Chapter 2

Non-Wooden Cellulose Materials Sourced From Plant Wastes

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ABSTRACT

Cellulose is the most abundant plant waste material, making it a strong candidate to replace petroleum products as a future polymer material. Since cellulose is also abundant in food wastes, upcycling technology to obtain functional materials from these wastes is reviewed from the perspective of resource recycling. Cellulose, which is particularly difficult to handle as a material, has the property of being insoluble in solvents due to its strong cohesive nature. For this reason, recycled cellulose also is discussed as regenerative celluloses. However, compared to these chemically modified celluloses, the utilization of biomass cellulose fibers obtained from plant waste, which are a less scientific process and inexhaustible, enable to contribute to a sustainable society. The current status and technology of unmodified cellulose fibers is presented.Especially, the properties of cellulose hydrogels, which are agglomerated cellulose, and films are introduced in this chapter.

INTRODUCTION

Humanity's social life and profit-seeking economic society have prioritized affluence and we now face the collapse of the global environment and are being forced to take countermeasures. Under these circumstances, we are now opening the door to economic vitality rooted in a low-carbon and recycling-oriented society. But contrary to this trend, plenty of wastes is produced due to the increase activity of agricultural, food and paper industry representing a tremendous challenge for the environment. Mean-

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while, industrial waste products are considered as the promising and the suitable material to meet the growing demand for feedstock in terms of resource depletion and conservation of environmental resources (Jawaid & Khalil, 2011). Following this social trend, the conversion of currently underutilized wastes into resources is necessary for the economy to coexist in harmony with nature (Kobayashi, et. al 2022). Reflecting the seriousness of the huge annual disposal of petroleum-based plastics, sustainable green materials are becoming an interesting alternative. Therefore, it is essential to reduce the plastic availability of non-biodegradable petrochemical-based materials, and alternatives such as biomass-based materials are attracting attention. So, it is inevitable that biomass increasingly used in the development of biodegradable films would become value-added bioproducts, and the following approaches can be considered. Natural and non-synthetic polymers are attracting attention to overcome environmental problems, and biomass-derived materials will contribute significantly to a low-carbon society. As a material that can replace synthetic plastics derived from petroleum resources, biomass-derived materials are attracting attention now. Among these sources, as a usual biomass material, polysaccharide is well-known and representative natural polymers like cellulose, which is the most abundant source in the biosphere. In particular, cellulose waste, which has high content of raw materials, is a promising biomass alternative source like food waste and agro-waste. For example, several plants waste of bagasse and agro-waste of bamboo, banana, corn stalks, coir, rice and husk and also oil palm waste are mostly popular sources and the cellulose contents in them are abundant in natural cellulose fiber (Joshi et al., 2004, Jawaid & Abdul Khalil, 2011; Kalia et al., 2009). However, cellulose fiber is found with other materials such as lignin, hemicelluloses and pectin and the percentage in each fiber depend on fiber source, variety, harvest conditions and more (Doree, 1947). For the regenerated cellulose processes from such sources, cellulose has stiffness structure with microfibriles having hydrophilic and hydrophobic parts with complexity structures of the partial crystalline (Swatloski et al., 2002). Therefore, the isolation of cellulose fiber from waste products needs intensive treatment. There are several methods for cellulose obtaining from fibers such as chemical treatments, mechanical treatment, and chemo-mechanical treatment. However, the regenerated cellulose process is limited in dissolving cellulose due to the rigid structure of microfibrils, which have hydrophobic portions and a complex structure of partial crystals (Swatlowski et al., 2002). To date, several studies have been conducted on solvents that dissolve cellulose, especially for solvent systems providing an unstable structure of ether, ester, and acetal derivatives like cellulose acetate, cellulose nitrate, and cellulose xanthate (Heinze & Liebert, 2012). Such regenerated celluloses are fibers that are created by chemically dissolving cellulose and then regenerating it into fibers. These fibers are produced by dissolving cellulose in specific solvents and regenerating by precipitating in an aqueous medium. But there are not many reports on unmodified cellulose (Figure 1). In recent years, there has been a trend to reconsider the use of conventional plastics, which cause oceanic problems such as microplastics (Li, 2007) and require huge amounts of energy to produce, however, this is in contrast to the issue of a low-carbon, recycling-based society. In addition, the recent trend toward energy reduction through lighter weight materials is also driving progress in the study of cellulose-added reinforcing materials. For these reasons, Japan's Ministry of the Environment has been focusing on cellulose nanofibers (hereafter referred to as CNF), a plant-derived material (Japan ministry environment, 2021).

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