility, making it suitable for certain medical applications.

Proposal

Acetobacter species, particularly **Komagataeibacter xylinus**, are remarkable for their ability to synthesize cellulose. This cellulose is highly pure, holds significant water, and has a unique nanofibril structure. However, the hydrophobicity of cellulose is not a characteristic associated with K. xylinus or its cellulose production. While cellulose itself is hydrophilic, modifications can be made to impart hydrophobic properties, but this typically involves additional treatments or the introduction of other substances.

The proposal consists of transferring hydrophobic properties from Nelumbo Lucifera, specifically its wax biosynthesis-related genes that contribute on the lotus effect, in order to allow K. Xylinus to produce a waxy coating on its cellulose surface, eliminating the need of additional in-situ or ex-situ treatments.

The lotus effect is based on the micro/nano-structures creating roughness on the surface and the **hydrophobic wax coating** on the lotus leave. These features make it difficult for dirt, dust, and water to adhere to the surface, helping to keep it clean. Because of this, ultra-hydrophobicity is believed to be an advantage in the evolution of the lotus.



Genes

Key genes related to cellulose production in **Komagataeibacter xylinus** occur in the four-gene operon **bcsABCD**, which codes for the four subunits of the cellulose synthase enzyme. All four genes are required for efficient cellulose production in vivo, although **BcsA** and **BscB** are sufficient in vitro. Several other genes in the K. Xylinus genome are also involved in cellulose production and regulation, including a cellulase enzyme.

There has been experiments on **Nelumbo Lucifera** where two wax biosynthesis-related genes **(NnCER2 and NnCER2-LIKE)** were cloned from the lotus, and transformed in Arabidopsis, which resulted in an alteration of the cuticle wax structure in inflorescence stems, and proved their function in the biosynthesis of the extra-long fatty acids [36]. More studies on the lotus leaf chemical compositions and structure might be very helpful in producing materials with super-hydrophobicity and self-cleaning features.

Applications and Benefits

- **Water-Resistant Materials:** Hydrophobic cellulose could be used to create water-resistant paper, packaging, or even textiles. This opens up exciting possibilities in various industries, from fashion to electronics.
- **Biomedical Uses:** In medicine, such materials could be used for wound dressings or implants that resist moisture but maintain breathability.
- **Environmental Impact:** Since bacterial cellulose grows itself and is biodegradable, offers a more sustainable alternative to synthetic water-resistant materials.

Conclusions

This GMO generates the possibility of obtaining a self-growing hydrophobic biopolymer that can substitute petroleum-based polymers.

Further studies are needed to compare this process of genetically modified bacterial cellulose, and other methodologies already studied to provide hydrophobicity, such as ex-situ and in-situ approaches like addition of external waxes, ultra-sonification of the matrix, etc...

Further studies have to be made in order to ensure effective biodegradability and low environmental impact of the new material.

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