Synthetic Biology Approach for the Development of Customized Polysaccharides

Norma J. Wendel, Jochen Schmid, Volker Sieber and Dominik Heider
Straubing Center of Science, Germany
n.wendel@wz-straubing.de

Glycosyltransferases catalyze the transfer of sugar moieties from activated donor molecules towards an acceptor molecule. Thus, they play important roles in the biosynthesis of disaccharides, oligosaccharides, and polysaccharides. By now, most of the commercial polysaccharides are obtained from plants and most of them show a simple chemical structure. They can be isolated efficiently, but their simple chemical structure limits the field of applications [SHW+16]. Microbial polysaccharides show a much higher diversity in their chemical structure and are used in different areas, e.g., as thickening agents in food and cosmetic products [LP95, BSC83, WJ12], wastewater treatment [LRC14], and in general as substitute of fossil oil-based polymers [Fra]. The synthesis of tailor-made polysaccharides with specific properties is limited, due to the poor knowledge and insights in the mechanisms of glycosyltransferases and the bacterial biosynthesis pathways of polysaccharides. This missing information limits and prevents the production of tailor-made polysaccharides [SHW+16].

Glycosyltransferases are a highly diverse class of enzymes and show a low similarity on sequence level. Due to the fact that mammalian glycosyltransferases show a lower sequence similarity in comparison to bacterial ones, we focused on bacterial glycosyltransferases in our study [SHW+16]. The aim of our study is to understand the mechanism of the specificity of the different glycosyltransferases concerning sugar transfer in more detail. Different motifs will be examined, which determine the specificity of sugar donor and acceptor domains. First, functionally and structurally known glycosyltransferases will be used as templates for motif prediction and to align unknown glycosyltransferases to the known tertiary structures. Docking experiments with sugar molecules will follow in order to identify the binding sites and affinities. Finally, the unknown glycosyltransferases will be enriched with in silico predictions, which will be experimentally verified in order to enable a sequence-based prediction of glycosyltransferase specificity in the future. Finally, customized polysaccharides with specific properties will be generated based on specific synthetic arrangements of polysaccharide chains in a synthetic biology approach.

References

[BSC83] JK Baird, PA Sandford, and IW Cottrell. Industrial applications of some new microbial polysaccharides. *Nature Biotechnology*, 1(9):778–783, 1983.

[Fra] Fraunhofer. Besser schmieren ohne Öl. https://www.fraunhofer.de/de/presse/presseinformationen/2012/mai/besser-schmieren-ohne-oel.html. Accessed: 2016-07-18.

[LP95] R Lapasin and S Pricl. Rheology of polysaccharide systems. In *Rheology of industrial polysaccharides: Theory and applications*, pages 250–494. Springer, 1995.

[LRC14] CS Lee, J Robinson, and MF Chong. A review on application of flocculants in wastewater treatment. *Process Safety and Environmental Protection*, 92(6):489–508, 2014.

[SHW+16] J Schmid, D Heider, NJ Wendel, N Sperl, and V Sieber. Bacterial Glycosyltransferases: Challenges and Opportunities of a Highly Diverse Enzyme Class Toward Tailoring Natural Products. *Frontiers in Microbiology*, 7(182), 2016.

[WJ12] WAJP Wijesinghe and YJ Jeon. Biological activities and potential industrial applications of fucose rich sulfated polysaccharides and fucoidans isolated from brown seaweeds: A review. *Carbohydrate Polymers*, 88(1):13–20, 2012.