

in which the alginate poly(lactic-co-glycolic acid) (PLGA) is loaded with the alginate lyases into alginate hydrogels. The alginates were found to be degraded enzymatically, and neural progenitor cells' (NPC) culture in these degrading alginates showed a better expansion rate than cells cultured in nondegradable alginates.

14.6.4 Alginate Oligosaccharides

Alginate oligosaccharides have found their application in the field of medicine for various ailments. Guluronate oligosaccharide (GOS-ED), an alginate oligosaccharide with G blocks prepared by enzymatic degradation, was found to have effective immunomodulatory effects such as inducing nitric oxide synthase expression and stimulating reactive oxygen species (ROS) and tumor necrosis factor α (TNF α) expression. The activity of this GOS-ED was found to be maximal when compared with no or minimal effect of alginate oligosaccharides (AOS) [144]. The inhibitory action of AdO (alginate-derived oligosaccharides) in neuroinflammatory BV2 microglial cell lines showed that AdO are active in inhibiting nitric oxide and prostaglandin E2, and promoting expression of inducing nitric oxide synthase, cyclooxygenase 2, and proinflammatory cytokines. They were also found to inhibit the expression of nuclear factor (NF- κ B), Lipopolysaccharide (LPS)-activated overexpression, and toll-like receptor 4 in BV2 cells. These findings on neuroinflammatory attenuation of alginate oligosaccharides suggested that they can be used as therapeutic agents in treating neurodegenerative disorders [145].

Similar studies on alginate oligosaccharides on their medicinal application show that alginate oligosaccharides and guluronate-derived oligosaccharides can efficiently activate macrophages, thereby increasing immune response, inducing cytokine secretion and (TNF) secretion, and they also act as antitumor agents in osteosarcoma patients [146–148]. Exploration of alginase from biological sources like microorganisms has been studied for degradation of alginates. Alginase obtained from *Flavobacterium* sp. has been found to be used in the production of alginate oligosaccharides [149]. Similarly, an alginate-degrading enzyme capable of degrading alginate oligosaccharides except sodium alginate has been studied in *Alteromonas* sp. [150]. The use of these biologically derived alginases makes the process of alginate oligosaccharide production more biological and harmless.

Alginate oligosaccharides find their application in food industry and also in plant growth to be expanding. A study by Falkeborg *et al.*, [151] showed that alginate oligosaccharides inhibited lipid peroxidation and promoted radical scavenging activity toward 2,2'-Azino-bis(3-ethylbenzothiazoline-