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# Actinobacteria: A Promising Source of Enzymes Involved in Lignocellulosic Biomass Conversion

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**Abstract**

Lignocellulosic materials are the most abundant and bio-renewable biomass on Earth, However, the breakdown of their major components (Cellulose, hemicellulose and lignin) requires the actions of different types of lignocellulolytic enzymes. Actually, several studies report that bacterial species belonging to Actinobacteria are able to produce a wide array of valuable enzymes implicated in biomass decomposition. In this mini-review, we attempt to provide an overview of the actinobacterial enzymes mainly involved in biomass conversion.

**Keywords:** *Actinobaceria*; lignocellulosic biomass; Enzymes; Conversion; Breakdown

## Introduction

Lignocellulosic materials (plant cell walls) are the most abundant and bio-renewable biomass on Earth with more than 150 billons of tons produced annually [1,2]. Lignocellulose in nature derives from agricultural residues, forest-based woody materials and municipal and industrial solid wastes. However, the natural recalcitrance of these materials is the main obstacle for the separation of the major components [3]. Among the pretreatment methods used to break biomass recalcitrance, biological methods based on microbial enzymes, appear to be a promising technique without risks, low energy input and low capital costs [4]. Currently, *actinobacterial* enzymes are extensively studied due to their high efficiency in the bioconversion of biomass into interesting derived products [5,6]. In the same context, the present mini-review mainly contemplates on the actinobacterial enzymes involved in lignocellulosic biomass conversion.

### Composition, structure and degradation of lignocellulosic biomass

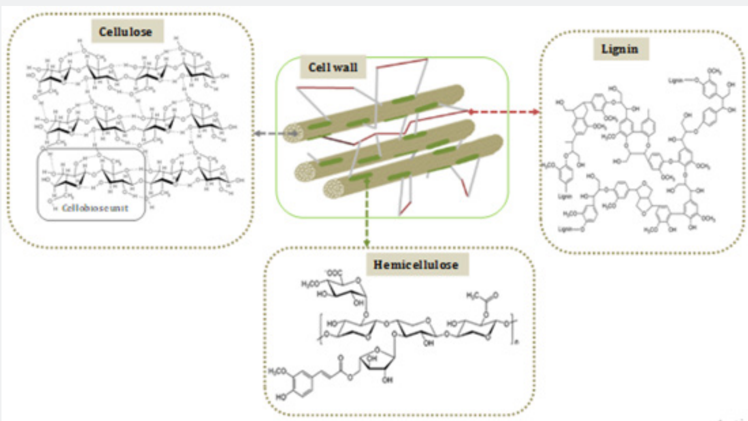


**Figure 1:** The main components and chemical structure of lignocellulosic biomass.

Lignocellulosic biomass is mainly composed of three major polymeric components namely cellulose (30-50%), hemicellulose (20-35%) and lignin (10-25%) that are strongly interlinked [1,7-9] (Figure 1). Cellulose is the major component of fibrous lignocellulosic material consisting of glucose and arabinose units linked by β-1,4 glycosidic bonds forming cellobiose molecules connected together by hydrogen bonds. The complete breakdown of cellulose requires the synergistic action of three types of cellulolytic enzymes (Endoglucanases, Exoglucanases and β-glucosidases) [6]. Hemicellulose is the second constituent of lignocellulose composed of hexoses (mannose), pentoses (xylose) and sugars acids. The complete degradation of Xylan the most important carbohydrate component found in hemicelluloses requires the cooperative action of a variety of hydrolytic enzymes such as endo-1,4-b-xylanase (endo-xylanases, exo-xylanases), xylan 1,4-b-xylosidase and xylan esterases [10]. Lignin is the last major part of lignocelluloses, basically composed of phenylpropane units linked to each other by the irregular coupling of C-C and C-O. Lignin degradation is mediated by three principal enzymes namely laccases, manganese peroxidases, and lignin peroxidases [11].

### Actinobacteria: a source of lignocellulolytic enzymes

Actinobacteria are Gram-positive bacteria with high G+C content. They are ubiquitous in nature, found in different ecological niches [12]. The abundance, the diversity and the ability of Actinobacteria to colonize different ecological niches, have drawn considerable attention of the scientists to search novel enzymes with broader range of tolerance to environmental conditions [13]. Various studies have evaluated the lignocellulolytic ability of Actinobacteria (Table1). In the case of cellulose, the genera *Streptomyces*, *Cellulomonas* and *Acidothermus* were reported as promising source of endocellulases [14-16], whereas exocellulases were found in Thermobifida, *Cellulomonas* and *Cellulosimicrobium* genera [17]. On the other hand, species belonging to the genera *Sreptomyces*, *Clavibacter*, *Terrabacter*, *Micrococcus* and *Microbacterium* were widely studied for the production of β-Glucosidases [18,19]. Enzymes as xylanases involved in biotransformation of hemicellulose were reported in multiple genera, including *Streptomyces*, *Cellulomonas*, *Cellulosimicrobium* and *Kocuria* [10,20]. Lignin-degrading enzymes were mainly studied for fungi, but recent reports showed that Actinobacteria are able to breakdown lignin. Indeed, 10 laccase enzymes with industrial importance were reported in *Streptomyces* genus [21]. Other studies also reported peroxidase secretion by Nocardia, *Rhodococcus*, *Streptomyces* and *Nonomuraea* [22-24]. These studies represent recent examples research attempts interested to potential utility of Actinobacterial enzymes in breakdown of lignocellulosic biomass as well as in different industrial applications.

**Table 1:** Actinobacterial enzymes involved in breakdown of lignocellulosic biomass.

| Biomass polymers | Enzymes | Producers(*Actinobacteria* gernera) | References |
|---|---|---|---|
| Cellulose | Endo cellulases | *Streptomyces, Cellulomonas Acidothermus* | Ventorino [16] Enkhbaatar [14] Yin [15] |
| | Exo cellulases | Thermobifida, *Cellulomonas* and *Cellulosimicrobium* | Song JM [17] |
| | β -glucosidases | *Sreptomyces*, *Clavibacter*, *Terrabacter*, *Micrococcus* and *Microbacterium* | An [18] Quan [19] |
| Hemicellulose | 1,4- β-Xylanases (Endo-xylanase and exo-xylanases) | *Streptomyces, ellulomonas, Cellulosimicrobium* and *Kocuria* | Maehara [10], Lisov [20] |
| Lignin | Laccases | *Streptomyces* | Fernandes [21] |
| | Peroxidases (LiPs, MnPs, and VPs) | *NonomuraeaNocardia, Rhodococcus, Streptomyces* | Ahmad [22] Casciello [24] Sugawara [23] |

LiPs: lignin peroxidases; MnPs: Manganese peroxidases; VPs: Versatile peroxidases.

## Conclusion

It is interesting to note that the screening of Actinobacteria with high ability for producing a wide range of lignocellulolytic enzymes, support their efficient contribution to biomass conversion. This may contribute to promote various biotechnological applications.

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