# BIOTECHNOLOGICAL MODIFICATION AND FUNCTIONALISATION OF POLYESTER SURFACES

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**ABSTRACT**

Synthetic fibers form an important part of the textile industry, the production of polyester alone surpassing that of cotton. A disadvantage of synthetic fibers is their low hydrophilicity. Polyester fibers are particularly hydrophobic. This affects the processability and functionalisation of the fibers. A relatively new and promising alternative is the use of enzymes in surface modification of synthetic fibers. Synthetic materials have generally been considered resistant to biological degradation; recent developments at different research groups demonstrate that enzymes are very well capable of hydrolysing synthetic materials.

**Keywords**: textile biotechnology, enzymes, surface functionalisation, surface modification, (bio)polymers

## INTRODUCTION

In 2007 the annual world production (fibres and yarns) was 30.7 million tons of polyester, 4.0 million tons of polyamide, 2.4 million tons of acrylics, and 26.1 million tons of cellulose [1]. PET-fibres are used in a wide range of applications, e.g. in advanced applications such as biomedical textiles.

The general aim of the current project is to functionalise (bio)polymeric textile materials using modern biotechnology. The research will result in new, specific knowledge and technologies to create biotechnologically modified textile materials with unique properties. The research contributes to bio-based economy through the development of novel processes for textiles exhibiting the desired functionalities and through development of novel enzyme technology for structuring and functionalisation of surfaces.

The aim of the enzymatic surface modification of PET is to increase hydrophilicity locally, allowing specific functionalisation. The advantage of enzymes over conventional techniques us that the favourable bulk properties of PET are not affected because the enzymes are to big to penetrate into the bulk phase of the material. The last years research efforts focused on the potential of lipases, polyesterases and cutinases for the modification and eventually functionalisation of poly(ethylene terephthalate) (PET). Enzymes have been reported to increase hydrophilicity of polyesters by hydrolysis of ester bonds. This facilitates functionalisation processes.

Manipulation of surface characteristics of textile materials is of fundamental importance in the production of advanced functional textiles. While a lot of research focuses on chemical modification or structuring of the surfaces, the introduction of functionalities using enzymes is a relatively unexplored and modern scientific area (Figure 1). The advantage of biotechnology or more specifically enzymes over other technologies is their high specificity towards a certain reaction or substrate.

## ENZYMATIC SURFACE MODIFICATION AND FUNCTIONALISATION

Synthetic materials have generally been considered resistant to biological degradation. Enzymatic surface modification of textile materials involves processing of fibres or (bio)polymers to modify the physical chemical surface properties or the introduction of functional groups on the surface. The research presented focuses on specific, targeted enzymatic surface modification to obtain functional structured surfaces. In this work the potential of cutinases in surface modification of PET will be reported.

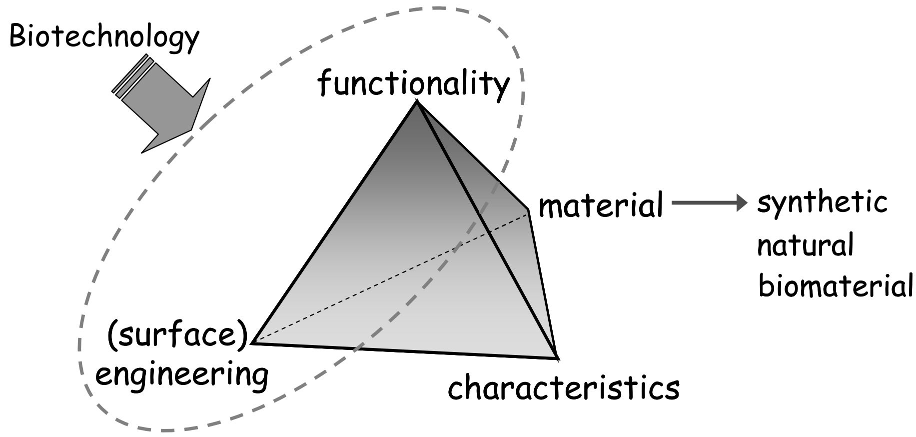


**Figure 1.** Enzymatic surface modification and functionalisation of textiles.

Cutinases (EC 3.1.1.74) are serine hydrolases specific for the hydrolysis of cutin. Cutin is a polymer, composed of hydroxyl and epoxy fatty acids, in the cuticle of higher plants. Cutin is a bio-polyester [2]. Cutinases are extracellular esterases mainly produced by pathogenic fungi and pollen, though some cutinases are produced in bacteria. Cutinase from *Fusarium solani pisi* is the most studied cutinase [3]. Cutinase from *Fusarium solani pisi* is a one-domain molecule, i.e. there is no quaternary structure. It is a relatively small enzyme with a weight of 22,000 g/mol and it is approximately 45x30x30 Å$^3$ in size.

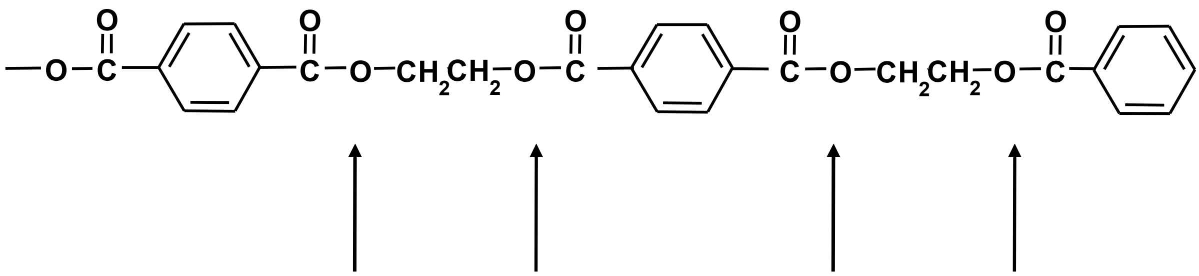

**Figure 2.** Enzymatic hydrolysis of PET.

Cutinase can accept a wide range of substrates such as poly(ethylene terephthalate) and polyamide (Figure 2) [3, 4]. Crystallinity greatly affects the capability of cutinase to hydrolyze the ester bonds [4]. Cutinase displays relatively high activity towards amorphous polyester and little activity on highly crystalline substrates.

An advantage of a cutinase or lipase treatment is that it does not result in pitting corrosion, as seen in alkaline treatments, but a more or less homogeneous surface treatment of PET [5].

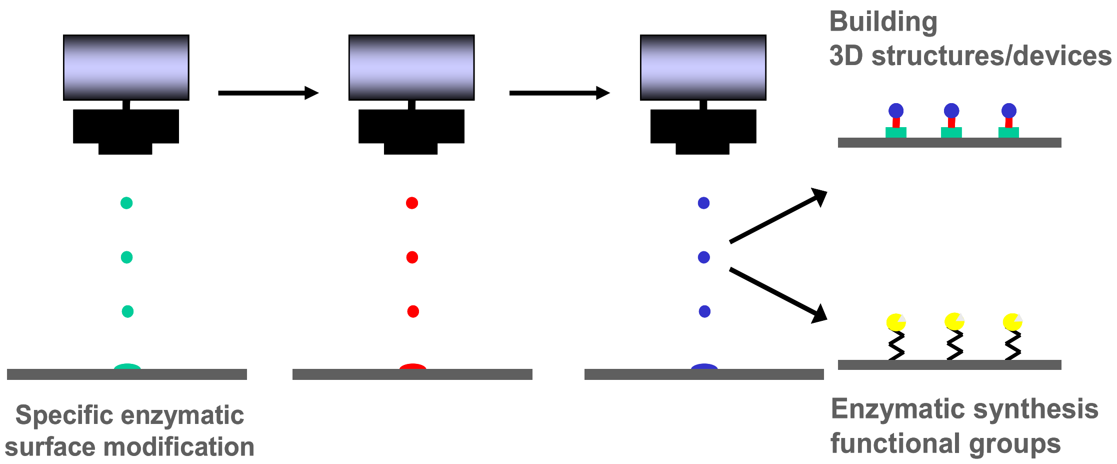


**Figure 3.** Specific surface modification and surface functionalisation.

Control of enzymatic action at correct time and length scales is a prerequisite to achieve the desired modifications and functionalities. Therefore the potential of sophisticated non-contact dispensing technologies and processes are explored in order to design novel production processes for textiles that exhibit the desired functionalities. Inkjet technology allows specific surface modification, and allows functionalisation and reactions at specific locations, allowing the design of highly specific localised functionalities (Figure 3).

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