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Green and Sustainable Biomaterials: Oxidized Polysaccharides

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Opinion

Polysaccharide-based materials, particularly in the field of biomaterials, have been widely adopted as first-choice choices for a variety of applications. The key reasons for this are the materials' long-term viability and high bioavailability. Their capacity to be chemically modified readily allows them to be used in a variety of ways, with oxidation of the backbone being one of the most prevalent. Furthermore, these materials degrade in a variety of ways (enzymatically and chemically), making them appropriate for biomedical applications. This study outlines current developments in the field of oxidised polysaccharides and their prospective applications. The creation of a novel degradable in vitro model that may be used in the preclinical phase of drug development has been the most coveted goal of materials science experts. Polysaccharides are promising materials with benefits such as biocompatibility, biodegradability, and abundance. They are formed of monosaccharide units connected together by glycosidic linkages and are one of the most common and commonly utilised polymers. Polysaccharides are considered green materials since they are naturally derived and biodegradable, and they are used in a variety of applications. Because of their safety, non-toxicity, and bioavailability, they are widely used in biological applications. The simplicity with which these molecules' chemical structures can be tweaked to introduce diverse functionalities for varied purposes is an important trait that is often exploited. Another essential attribute of these compounds is their biodegradability, which is commonly used in the Development of Drug Delivery Systems (DDSs) and tissue engineering scaffolds. Chemically modified hydroxyl groups in polysaccharide backbones can immobilise pharmaceuticals for the production of pre-drugs and cross-linkable functional groups for hydrogel formation. Many hydrophobic medications, such as the anticancer drug paclitaxel, are difficult to inject into the human body, necessitating the use of hazardous solvents.

The numerous hydroxyl groups in polysaccharide main chains are usually the targets of functionalization. When hydroxyl groups are oxidised, carbonyl or carboxyl groups are introduced into polysaccharides. Various oxidants attack hydroxyl groups at the C2, C3, and C6 locations in pyranosides, for example. To create aldaric acid compounds, full oxidation was carried out using strong acids such as nitric acid. On the other hand, mild oxidants such nitrogen dioxide, the stable nitroxyl radical 2,2,6,6-tetramethylpiperidine-1-oxyl (TEMPO), periodates, and hypochlorite have been used to try selective oxidation. The hydroxyl groups at the C6 position can be selectively oxidised with nitrogen dioxide to produce 6-carboxy cellulose or 6-carboxy starch from cellulose or starch, respectively. 6-Carboxy cellulose is used in the medical field as a hemostat. Because polysaccharides feature multiple 1,2-diol moieties in their major chains, this reaction has been used to functionalize them. Oxidized polysaccharides can react with amino-group-containing materials to produce Schiff bases due to the high reactivity of the added aldehyde groups. This reaction has been widely exploited to create adaptable building blocks for the manufacture of functional materials in biomedical applications, such as hydrogel formation and drug conjugation.

Because of the high water solubility of polysaccharides, conjugation of hydrophobic medicines onto them has been extensively researched as a possible remedy. In situ cross-linked molecules are also attractive biomaterials for cell treatment and DDSs as implantable injectable hydrogels with customizable mechanical properties, gelation times, and biodegradability. Many studies have concentrated on fine-tuning the usefulness of modified polysaccharides. To manage degradability, ester bonds have been inserted in dextran hydrogels for crosslink sites via click chemistry. To improve mechanical qualities, enzyme cross-linking with tyramine-modified polysaccharides has been employed. The pharmacokinetics, bioavailability,

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metabolism, and elimination of medicines can all be better controlled using these fine-tuned conjugations. After optimal functionalization, polysaccharides are also employed as surgical biomaterials such as bioadhesives, wound healing materials, and anticlotting materials. Enzymes such as hydrolases, lyases, and phosphorolases can all cleave glyosidic linkages, so polysaccharides can be degraded enzymatically. Chemical degradation provides fascinating options as well as the ability to control the rate of breakdown. In conclusion, because of their non-toxicity, selective reactivity, and scalability, oxidised polysaccharides made with recyclable periodate employing renewable naturally sourced ingredients have extended biological uses. Progress has been achieved in the field of polysaccharide-based biomaterials over the last few years. Despite the fact that multiple technologies are in use, further study on a variety of topics is required in order to develop universally applicable and reliable materials for a variety of applications. To begin with, simpler purifying procedures may be created. In addition, the structure-function relationship of oxidised polysaccharides must be thoroughly investigated. The functionalities of original polysaccharides after oxidation, such as COOH groups in hyaluronan; ionic crosslinking for alginate; hydrophobicity; crystallinity of cellulose; low viscosity at greater concentrations for dextran; and so on, must be used. Because stimuli-responsive biomaterials are a prominent issue in the area, they should be integrated with oxidised polysaccharide functionalities. Controlling the rate of biodegradation is another essential element that should be carefully considered. To this aim, Schiff base production that causes biodegradation is an intriguing occurrence for controlled degradation, and more research is needed to fine-tune the pace to specific needs. Further study is needed on oxidised polysaccharide composites for smart healthcare materials such as implanted scaffolds, controlled medication release materials, and wearable devices. The next generation of oxidised polysaccharides could pave the way for a variety of environmentally friendly bioengineering materials. Given the significant progress made in recent decades, it will be fascinating and thrilling to see what new breakthroughs and research emerge in the next years, which may catapult the field to new heights and answer many of the area's current issues.