International Journal of Biological Macromolecules 103 (2017) 508–514

Contents lists available at ScienceDirect

International Journal of Biological Macromolecules

journal homepage: www.elsevier.com/locate/ijbiomac

Review

An overview of natural renewable bio-polymer lignin towards nano and biotechnological applications

Selvaraj Mohana Roopan

Chemistry of Heterocycles & Natural Product Research Laboratory, Department of Chemistry, School of Advanced Sciences; VIT University, Vellore 632 014, India

ARTICLE INFO

Article history:
Received 6 March 2017
Received in revised form 31 March 2017
Accepted 16 May 2017
Available online 18 May 2017

Keywords:
Lignin
Bio-polymer
Nanoparticles
Anti-microbial
Anti-oxidant

ABSTRACT

Lignin were said to be major bio-polymer next to cellulose which is an abundant biopolymer. This type of lignin was mostly isolated from woods which were named after their physical, morphological appearances and majorly on extracting sources. Still now there are very few reports on isolation, identification of pure lignin and isolating pathways are also not well defined. Molecular weight of lignin varies from thousands to ten thousands which are not explored accurately. Even-though lignins were surrounded by these many hurdles it has various application studies which were studied and reported. Nowadays researchers focused on synthesizing lignin nanoparticles which were subjected for various application studies in day today life. This lignin contains wide range of applications in several fields like medicinal, industrial, pharmaceuticals, etc., Most of the researcher are focused on applications like anti-oxidant and microbicidal agents. So this review will comprises of outlook of bioprocessing lignin and its application focused on nanoparticles synthesis, anti-oxidant and microbicidal agents. This was the first review on renewable bio-polymer lignin with its bio-pharmaceutical and nanobiotechnological applications.

Contents

1. Introduction

A polymer which contains aromatic substance usually derived from phenylalanine were said to be lignin [1].This lignin was said to be second most abundant bio-polymers present in terrestrial ecosystems which contains organic carbon 30% approximately [2].This type of polymers performs its role of safeguarding polysaccharide components by formation of matrix layer in plant cell walls [3]. Even though lignin were said to be heterogeneous towards chemical reactions and structural complex, it contains various functional groups like thiols, aliphatic hydroxyl and phenolic hydroxyl [4]. Lignin contains rigid structural formation for tracheophytes to stand erect and also to the cell wall surface with the help of these functional groups [5]. However mainly the functional groups present in lignin are mostly result in abundance due to usage in reinforcing filler for rubbers, plastics, foamed and elastomers, and also in composite materials [6–8].Mostly commercial available lignin cannot be obtained in nanometers due to these reasons it exhibits different properties in microfiller containing composites. The reinforcing effect of lignin for polymer matrix intensively

Abbreviations: MWL, mild wood lignin; MBC, minimum bactericidal inhibition; MIC, minimum inhibitory concentration; ATCC, American type cell culture; ORAC, oxygen radical absorption capacity; DPPH, 1,1-diphenyl-2-picrylhydrazyl; ABTS-2, 2′-azino-bis(3-ethylbenzothiazoline-6-sulphonic acid); GPC, gel permeation chromatography; THF, tetrahydrofuran.

E-mail addresses: mohanaroopan.s@gmail.com, mohanaroopan.s@vit.ac.in

http://dx.doi.org/10.1016/j.ijbiomac.2017.05.103
0141-8130/

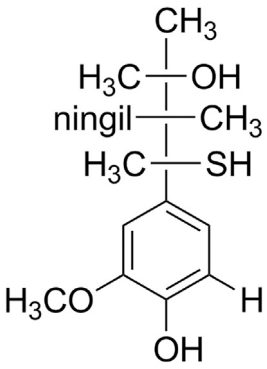

Fig. 1. Structure of lignin.

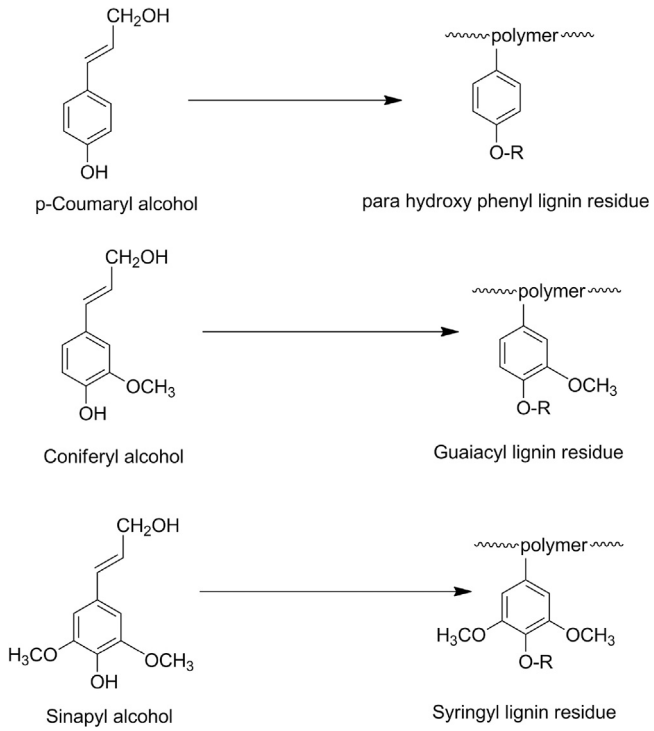

Fig. 2. Structure three monolignols.

depends on particle size and strong interfacial bonding with the matrix [9]. Lignin was first mentioned by a botanist in Swiss named A.P. de Candolle. He described it as fibrous material which can collect by the method of precipitation by using various acidic solutions [2]. Mostly lignin's were divided into three major groups like grass lignin's, softwood lignin's and hardwood lignin's. Inspite of that mostly lignins were separated or isolated from wood are typically called as mild wood lignin (MWL) or enzymatically liberated lignin. According to the starting material, naming of lignin varies like lignin with alkali nature, lignin in the form of Kraft and lignosulfonates are extracted from various natural sources [10]. The physical appearance of isolated lignin were said to be brown in color with amorphous powder in nature. This physical appearance may vary for each fraction of isolation and also its characteristic feature also may change. One of the major applicational properties of lignin is to absorb UV-light which may differ according to its physical and chemical parameters [11].Lignin composition was varied from one species to another species with the main constituents of carbon, hydrogen, oxygen and ash with the chemical formula of $(C_{31}H_{34}O_{11})_n$ [12] with the molecular weight ranging from thousands to some ten thousands, still not yet explored clearly [13]. Lignin can also be utilized as various alternative sources for energy with high sustainability [14]. In lignocellulose biomass membrane lignin consists of 10–25% which was completely insoluble in water [15–17]. Lignin structure consistsof three dimensional cross linked macromolecules were illustrated in (Fig. 1)with three sub-divisions of alcohols namely Sinapyl, Coniferyl and *P*-coumaryl alcohol with various lignin residues were clearly illustrated in (Fig. 2) and also it can acts as building blocks in phenyl propanoid pathway shown in (Fig. 3) and which helps in precipitation of lignin while adding acidic solutions [18,19].By enhancing the carbohydrates hydrolysis one can remove various parameters of lignin but this technique was completely based on the lignin structure which is not yet developed clearly in the field of pre-treatment of lignin [20]. Lignin can be stated as one of the natural and renewable raw material which was majorly isolated from wood pulp, jute, hemp and cotton and also cheaply available with high properties of physical and chemical parameters [21].Lignin plays major application role in several fields which includes paints, fuels, dyes, sequestering, floorings dispersal agents, etc., were studied and reported [22].Lignin were said to be major interest in several areas of industrial and science sectors for carrying his potency towards various biological applications [23]. In industrial sectors ethanol is based on second generation biomass

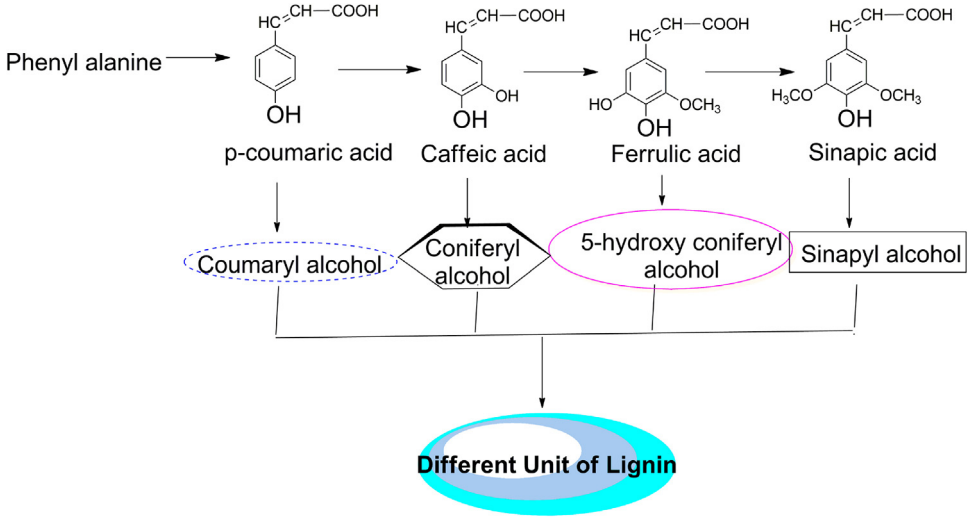

Fig. 3. Phenyl propanoid pathway.