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Polysaccharide Derived Light Harvesting Materials: A Comprehensive Review on Enhancing Performance

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Abstract

Polysaccharides, intricate natural carbohydrates, have gained acclaim for their versatility and broad applications across various fields. This thorough investigation explores their pivotal role in light harvesting and their far-reaching impact on technology. Highlighting their unique attributes like sustainability, compatibility with living organisms, and diverse functionalities, the study showcases their utilization in material science, chemical processes, and industrial settings. Emphasizing catalysis, the research delves into the potential of polysaccharide-based catalysts for oxidation reactions, stressing their eco-friendliness and potential to reduce reliance on finite resources. Moreover, it explores their role in photocatalysis, particularly in breaking down organic compounds in wastewater, presenting them as plausible solutions for environmental concerns. The study further examines how integrating polysaccharides into solar cells enhances dye-sensitized solar cells, boosting electron transport and device efficiency. Nanostructured cellulose-based materials show promise in improving light absorption and electron transfer, advancing photodetectors and related technologies. This research highlights polysaccharides' multifaceted applications, including their effectiveness in pesticide and dye removal, affirming their potential as sustainable and effective environmental adsorbents. It also elucidates their crucial role in photocatalysis and solar cell technologies, offering a comprehensive view of their contribution to renewable energy solutions. Ultimately, this work underscores polysaccharides' immense potential to drive innovation across sectors, from catalytic reactions to harnessing solar power. Leveraging their distinctive traits, polysaccharides emerge as crucial elements in tackling contemporary challenges and advancing sustainable technological progress.

Keywords: Cellulose, Nanostructured, Polysaccharides, Sustainable.

Introduction

Oxidation changes have gotten a lot of attention because they are useful and could be used in the material, chemical, and industrial fields. The conversion of usable oxygenic molecules from substances such as alcohols, alkenes, carbon monoxide, olefins, and others is a well-known and significant oxidation reaction. Historically, these transformations have been carried out using toxic oxidizing agents, including hypervalent halogen (iodine) reagents, metal-containing reagents (Cr, Mn), and a wide range of metal catalysts like TEMPO, per-oxides, etc. (1). H2O2, halogens, and oxygen are the most potent oxidants (2). Toxic and dangerous oxidants include things like permanganates, chromium (VI), and organic oxidizing agents K2Cr2O7 is a non-toxic compound that is useful in a variety of oxidation reactions. Many organometallic catalysts have also been devised; however, the fundamental disadvantage is that separating the catalysts once the reaction is complete is challenging (3). An increasing number of researchers in the fields of catalytic reactions and the manufacturing of fine organic substances are interested in the creation of a novel method for the creation of heterogeneous catalysts because of their advantageous properties. These advantages include the catalysts' insolubility in cleaning agents, good thermal stability, ease of handling, recyclability and recyclability, recovery from the reaction medium, and readily available supports (4). Due to their high stability, nanoparticles, and complexes supported by polymers are becoming increasingly viable alternatives as catalysts in organic synthesis reactions (5).

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The use of novel, ecologically acceptable polysaccharides as effective support complexes has aided in the production and functionalization of metal nanoparticles (MNPs). Polysaccharides are the most commonly used and have sparked considerable interest in the creation of hetero-homogeneous catalysts (6). These materials have the potential to lessen the environmental damage caused by manufacturing and cut down on the consumption of nonrenewable resources. For instance, polysaccharides can take the form of celluloid, Gum, pectin, chitin, alginate, starch, pectin, and chitosan. Monosaccharides serve as the repeating unit in polysaccharides, which are organic polymers. further classified into tetrose, pentose, hexose, etc., (7). The polysaccharides listed above enable low-cost, green catalytic systems, and demand and price for cellulose, as well as its derivatives, are growing rapidly (8). The materials have promising futures as catalysts for a wide range of chemical processes, including oxidation reactions. They have a high oxidative therapeutic efficacy and can be reused in a variety of catalytic procedures. To date, however, there are no extensive summaries of the theoretical underpinnings of polysaccharide catalysts for oxidation processes. In this article, Here, we study the possibility of various polysaccharides to act as oxidation reaction catalysts. These polysaccharides include cellulose, starch, lime, gum, gelatine, chitosan, and chitosan. In the relatively near future, the production of (nano) catalysts from such polysaccharides represents a promising prospect for achieving the requirements of catalytic activity. Because research on these topics is still in its infancy, it is essential to provide a review for those interested in this burgeoning field of study and the creation of polysaccharide-based (nano) catalysts (9).

Research has shown promising evidence suggesting that polysaccharides could enhance the efficiency of materials used in light-harvesting systems. The potential lies in their unique properties that could positively influence the performance of light-harvesting devices, such as solar cells. One hypothesis revolves around the use of polysaccharides, specifically as part of composite materials, to improve the light-harvesting capabilities of photovoltaic devices (10). Polysaccharides possess properties like biocompatibility, abundant availability, and the ability to form structures conducive to light interaction, making them intriguing candidates for enhancing light absorption and electron transfer in solar cells. A study by Li *et al.* (2019) explored the incorporation of polysaccharides, particularly chitosan, into dye-sensitized solar cells (DSSCs). Chitosan, a derivative of chitin found in crustacean shells, was used as a natural polymer matrix. This addition improved the electron transport and recombination processes within the solar cell, enhancing its overall efficiency. Another research direction involves the utilization of polysaccharides in nanostructured materials for light harvesting. For instance, cellulose-based nanomaterials have garnered attention due to their excellent mechanical strength, high surface area, and potential for light absorption. These properties are advantageous for constructing efficient light-harvesting devices (11).

Recent work by Wang *et al.* (2021) demonstrated the fabrication of nanostructured cellulose-based materials for use in photodetectors. The inherent properties of cellulose, a polysaccharide abundant in plants, were leveraged to develop high-performance photodetectors with improved light-harvesting capabilities. These studies highlight the potential of polysaccharides in improving the efficiency of light-harvesting materials. The unique structural and functional characteristics of polysaccharides, when integrated into composite materials or nanostructures, have shown promise in enhancing light absorption, electron transfer, and overall device performance in light-harvesting applications (12).

Please note that while these examples illustrate the potential benefits of polysaccharides in light harvesting, ongoing research continues to explore and refine these concepts for practical implementation in improving the efficiency of materials used in light-harvesting technologies.

Polysaccharides

Polysaccharides are natural macromolecules (biopolymers) that are made up of connected monosaccharide units. Because of this, polysaccharides have a high molecular mass, which is proportional to the number of units that make up the polymer. Polysaccharides are also known as glycans. In general, polysaccharides are composed of more than 20 monosaccharide molecules, which can include glucose, fructose, and glyceraldehyde. In addition, it is not possible to objectively determine how big a carbohydrate must be for it to be classified as either a polysaccharide or an oligosaccharide. These carbohydrates are hydrolyzable into oligosaccharides, disaccharides, or monosaccharides via a wide range of chemical, physical, and biological processes (13). Polysaccharides are long-chain molecules made up of either identical (homopolysaccharide) or separate monosaccharide units, and they can have a linear and highly branching chemical structure (heteropolysaccharide). Physiochemical characteristics are acquired by structural modifications. Some of these polysaccharides are insoluble in water, cellulose, while others, like pectin and alginate, form gels when exposed to liquid water. Since carboxylic acid, phosphate, and sulfuric ester can all be found in their molecular structures, some polysaccharides are also acidic. Polysaccharides are categorized as either electricity polysaccharides or structural polysaccharides by living organisms. Both plants and animals can store glucose as a reserve carbohydrate known as starch or glycogen, respectively, when the sugar is not used in a metabolic pathway. Cellulose, a most common and plentiful substance throughout nature, chitin, the principal component of fungus cell walls, or agar from red algae are all organic structures formed from polysaccharides. Chitosan, a water-soluble chitin derivative, stimulates the development of plant defenses. Chitin, on the other hand, is insoluble in water. Secreted polysaccharides from the capsular adaptations of bacteria, microorganisms, fungi, and microalgae improve surface adhesion and protect the organisms from drying out. Plants primarily consist of cellulose, which is the most common biopolymer. It is continuously created by photosynthesis and accounts for one-third to two-thirds of any plant tissue (14). Microfibrils of cellulose are organized in the cell wall, separated from one another by hemicellulose, and covered by a lignin matrix; cellulose is the principal structural constituent of plants and is responsible for their strength and durability. Crystalline cellulose in a plant's natural cell wall is linked with these chemicals, making it challenging to extract pure cellulose (15). Cellulose fibers are progressively replacing fiberglass as reinforcement fibers in thermosets due to their distinctive qualities, such as recyclability and low density, thermoplastic polymeric matrices, or high specific strength (16). The cellulose-containing plants include linen, wood, bamboo, linen, hemp, sisal, and jute.

Photocatalyst

Photocatalysis is a distinct category of chemical processes. It uses the energy provided by light to propel reactions that are difficult or perhaps impossible to carry out in darkness (17). The modern world is rapidly expanding as a result of industrialization. Despite the many benefits of industrialization, we must be mindful of environmental concerns. As a result of industrialization, major global issues such as water contamination are arising, compelling us to consider long-term solutions (18). The primary source of this problem is industrial effluent, which contains persistent and non-biodegradable organic compounds and is dumped directly into rivers and seawater. Textile dyeing is one of the most serious issues that can harm the environment and human health (19). To avoid the aforementioned issue, harmful chemicals such as colors and organic compounds must be degraded in wastewater. Traditional wastewater treatment systems involve a multitude of inefficient, costly, and complex physical, chemical, and biological processes (20). Therefore, it is necessary to create superior treatment technology for the degradation of wastewater containing dangerous chemicals. For the full mineralization of many organic dyes and hazardous compounds, semiconductor photocatalysis is a potential technology. The issue of water pollution has received a lot of attention recently (21). The photocatalysis of dyes utilizing metal oxides like TiO_2, CeO_2, or ZnO has been the subject of numerous investigations. Recently, (22, 23) MO (metal oxides) have been touted as among the most potential photocatalysts due to their capabilities as semiconductors with a substantial exciton binding affinity (60 meV) and a band edge (3.37 eV) (24, 25). However, its huge band gap means it can only absorb UV light, and the rapid recombining of electric charge is a significant barrier to achieving high photocatalytic activity. Numerous initiatives have been launched to boost the photocatalytic properties of MO to overcome these constraints. Various methods, such as the production of composite materials or noble metal doping, have been utilized to modify MO (26). Transition metals like Pt, Ag, and Fe among others can improve photocatalytic activity by facilitating charge transfer by collecting photoinduced charge carriers. It has been shown to increase photocatalytic activity in sunlight. Utilizing the plentiful and pure natural energy of the sun creates a fresh pathway for a photocatalytic procedure that is economically viable (27, 28).

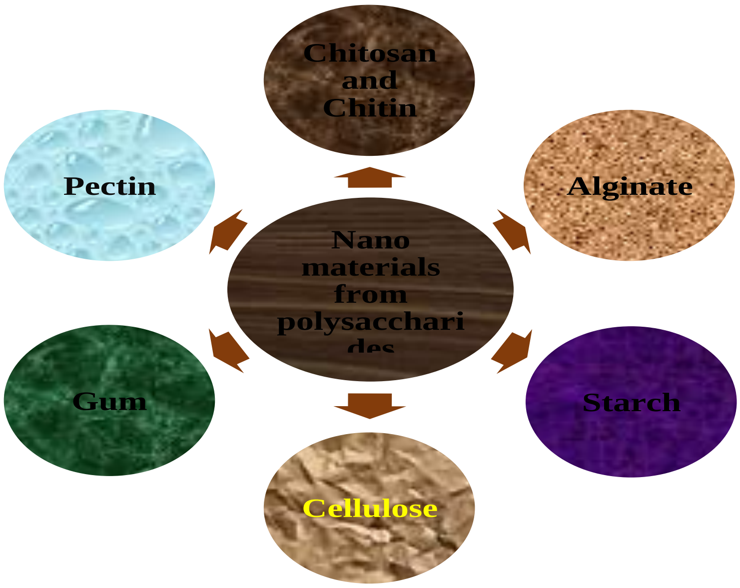

Fig.1: Eco-friendly organic polysaccharides (Self)

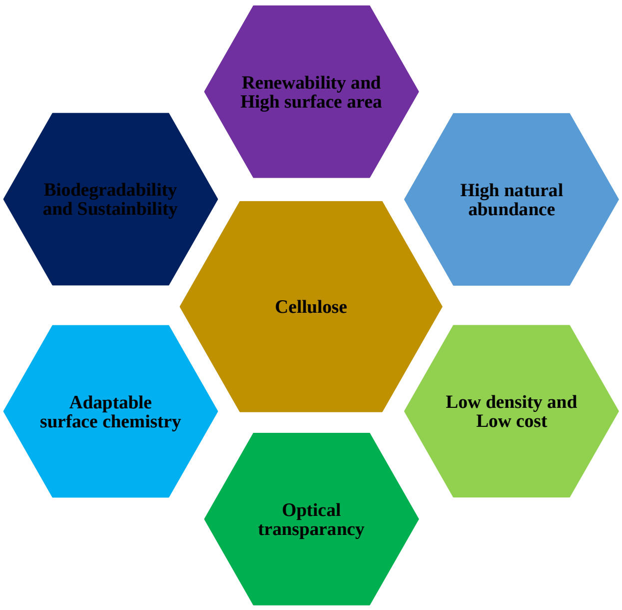

Fig 2: Superlative properties of cellulose (Self)

Light-harvesting materials depend on polysaccharides

Polysaccharides are paramount for light harvesting

The next most common biopolymers after cellulose are chitin and chitosan. A glycosidic linkage connects the functionalized surface groups to the long, linear, chain-like structure of these polysaccharide biopolymers (29). These biomaterials' distinct structural features translate into exceptional physical and chemical capabilities that have enabled the creation of materials with features as diverse as low population density, permeability, recyclability, spontaneous biocompatibility, or environmental friendliness. Deacetylation of chitin obtained via chemo-mechanical and ecologically sound biological processes yielded chitosan. Chitosan undergoes a series of chemical transformations during production, each of which results in a somewhat different set of characteristics. Thanks to their antibacterial, non-toxic, or biodegradable qualities as well as their simple production, these polymers may replace their synthetic analogs in environmental and energy applications (30).

Why polysaccharides are used as light-harvesting devices?

The increasing focus on components derived from polysaccharides stems from their unique properties and multifaceted applicability across diverse industries. Polysaccharides, complex carbohydrates formed by chains of monosaccharides, exhibit several distinct characteristics that make them highly sought-after: Sustainability and Biodegradability: Polysaccharides are predominantly sourced from renewable natural resources like plants, algae, and microbes. Their biodegradability offers a sustainable alternative to conventional materials, addressing concerns about environmental impact and resource depletion (31).

Biocompatibility and low toxicity: Many polysaccharides possess excellent biocompatibility and low toxicity, making them suitable for various biomedical applications. They can interact favorably with biological systems without causing adverse reactions, hence being utilized in drug delivery systems, tissue engineering, and wound healing.

Functional diversity: Polysaccharides exhibit a wide array of functional properties such as thickening, gelling, stabilizing, and emulsifying. These properties find applications across industries; for instance, in the food industry, polysaccharides act as stabilizers and thickeners, improving the texture and shelf life of products.

Health benefits: Certain polysaccharides, notably dietary fibers found in natural sources, contribute to improved health. They aid in digestion, regulate blood sugar levels, and promote gut health, leading to their inclusion in functional foods and dietary supplements.

Materials science innovation: Polysaccharides have sparked interest in materials science due to their potential in creating biodegradable plastics, films, and coatings. By manipulating their chemical structure or combining them with other compounds, researchers explore novel ways to develop sustainable materials for various industrial applications.

Customizability and modification: The versatile nature of polysaccharides allows for modification to suit specific requirements. By altering their structure or properties, scientists can tailor polysaccharides to meet targeted needs, expanding their potential in diverse sectors.

In essence, the emphasis on polysaccharide-derived components arises from their inherent advantages, aligning with the growing global emphasis on sustainability and eco-friendly solutions. Their versatility, combined with properties conducive to various applications, positions polysaccharides as pivotal components across industries, driving innovation and addressing contemporary challenges (32-35).

Characteristics of Chitin, Chitosan, and cellulose

Chitin, Chitosan

The extraction method and surface functional groups utilized to create chitin and chitosan determine their final qualities. Chitin's high thermal or crystallinity indices are a result of strong intermolecular interaction between its molecules. N-acetyl-d-glucosamine or d-glucosamine may be present in the polymers as separate building blocks. Among the many distinctions between chitin and cellulose, denitrification of chitin is the most crucial (36).

Thermal stability

Chitin and chitosan disintegrate when their glycosidic connections are broken. The first phase of thermal deterioration is linked to water evaporation and takes place between 50 to 110 °C. Saccharide rings and acetylated and derivatives unit's breakdown and hydrate in the second phase of heat degradation. Primary thermal deterioration peaked at 273 °C and occurred from 230 and 400 °C. Possible explanation: chain depolymerization results in volatile breakdown products (37).

Crystalline character

The crystallinity of the chitosan may be damaged during the deacetylation process that is used to extract it. According to the work that was reported, it was demonstrated that the extraction procedure had an impact on the crystallinity at various stages of the extraction process. Whenever N-acetyl-2-amino-2-deoxy-d-glucose accounts for more than 50% of the biopolymer, it is referred to be chitosan. One kind of chitin is chitosan. It has a higher crystallinity index value after being heated with both microwave and conventional heating methods (38, 39).

Cellulose

CNFs and CNCs have several uses in medications, nanocomposites, electronic components, pharmaceuticals, bioplastics, barrier films, membranes, super-capacitors, and cosmetics, for example. As a result of their unique properties, these nanomaterials have attracted a lot of attention as potential (nano) sorbents. While modified cellulose nanomaterials have shown promise in removing a wide range of contaminants, more research into their environmental effects is needed. Stability tests on the materials' non-toxicity and biodegradability are also warranted to ensure they are safe for use in wastewater treatment. For restorative applications, large quantities of cellulose nanoparticles are required. Even though these nanoparticles have environmental benefits superior to those of activated charcoal obtained from charcoal, these advantages need to be weighed against concerns regarding cost, accessibility, or life cycle impacts (40).

Using cellulosic nano- and microfibers, membranes have been developed for application in water management and treatment. Polymers like regenerated cellulose, conjugated polymers, polyester (vinylidene fluoride), polymer (ethylene oxide), polymer (ether sulfone), polymer (vinyl alcohol), or poly (acrylonitrile) have all been used to create membranes with nanomaterials like cellulose put into them (3-hydroxybutyrate) (41). For example, adding cellulose nanomaterials, which are very safe for humans and the environment and work well in pharmaceutical, biomedical, and environmental applications, The membranes developed by Yin, Deng et al. have improved tensile strength, hydrophilicity, excellent porosity, biofouling resistance, and selectivity (42). For polymers that aren't perfectly crystalline, such as amorphous or semi-crystalline ones, cellulose nanoparticles that homo-aggregate are a bad idea.

Polysaccharides as a sustainable material

Nowadays polysaccharide is used as light harvesting and sustainable devices

As a pesticide removal

Pesticides are one of the main organic contaminants in water bodies, and they are often cleaned up utilizing a range of technologies, including advanced oxidation processes, ozonation, ultrasound, photocatalytic degradation, and aerobic degradation (43, 44). For increased output, many agrochemicals are being used (45). The amount of 2,4-D that can be present in drinking water is 100 gL1 (46). The capacity of the chip to detect 2 photons was evaluated by first depositing fluorescent signal materials, known as Cd-Te quantum dots (QDs), onto cellulose papers, which served as the foundation material, 4-D in real-time is a novel and straightforward approach to produce fluorescent microfluidic paper chips (47).

As a dye removal

Organic dyes are sophisticated organic pollutants used to color a variety of products and come from several industries, including textile, printing, pulp and paper, tanning of leather, and cosmetics (48). Many of these carboxylate-modified CNCs are made by hydrolyzing microcrystalline cellulose with ammonium persulfate (APS) (49). Increasing the sorption capacity of cellulose-based nanomaterials through adsorption is one of the most researched methods. The insertion of pure nanocellulose into various nanocomposite hydrogels or polymers is one of the most basic methods for the production of reusable adsorbents. In several scientific fields, including the cleanup of harmful contaminants through adsorption and degrading processes, New, easily-recoverable CNCs are of critical importance, hence their development must be prioritized. The tensile performance of CNF films can be increased by the incorporation of metallic NPs, allowing for their reuse and prolonging their lifespan.

Role of polysaccharides in light harvesting device as a photocatalysis

The term "photocatalysis" refers to a chemical reaction that is normally defined as one that is initiated by the absorption of photons by a solid substance (photocatalyst) (50). On the other hand, there is a continuing debate regarding the correct way to characterize the photocatalytic process. It is important to point out that the chemical properties of the photocatalyst do not change either during or after the reaction. In the scientific literature, the terms "catalyst" and "photocatalyst" are frequently interchanged with one another. Photocatalysis can drive energy-storing processes (DG greater than 0), whereas catalysis is limited to thermodynamically feasible reactions (DG equal to 0). The rate of reaction, either absolute or relative, that occurs during a photocatalytic process is referred to as "photocatalytic activity." In a typical instance of photocatalysis, five separate processes take place.

Contamination transport to the surface of the photocatalyst;

Surface adsorption of pollution;

Adsorbed molecule activation and destruction by photons;

Products of reaction desorption;

Removal of reaction products from the surface of the photocatalyst;

It is possible to convey the fundamental idea behind photocatalysis by making use of a method that is quite well-known. When photocatalytic substances are subjected to sunlight with just an energy that is either greater or Electron-hole pairs are created at a rate equal to the material's band gap. This happens when sunlight energy is converted into chemical energy by photocatalytic materials. The formation of electron-hole pairs in the conduction band results in their disintegration into valence band electrons and holes. The molecules that bind to the surface of photocatalytic materials are reduced and oxidized as a result of the letters “e and h.” However, electron-hole recombination frequently happens, which would explain why there are no oxidation or reduction processes on the surface of the photocatalytic material (51, 52). The concepts of catalysis and photocatalysis are not the same. The concepts of catalysis and photocatalysis are not the same.

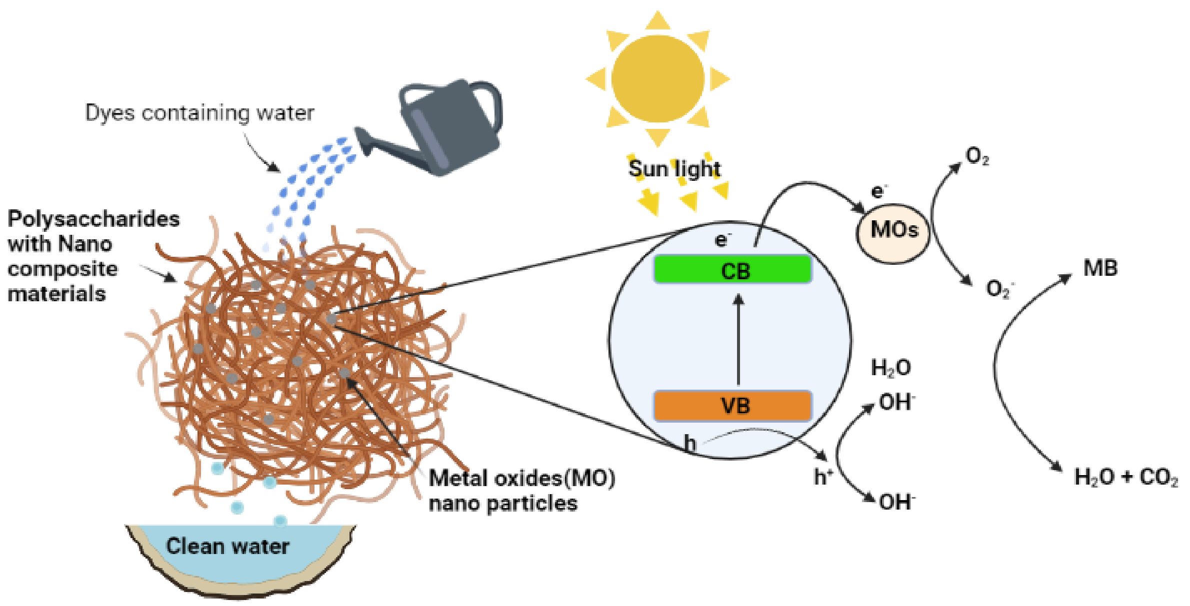

Fig. 3: Schematic diagram of adsorption and photodegradation by nanohybrid hydrogel

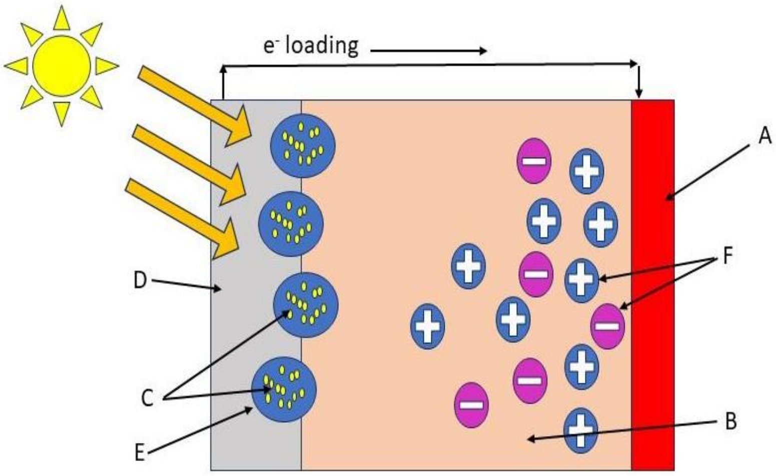

Fig.4: Cross-section of a dye-sensitized solar cell (self). A-Platinum electrode, B-Electrolyte, C-Sensitizing dye, D-Transparent conducting glass, E-Oxide based nanoparticles, F-Redoxing mediate

Role of polysaccharides in a solar cell

Dye-sensmediate.solar cells (DSSCs)

The electronic conduction in DSSCs is enabled by a coating of nanoparticle materials that have been fused at the center of the device. TiO2 (anatase), even though other wide-bandgap oxides, such as ZnO and Nb2O5, have also been investigated, has emerged as the material of choice. Charge transfer dye is deposited on the nanocrystalline film. Photoexcitation adds one electron to the oxide's conduction band. The oxide's photoexcitation causes this (53). Nanocrystalline (polysaccharide-based) MO film's light-absorbing capabilities (TiO2, ZnO, Nb2O5) Undoped (insulating) MO nanocrystallites (TiO2, ZnO, Nb2O5) operate as a dye-derivatized mesoporous sheet for light absorption. Carboxylate, phosphonate, and hydroxamate are used to graft the sensitizer onto MO (TiO2, ZnO, Nb2O5). MO (TiO2, ZnO, Nb2O5) becomes conductive when light-induced electron infusion from the adsorbed dye enters the nanocrystals. Low production cost, ease of fabrication, and aesthetic characteristics like color and transparency make DSSCs a popular solar energy conversion technology.

Figure 4 depicts the essential components of a DSSC. Solar energy interacts with semiconducting oxides, frequently MO (e.g., TiO2, ZnO, Nb2O5) nanoparticles doped with photosensitizer dyes to kick off the DSSC's standard operating procedure, which results in current flow across the anode plate of glass and on to the load. In a redox process, electrons are transmitted from of the electrolyte system via iodide ions to the photosensitizer dyes. The electrolyte is required for the oxidized dye sensitizer to regenerate. To accomplish this, electrolytes must be chemically, optically, electrochemically, thermally, and interfacially stable, as well as not cause the dye to desorb or degrade. Additionally, electrolytes are needed to swiftly diminish the oxidized dye and allow charge carriers to pass through to maintain a steady light energy conversion (54).

Solar cell

The open-circuit voltage of the DSSC cell is now 0.7 V, and the magnetic dipole current is 5 mA cm2; both improvements are attributable to the improved conversion efficiency. Once the optimal amount of Co3O4 was reached, this electrolyte's conductivity was 6,000 mS cm. The maximum ionic conductivity was found in a (CH2)3O2 Ni-agarose-electrolyte composite. The electrical performance of the sodium alginate polymer host was much improved by the addition of a KI salt and an MPI ionic liquid. The efficiency of energy conversion was 2.97 percent, while the voltage level was 0.58 volts. The density of the short-circuit current was 10.75 milliamperes every square centimeter. However, several considerations must be made regarding the quantum-dot penetration of the nano-structured electron conductor. QDSSCs are very similar to DSSCs in terms of how they work (55).

Polysaccharide-based solar cell

High solar power conversion rates are offered by organic solar cells, which are imitations of traditional methods for absorbing light from the surrounding environment. More than ten percent are genuine. It is possible to concoct a wide variety of molecule mixtures to address specific or extended spectral ranges preparing solutions for processing. The use of enormous regions of organic solar cell components has the potential to produce photovoltaics with significantly less embedded energy and significantly lower production costs. Emerging new methods for improving the efficiency of solar cell harvesting include light, plasmon augmentation, and spectrum reshaping.

Photovoltaic Cells Chitosan is the only polysaccharide that is commercially available and contains amino groups. In addition, it is the second most prevalent type of biomass on Earth, after cellulose. Chitosan became a promising material for cathode interlayers after hydroxyl or amino groups were added to its main chain. Researchers have shown a lot of interest in employing chitosan to make translucent films because of its net canonicity, which is essential for the advancement of solar energy-based cells.

Solar cells with a maximum efficiency of 10.18 percent were built by Zhang et al. to use a layer-by-layer (LBL) technique using egotistical chitosan with uniform changing thickness just on a nanoscale scale. The ordered pane structure of a solar cell, which can generate both molecular and interface dipoles, was thought to be the source of its improved efficiency. This performance improvement may be attributable to the fact that these dipoles were used to lower the electrode's work function. In comparison to cells without a cathode interlayer, the self-assembled chitin interlayer achieved an efficiency of power conversion of 9.34%, or around a 200% improvement in organic solar cells depicted schematically. Incorporating a chitosan-based polymer electrolyte, Buraidah et al. created a high-performance plasmonic color solar cell. Polypropylene oxide (PEO) was used in the chitosan solar cell between both the TiO_2/dye light electrode and the Pt auxiliary electrode. Using a straightforward solution casting method, we were able to add the ion donor NH_4I into this system. They consist of PEO (38.5%) and PEO (45%) and chitosan (16.5%). Improved NH_4I conductivity can be attributed to the fact that chitosan and PEO enhance electrolyte fluidity and ion mobility. Despite having the highest open-circuit voltages (Voc) at 0.39 V and the highest short-circuit frequency at 0.31(JSC value) mA/cm2, the red cabbage extract dye, or DSSC, had the lowest efficiency (0.06%). Solar cells dyed with blueberry extract produced lower JSC values (0.27 mA/cm2) and Voc values (0.34 V). After TiO_2 particles were introduced to the cell system, it increased efficiency from 0.06 to 1.13 percent (56).

Role of polysaccharides

Charge separation just at the interface of two different conduction materials is essential to photovoltaic systems. Due to its expertise and resources, the semiconductor industry has made solid-state junction devices, typically made of silicon, the standard in this field. Inorganic solid-state connection devices face competition from third-generation solar cells built on nanocrystalline and conducting polymer films. These products are easy to join the market and have low manufacturing costs. By substituting the semiconductor's contacting phase with an electrolyte, it's feasible to build a photo-electrochemical cell. Recent advances in nanocrystalline material fabrication and characterization have opened up many new possibilities for these systems. Contrary to expectations, mesoscopic semiconductor-based devices have achieved astonishingly high conversion efficiencies. The first is a dye-sensitized solar cell. It combines a broadband-gap semiconductor with a nanocrystalline sensitizer for optical absorption and charge separation. In most algal polysaccharide architectures, hydroxyl and ester groups are present. Ion transit is made possible by this. In a DC electric field, iodide ions (I) weakly linked with etheric oxygen groups can pass through oxygen-containing groups. Enhancing the cation front of and ionic conductivity of algal polysaccharides. Carboxymethyl k-carrageenan was created using mono-chloroacetic acid and k-carrageenan. While maintaining its amorphous structure, this bifunctional algal polysaccharide exhibited three times greater ionic conductivity. Hybrid carrageenan electrolytes' ionic conductivity is enhanced by carboxymethylation (57, 58). Chitin and chitosan-based composites create eco-friendly, low-cost alternatives to synthetic energy appliances. This is due to their net cationic charge, low cost, ease of processing, and abundance. The increasing need for sustainable materials required the manufacturing of chitosan for many uses. These applications include fuel cells, supercapacitors, and solar cells. The applications use chitosan (59).

The last two decades have seen a surge of research into these substances as a potential replacement for the traditional synthetic energy device. Recent years have seen many exciting experiments into using polysaccharides as just a polymeric electrolyte membrane or electrode in fuel cells. Because most biopolymer characteristics can be altered through deacetylation and functionalization, this could pave the way for a new generation of energy-related research involving biopolymer-based materials (60).

Conclusion

We conclude that polysaccharide is used for making many types of devices, useful applied-based materials, drug delivery systems, etc. Polysaccharides are most likely used as supportive materials for preparing many applied-based materials. Polysaccharides are eco-friendly and very easily available. Next, we can say that these are cost-effective materials. Polysaccharide gives unreactive support for the degradation of organic dyes with the help of nanocatalysts. Physical interaction between nanocatalysts and polysaccharides is very good compared with organic or inorganic catalysts.

Abbreviation

TEMPO: (2,2,6,6-Tetramethylpiperidinyloxy or 2,2,6,6-tetramethylpiperidine-1-oxyl)
CNC: Cellulose nanocrystal
CNF: Cellulose nanofibers
CB: Covalent band
VB: Valence band
MP: 1-methyl-3-pentyl-imidazolium
Jsc: Changes linearly with light intensity
Voc: Changes logarithmically

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Author contributions

Conceptualization and Supervision – Dr. Hardik Bhatt, Dr. Gayatri Prasad.
Investigation, writing, and editing- Jitubhai Morabiya and Sanjay Bamaniya.
All authors have read and agreed to the published version of the manuscript.

Conflict of interest

The authors declare no conflict of interest.

Ethics approval

This work was completely self-investigated and all generated data are from the Google Scholar literature survey Given that all the figures are drawn by the author, further no need for any approval.

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