Biopolymer microencapsulation strategies for environmentally friendly hydrophobic textile coatings

Anja Verbič[1], Barbara Golja[1,2], Blaž Likozar[1], Uroš Novak[1], Blaž Stres[1,*]

1 National Institute of Chemistry, Hajdrihova 19, 1000 Ljubljana, Slovenia; 2 University of Ljubljana, Faculty of Natural Sciences and Engineering, Snežniška ulica 5, 1000 Ljubljana, Slovenia

**Corresponding author: blaz.stres@ki.si*

Highlights

- The research presents the development of PFAS-free alternative for textile industry, using microencapsulation approach.
- The objective of the study is to develop non-toxic, eco-friendly microcapsules, which when applied to textiles, enable sustainable textile hydrophobicity.
- Natural compounds are used as raw materials for microcapsule formulation.
- Addressing industry demands, our solution aligns with growing eco-conscious practices.

1. Introduction

Perfluoroalkyl and polyfluoroalkyl substances (PFAS) are a large group of synthetic compounds containing carbon-fluorine bonds. They are used in almost every industry to impart new functional properties to various materials, such as hydrophobic, oleophobic, stain-resistant or non-stick. PFAS have excellent thermal, chemical, and mechanical stability, making them extremely durable. Due to their chemical composition, they are difficult to degrade and tend to bioaccumulate. The release of these substances into the environment leads to widespread contamination of the air, water, soil and wildlife, exposing humans through the environment, food and drinking water. PFAS have already been detected in human tissues, such as blood, urine, breast milk, liver, kidney, lung, etc., and are associated with a variety of negative health effects, including infertility, thyroid and kidney dysfunction, weakened immunity, developmental problems and cancer [1-4]. The health risks associated with PFAS have led to extensive regulatory controls and restrictions. Authorities already regulate the use, manufacture, and disposal of PFAS. In particular, the use of some PFAS compounds has already been banned, while others are highly regulated in terms of acceptable concentrations used. Due to the growing environmental and health concerns regarding PFAS and the regulations established, there is an urgent need to find sustainable and non-toxic alternatives.

The textile industry is considered the largest consumer of PFAS, and accounts for approximately half of the global PFAS consumption [5]. Their ability to repel water (hydrophobicity) and oil (oleophobicity) allows coated textiles to be extremely resistant to stains and liquids. This makes them essential in the protective, medical or apparel industry, providing safety, health and comfort. Theoretically, the water repellency of textiles can be achieved by modifying two properties, the surface energy and the surface roughness. In order to achieve a water and oil repellency, the surface energy of the fibres must be reduced or the roughness increased. The surface energy depends on the chemical structure of the surface and can be altered by chemical modification of the fibres [6]. Increased roughness can be achieved by changing the morphology of the fibres by applying coatings containing nanoparticles or by etching the surface of the fibres.

2. Methods

One possible approach to achieve hydrophobicity is the application of microcapsules to a textile substrate, yet this area still remains largely unexplored. In the literature review, only one article was found that describes the connection between the microcapsule application and the achievement of hydrophobicity [7]. Therefore, the aim of our research is to develop bio-based microcapsules using environmentally friendly natural compounds such as cellulose, agar, alginate, chitosan, waxes, starch, nanoparticles, etc., with the aim of reducing surface tension or increasing surface roughness of the textile surface, which will consequently lower the fabric's wettability.

3. Results and discussion

In order to develop bio-based microcapsules to improve textile hydrophobicity, we will follow a systematic approach involving the following steps:

- Material selection: Environmentally friendly materials, such as cellulose, agar, chitosan, waxes, starch and nanoparticles, will be identified and selected for the formulation of bio-based microcapsules.
- Microcapsule synthesis: A suitable synthesis method for producing microcapsules from the selected materials will be developed. The encapsulation process will be optimised to ensure the desired properties, such as size and shell thickness.
- Application on textile substrates: different application techniques for applying the bio-based microcapsules to textile substrates will be tested and investigated. The application process will be optimised in order to achieve uniform distribution and adhesion.
- The samples will be analysed for their wettability (water contact angle measurements, WCA) and compared with untreated textiles. The mechanical properties of the samples will be monitored, as the coating should not impair the basic textile properties. The changes in morphology and surface roughness will be analysed using scanning electron microscopy (SEM).

4. Conclusions

By approaching these steps systematically, we aim to develop a sustainable and effective solution for improving the hydrophobicity of textiles using bio-based microcapsules made from environmentally friendly materials. Our comprehensive analysis will not only validate the effectiveness of the microcapsules but also ensure their practicality and longevity in real-life scenarios. The potential benefits of this research extend beyond improved fabric performance. They include environmentally conscious practices that align with the growing demand for eco-friendly solutions in the textile industry.

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Keywords

PFAS; hydrophobicity; microcapsules; textile