Chapter 12
Role of Algae in the Production of Biomaterials

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ABSTRACT

Algae have drawn a significant attention for the manufacture of biomaterials with unique features and extraordinary uses because of its large yields, short growth time, and variable culture conditions. Algal polymers, blends, and combinations of biomass or algal biomolecules with other polymeric materials are examples of algae-based materials. Polysaccharides and sulfate polysaccharides such as agar, carrageenan, alginates, and polyhydroxyalkanoates are essential algal polymers. Algal and biomass polymers have improved mechanical characteristics, biocompatibility, and biodegradability when included into synthetic polymer systems. Algal-based biomaterials are interesting contenders to replace existing, non-renewable polymer materials derived from fossil fuels. This chapter discusses the numerous applications of biomaterials obtained from algae. Furthermore, as biotechnology advances, algae-based polymers, blends, and composites have found many applications in a variety of domains of human existence, ranging from medicinal applications to sophisticated technological applications.

INTRODUCTION

Green materials that are renewable and biodegradable are aimed to produce and develop due to the shortage of non-renewable petroleum resources and their impact on the environment (Xia et al., 2017) at a rate 25 x 10^6 tonnes/year (Balaji et al., 2013). Green materials include bioplastic, biopolymers, and bio-composites which are driven from the bio-based materials like agricultural waste, feed stock, and plant proteins like corn zein, wheat protein, sunflower protein, and soy protein (Xia et al., 2017) to reduce greenhouse gases. Increasing population results in more production of these green materials, this would

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be burden on the food, arable land, water supply, and would lead to the competition. There are three types of feedstocks: 1st generation feedstocks comprise edible biomass such as maize, sugarcane, and whey, which contributes to food competition in society; 2nd generation feedstocks contain non-edible biomass such as lignocellulosic feedstocks from wastes such as agriculture, forest, or energy crops, which leads to competing for land use and soil replenishment. To overcome the competition for food, agricultural land, and their byproducts, micro-algal biomass, a 3rd generation feedstock with high biomass and CO_2 capture potential (Coppola et al., 2021a; Hjuler & Hansen, 2018), is an excellent alternative to produce green materials. Alga, also known as water plant or seaweeds are present in marine, fresh, and waste water environment (Gautam & Mannan, 2020); are autotrophic organisms having capacity to transform CO_2 into biomass including carbohydrates, proteins, lipids, and fats. They are microscopic organisms having fast doubling time, requires less space and water, classified as macroalgae and microalgae. Both these algae are excellent source of vitamins, proteins, fats, carbohydrates, fibers, lipids, and secondary compounds. Macroalgae are multicellular organisms having chlorophycease, phaeophyceae, rhodophyceae, brown algae, and red algae while microalgae are microscopic having diatoms, blue green algae, and dinoflagellates (Sanjeewa et al., 2016). High-performance biodegradable polymers must be blended with low-cost macromolecules like natural fibers, proteins, and starch to develop green materials like bioplastics. Plastics have become the most extensively used material in today's society, with applications in medical devices, computer equipment packages, domestic appliances, and automobiles. (Balaji et al., 2013). Polymers, or solid macromolecules, on the other hand, are so linked with people in every part of life that it is difficult to fathom living today without them. They come from a range of sustainable sources, and because they are easy to sterilize, biodegradable, and have a long shelf life, they do not create any hazardous or inflammatory reactions (Azeem et al., 2017). Algae-based biopolymers have better mechanical properties than petroleum-based polymers, and they can be modified by adding plasticizers, additives, and compatibilizers to improve their durability, strength, and flexibility (Onen Cinar et al., 2020). The use of algae as a natural fiber to build bio-composite from residual biofuel process of extraction or water reservoir (Constante et al., 2015) is advantageous since it does not harm the environment. This chapter reviews important green materials like bioplastics, biopolymers, and bio composites derived from algae.

BIOPLASTICS

Plastics play an important role in everyday life as they have undoubted utility and convenience but they are synthesized from non-biodegradable petroleum which put up two major world crises-depletion of fossil fuels and degradation of environment by accumulating in marine and terrestrial region (García et al., 2021). Plastics are produced by chemical synthesis of polymers whose molecular weight is comparatively high. Synthetic plastics, derived by poly-condensation, polymerization or poly-addition of monomers can be grouped into four categories- thermosets, elastomers, synthetic fibers, and thermoplastics. The most common synthetic polymers are polyethylene (PE), polystyrene (PS), polyvinyl chloride (PVC), polycarbonate (PC), polypropylene (PP), and polyamides (PA). These plastics have slow breakdown, hence non-biodegradable (Coppola et al., 2021a). To overcome plastic waste accumulation in the world, an environmentally friendly, renewable and biodegradable substitute, bioplastics have taken much attention (García et al., 2021).

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