

Alginates: Biology and Applications

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Preface

Alginates are well established as food additives and as encapsulation agents in biotechnology. Commercial production from harvested brown seaweeds commenced in the early twentieth century. Alginates belong to exopolysaccharides and are non-repeating copolymers of β -D-mannuronic acid (M) and α -L-guluronic acid (G) which are linked by 1–4 glycosidic bonds. These comonomers can be arranged in blocks of continuous M-residues (M-blocks), G-residues (G-blocks) or alternating residues (MG-blocks). The comonomer composition and arrangement strongly impact on the alginate material properties, which range in nature from slimy and viscous solutions to pseudoplastic materials. Brown seaweeds and only the two Gram-negative bacterial genera *Azotobacter* and *Pseudomonas* are capable of alginate production. The bacterial alginates are characterized by acetylation of M-residues to a variable extent at positions O-2 and/or O-3. The degree of acetylation was also found to affect the material properties of the alginate. In *Pseudomonas aeruginosa*, for example, alginate is mainly composed of M-residues mediating viscous solution properties required for its function as a biofilm matrix polymer. However, in *Azotobacter vinelandii* a pseudoplastic alginate with a high G-residue content is produced when this bacterium forms a desiccation-resistant cyst under adverse environmental conditions. The mature cysts are surrounded by two capsulelike layers containing a high proportion of alginate to maintain structural integrity and resistance to desiccation. In brown algae alginate is produced as an intercellular gel matrix contributing to the mechanical stability of the plants.

Current knowledge of the genetics, gene regulation and biosynthesis of alginate is mainly based on extensive studies implementing the two bacterial species *A. vinelandii* and *P. aeruginosa*. Seminal work by Govan et al. and Chakrabarty et al. in the early 1980s kick-started research directed towards understanding the molecular mechanisms underlying alginate biosynthesis (Darzins and Chakrabarty 1984; Fyfe and Govan 1980; Ohman and Chakrabarty 1981). Interestingly, although the biosynthesis gene cluster was identified almost 30 years ago, the function of some genes essential for alginate biosynthesis has still not been assigned. The biosynthesis pathway leading to the formation of the activated alginate precursor GDP-mannuronic acid is well understood; however, the polymerization of GDP-mannuronic acid and the export of the resulting alginate are poorly understood. The enzymes (epimerase, transacetylase, lyase) which catalyse modification of the nascent

polymannuronate and hence strongly impact on alginate material properties have been studied in more detail. In particular, the epimerization process, i.e. the introduction of G-residues at the polymer level, is of great interest from an applied point of view. Alginate is currently used for a variety of industrial purposes, and the production was hitherto exclusively based on brown seaweeds. However, the possibility to engineer bacterial production strains capable of producing tailor-made alginates for medical applications especially has become increasingly attractive. This monograph provides an overview of the state of the art of alginate material properties, genetics and biosynthesis as well as applications of alginates and tailor-made alginates in medicine, food and biotechnology.

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