Review Article

International Journal of Bioassays
ISSN: 2278-778X
www.ijbio.com

LACCASES: SOURCES AND THEIR ENVIRONMENTAL APPLICATION

Vinit Kumar and Preeti Sonkar*
Institute of Environment & Development studies, Bundelkhand University, Jhansi (U.P.), India

Received for publication: April 22, 2013; **Accepted:** May 17, 2013

Abstract: Pollution increased day by day, laccase are an oxido reductases enzyme which play a significant role in remediation. Production of laccase has sink from plant, fungi, bacteria, and insect etc. Present study on their use in several industrial applications, includes dye decolourization, detoxification of environmental pollutants and revalorization of wastes and wastewaters etc. Here we provide a brief discussion of this interesting group of enzymes, increased knowledge of which will promote laccase based industrial processes in future.

Keywords: Laccase, Biodegradation and Bioremediation, Decolorization.

INTRODUCTION

Laccases (benzenediol: oxygen oxi-reductase, EC 1.10.3.2) exist widely in nature and belongs to small group of enzymes called the blue copper protein or cupper oxidases (Sivakumar *et al.,* 2010). These proteins are characterized by containing copper atoms. One copper is placed at the T1 site, where reducing substrate binds, and other three coppers are clustered in which molecular oxygen binds.

Laccases play an important role in several industry, paper and pulp industry, textile industry, synthetic chemistry, cosmetics, soil bioremediation and biodegradation of environmental phenolic pollutant and removal of endocrine disruptors. Recently laccases have been efficiently applied to nano biotechnology due to their ability to catalyze electron transfer reactions without additional cofactor (Shraddha *et al.*, 2011). In future, laccase are a useful enzyme for biotechnological application in decolorization and biodegradation of contaminating environmental pollutants. Laccases have many biotechnological applications because of their oxidation ability towards a broad range of phenolic and non-phenolic compounds (Mohammadian *et al*., 2010).

Laccases source:

In 1883, yoshida first described laccase when he extracted it from the Japanese lacquer tree, *Rhus vernicifera.* In 1896 laccase was demonstrated to be present in fungi for the first time by both Bertrand and laborde. Laccase are widely distributed in higher plants, bacteria, fungi, and insects which detail are present in below as:

Plant: Cabbages, Turnips, Beets, Apples, Asparagus, Potatoes, Pears, Peach, sycamore, tobacco and various other vegetables. Recently, laccase has been expressed in the embryo of maize (*Zea mays*) seeds (Bailey *et al.,*2004; Arora and Sharma, 2010).

Fungi: Fungal laccases have higher redox potential than bacterial or plant. Fungi from the deuteromycetes, ascomycetes (Aisemberg *et al*., 1989) as well as basidiomycetes are the known producers of laccase (Sadhasivam *et al*., 2008) which name detail as:

(A) Ascomycetes: *Monocillium indicum* was first laccase to be characterised and *Polyporus versicolor, Neurospora crassa* and *Aspergillus nidulans* etc.

(B) Basidiomycete: *Schizophyllum commune, Phanerochaete chrysosporium, Theiophora terrestris, Lenzites, Betulina*, White-rot fungy (*Phlebia radiate, Pleurotus ostreatus, Trametes versicolour*), *Trametes fungy, Coriolopsis fulvocinerea* and *Cerrena unicolor* etc.

Other wood-rotting fungi include *T. hirsuta* (*C. hirsutus*), *T. villosa*, *T. gallica*, *Cerrena maxima*, *Lentinus tigrinus*, *T. ochracea*, *Pleurotuseryngii*, *Trametes* (*Coriolus*) *versicolor* and *Coriolopsis polyzona*, etc. (Morozova *et al.,* 2007).

(C) Deuteromycete: Production of laccase by a newly isolated fungus was *Pestalotiopsis sp.* (Hao *et al., 2007).*

Bacteria: Bacterial laccase was first reported in *Azospirillum lipoferum* (Givaudan *et al.,* 1993); it plays a role in cell pigmentation, oxidation of phenolic compounds (Faure *et al.,* 1994, 1995) and/or electron transport (Alexandre *et al.,* 1999). Other name as *E. coli, Bacillus subtilis, S. laven dulae, S. cyaneus, Marinomonas mediterranea, Aquifex aceolicus, Azospirillum lipoferum, Bacillus sp., Bacillus halodurans, Leptothrix discophora SS1, Oceano bacillusiheyensis (cotA), Alpha-*

***Corresponding Author:**
Preeti Sonkar,
Institute of Environment & Development studies,
Bundelkhand University,
Jhansi (U.P.), India.

proteobacterium SD21, Gama-proteobacterium JB, Pseudomonas fluorescens GB-1, Pseudomonas maltophila, Pseudomonas putida GB1 (cumA), Pseudomonas syringae pv tomato (copA), Pseudomonas aerophilum (pae1888), Streptomyces antibioticus, Streptomyces griseus (epoA), Thermus thermophilus HB27, Xanthomonas campesteris (copA) and *Streptomyces psammoticus* MTCC 7334 etc. (Sharma *et al.,* 2007).

Insect: The insect laccase is a long amino-terminal sequence characterized by unique domain consisting of several conserved cysteine, aromatic, and charged residues. laccase enzyme has also been characterized in different insects, e.g., *Bombyx, Calliphora, Diploptera, Drosophila, Lucilia, Manduca, Musca, Orycetes, Papilio, Phormia, Rhodnius, Sarcophaga, Schistocerca* and *Tenebrio* (Arora and Sharma, 2010). Recently, two isoforms of laccase 2 gene have been found to catalyse larval, pupal and adult cuticle tanning in *Tribolium castaneum* (Arakane *et al.,* 2005; Sharma and Kuhad, 2008).

Laccases are classified into two groups in accordance with their source, i.e. plant and fungal. However, diphenol oxidases (Laccases) have also been identified in bacteria and insects (Shleev *et al*., 2004).

Role of laccase producing organism in environmental pollutant:

One of the goals of present work was to study and thoroughly compare the properties of laccase. Laccase is also used in bioremediation agent to clean up herbicides, pesticides and certain explosives in soil. Present time attention of researchers in the last few decades due to their ability to oxidize both phenolic and nonphenolic lignin-related compound as well as highly recalcitrant environmental pollutants (Shraddha *et al.,* 2011).

Phanerochaete crysosporium (TL1), laccase would be a good target for the development of biotechnological tools because of its laccase in lignin degradation, phenol degradation, waste water treatment and others industrial application. 2, 6 dichlorophenol is one of the most dangerous environmental contaminants. Under the experimental condition purified laccase is able to convert 2, 6 dichlorophenol directly, this result investigated by Xiao. *et al.,* 2003 (Prabu *et al.,*2006).

Dye decolorization: The treatment of industrial effluents containing aromatic compounds is necessary prior to final discharge to the environment (Khlifia *et al*., 2010). Nowadays, environmental regulations in most countries require that wastewater must be decolorized before its discharge (Moilanen *et al*., 2010) to reduce environmental problems related to the effluent (Tavares *et al*., 2009). A wide range of physicochemical methods has been developed for the degradation of dye-containing wastewaters (Vandevivere *et al*., 1998; Tavares *et al*., 2009). These classical processes can cause a problem in environment and better treatment can be obtained using bioprocesses. *T. versicolour* to be treat a black liquiors discharge for detoxifying and reducing the color, aromatic compound, COD etc. (Blanquez *et al.,* 2004). *S. maltophilia* to be decolorize some synthetic dyes (methylene blue, methyl green, toluidine blue, congored, methyl orange, and pink) as well as the industrial effluent(Romero *et al.,*2006). A newly isolate deuteromycete fungus *pestalotiopsis sp*. have high potential producer of industrially important laccase and decolorization of azo dye (Hao *et al*., 2007). Laccases from the white-rot fungi Cerrena unicolor and Trametes hirsuta for their ability to decolorize simulated textile dye baths (Moilanen *et al*., 2010).

Bioremediation and Biodegradation: Keum and Li obtained laccase from *T. versicolour* and *Pleurotus ostreatus* for degradation of PCB as well as phenol. *T. versicolour* is used for the bioremediation of atrazine in soil (Shraddha *et al.,* 2011). *T. villosa* remediates the soil by degrading 2, 4-DCP (2, 4- dichlorophenol). *Cerrena unicolosr* has the capability of reducing lignin content from sugarcane bagasse (D'sauza *et al.,* 2009). Decolourization and detoxification of a textile industry effluent by laccase from *trametes trogii* (Imran *et al.,* 2012). Large amount of polyphenol is present in the beer factory wastewater which is dark brown in colour and degraded by the white-rot fungus *Coriolopsis gallica* (Yague *et al*., 2000). Laccase produced from Trametes sp. bioremediate the distillery wastewater generated from the sugarcane molasses fermentation with high content of organic matter (Gonzalez *et al.,* 2000).

Laccase application in insects: Epidermis of the tobacco bornwarm, *manduca sexta*, and may oxidize toxic compounds ingested by insect (Diltmer, *et al*., 2004). Recently, a laccase in the salivary glands of *N. cincticeps* was identified. Salivary laccase rapid oxidization of potentially toxic monolignols to nontoxic polymers during feeding (Hattori *et al.,* 2005).

CONCLUSION

Laccases are produced by various sources like fungi, bacteria, plant, insects etc. They have many industrial applications because of their innate ability of oxidation of phenolic and nonphenolic compounds. Laccase enzyme has the property to act on a range of substrates and to detoxify a range of pollutants. They deccolorize and detoxify the industrial effluents and help in wastewater treatment. They act on both phenolic and nonphenolic lignin-related compounds as well as highly recalcitrant environmental pollutants which help researchers to put them in various biotechnological applications.

REFERENCE

1. Alexandre G, Bally R, Taylor BL, Zhulin IB. Loss of cytochrome oxidase activity and acquisition of resistance to quinine analogs in a laccase-positive variant of *Azospirillum lipoferum.* J. Bacteriol., 1999, 181: 6730-6738.
2. Arakane Y, Muthukrishnan S, Beeman RW, Kanost MR, Kramer KJ. Laccase 2 is the phenoloxidase gene required for beetle cuticle tanning. *PNAS., 2005,* 102: 11337-11342.
3. Arora DS, Sharma RK. Ligninolytic Fungal Laccases and Their Biotechnological Applications. Appl. Biochem. Biotechnol., 2010, 160:1760–1788.
4. Bailey MR, Woodard SL, Callawy E, Beifuss K,Lundback MM, Lane J. Improved recovery of active recombinant laccase from maize seed. *Appl Microbiol Biotechnol*., 2004, 63: 390–397.
5. Dittmer NT, Suderman RJ, Jiang H, Zhu YC,Gorman MJ, Kramer KJ, Kanost MR. Characterization of cDNA encoding putative laccase-like multicopper oxidases and developmental expression in the tobacco hornworm, Manduca sexta, and the malaria mosquito, Anopheles gambiae. Insect Biochem Mol Biol., 2004, 34: 29–41.
6. D'Souza-Ticlo, Sharma D., Raghukumar C. A Thermostable metal-tolerant laccase with bioremediation potential from a marine-derived fungus. Marine biotechnology., 2009, Vol.11, no.6, pp.725-737.
7. Faure D, Bouillant ML, Bally R. Isolation of Azospirillum lipoferum 4T Tn5 mutants affected in melanization and laccase activity. Appl Environ Microbiol.,1994, 60, 3413–3415.
8. Givaudan A, Effosse A, Faure D, Potier P, Bouillant ML, Bally R . Polyphenol oxidase in *Azospirillum lipoferum* isolated from rice rhizosphere : evidence for laccase activity in non-motile strains of *Azospirillum lipoferum. FEMS Microbiol. Lett*., 1993, 108: 205-210.
9. Gonzalez T., Terron M.C., Yague S., Zapico E., Galletti G.C., Gonzalez A.E. Pyrolysis/gas chromatography/mass spectrometry monitoring of fungal-biotreated distillery waste water using trametes sp. I-62(CECT20197). Rapid communications in mass spectrometry., 2000, Vol.14, no.15, pp.1417-1424.
10. Hao J., Song F., Huang F., Yang C., Zhanng Z., Zheng Y., Tian X. .Production of laccase by a newly isolated deuteromycete fungus Pestalotiopsis sp. and its decolorization of azo dye. J. Ind. microbiol biotechnol., 2007, 34 (3):233-4017171552 cit: 4.
11. Imran M., Asad J.M., Hadri H.S. and Mehmood S. . Production and industrial applications of laccase enzyme. Journal of cell and molecular biology*, 2012,* 10(1): 1-11, 2012.
12. Keum Y.S., Li Q.X. Fungal laccase-catalyzed degradation of hydroxy polychlorinated biphenyls. Chemosphere., 2004, Vol. 56, no.1, pp 23-30.
13. Khlifia R, Belbahria L, Woodwarda S, Ellouza M,Dhouiba A, Sayadia S, Mechichia T. Decolourization and detoxification of textile industry wastewater by the laccase-mediator system. J Hazard Mater., 2010, 175: 802–80.
14. Mohammadian M, Roudsari MF, Mollania N, Dalfard AB, Khajeh K. Enhanced expression of a recomninant bacterial laccase at low temperature and microacrobic conditions: purification and biochemical characterization. J Ind Microbiol Biotechnol., 2010, 5: 41-45.
15. Moilanen U, Osma JF, Winquist E, Leisola M,Couto SR. Decolorization of simulated textile dye baths by crude laccases from Trametes hirsute and Cerrena unicolor. Eng Life Sci., 2010,10 (3): 1–6.
16. Mongkolthanaruk W., Tongbopit S. and Bhoonobtong A. Independent behavior of bacterial laccases to inducers and metal ions during production and activity. African Journal of biotechnology., 2012, Vol.11 (39), pp.9391-9398.
17. Morozova OV, Shumakovich GP, Gorbacheva MA, Shleev SV, Yaropolov AI. "Blue" Laccases. J .Biochem., 2007, 72(10): 1136-1150.
18. Prabu P.C., Udayasoorian C. and Balasubramaniana. Isolation, Molecular characterization and Reactivity with 2,6 Dichlorophenol of a laccase and isolation of laccase gene specific sequences from lignin degrading basidiomycete *Phanerochaete chrysosporium*(TL1). Biotechnology, 2006, 5(4):522-529.
19. Sadhasivam S, Savitha S, Swaminathan K, Lin FH.Production, purification and characterization of mid-redox potential laccase from a newly isolated Trichoderma harzianum WL1. Process biochem., 2008, 43: 736-742.
20. Sharma KK and Kuhad RC. Laccase: enzyme revisited and function redefined. Ind J.Microbiol., 2008, 48: 309–316.
21. Sharma P, Goel R, Caplash N. Bacterial laccases. World J Microbiol Biotechnol., 2007, 23: 823-832.
22. Shleev S.V., Morozova O.V., Nikitina O.V., Gorshina E.S., Rusinova T.V., Serezhenkov V.A., Burbaev D.S., Gazaryan I.G., Yaropolov A.I. Comperison of physico-chemical characteristics of four laccase from different basidiomycetes. Biochimie, 2004, 86:693-703.
23. Shraddha, Shekher R., Sehgal S., Kamthania M., Kumar A. Laccase: Microbial sources, Production, and potential Biotechnological applications. Enzyme Research, 2011, Vol.2011:11 page.
24. Sivakumar R., Rajendran R., Balakumar C., Tamilvendan M. Isolation, Screening and Optimization of production medium for thermostable Laccase Production from Ganoderma sp. International journal of engineering science and technology , 2010, vol.2 (12), 7133-7141.
25. Tavares APM, Cristovao RO, Gamelas JAF,Loureiro JM, Boaventuraa RAR, Macedoa EA. Sequential decolourization of reactive textile dyes by laccase mediator system. J Chem Technol Biotechnol.*, 2009,* 84: 442–446, 2009.
26. Vandevivere PC, Bianchi R, Verstraete W. Treatment and reuse of wastewater from the textile wet-processing industry: review of emerging technologies. J Chem Technol Biotechnol*, 1998,* 72: 289–302.
27. Yague S., Terron M.C., Gonzalez T. et.al. Biotreatment of tannin-rich beer-factory wastewater with white-rot basidiomycete coriolopsis gallica monitored by pyrolysis/gas chromatography/mass spectrometry. Rapid communications in mass spectrometry, 2000, Vol.14, no.10, pp.905-910.

Source of support: Nil
Conflict of interest: None Declared