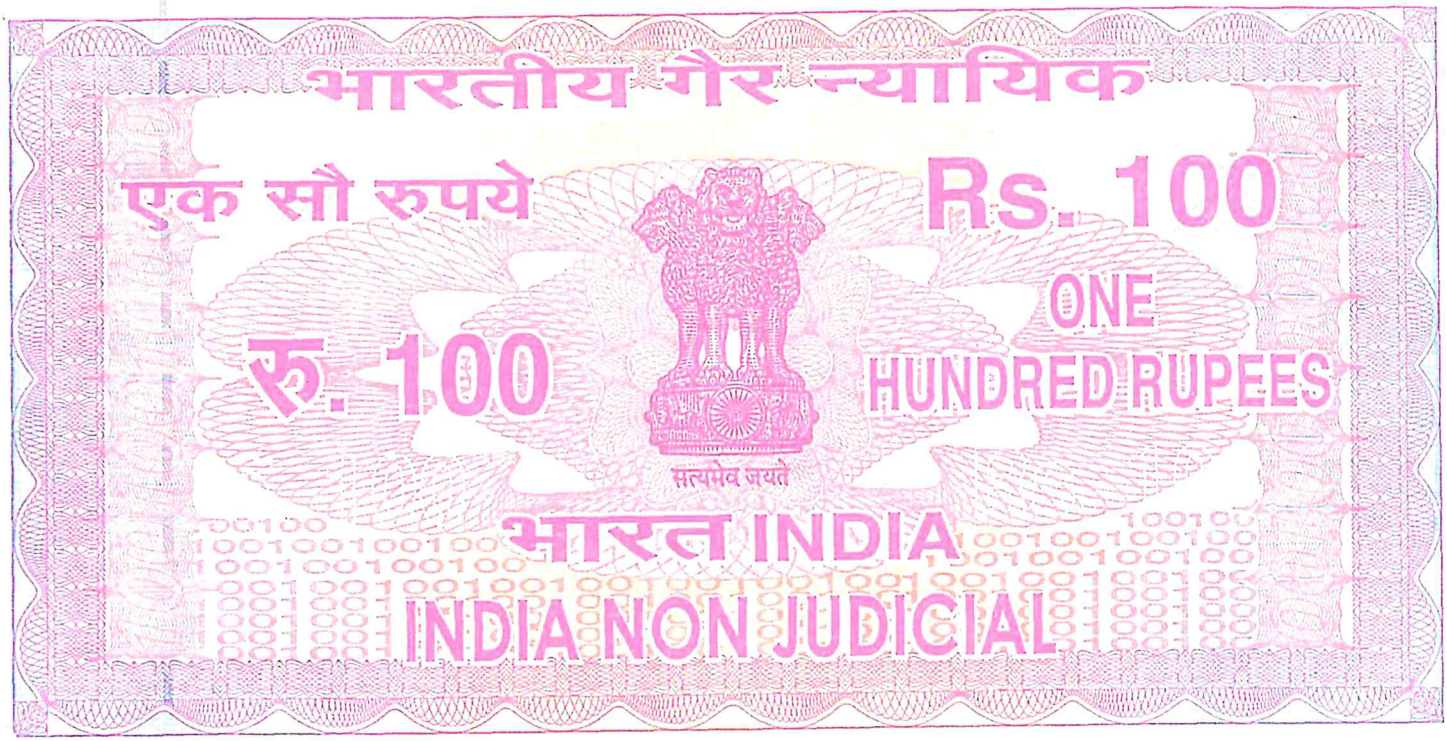

കേരളം केरल KERALA

AU 843082

MEMORANUM OF UNDERSTANDING

Between

KANNUR UNIVERSITY

Thavakkara Campus, Kannur-670 002

and

YENEPOYA UNIVERSITY

Derlakatte, Mangalore-575018

This memorandum of understanding entered into between Kannur University, a Government of Kerala undertaking represented by the Registrar Dr.Balachandran Keezhoth herein known as the first party and Yenepoya University, a Deemed University set up under section 3 of UGC act, 1956, represented herein by its registrar Prof.Dr.C.V.Reghuveer herein after known as Second party witnesses as follows:

1. Whereas Kannur University is a well established University with several Postgraduate Departments of study and Research, supporting the academics, research and extension activities in the areas of national and regional interests.

2. And whereas Yenepoya University, promoted by Islamic Academy of Education Trust, which has several well known medical, Dental, Nursing and Physiotherapy colleges and the University has now in its ambit Medical, Dental and other allied health science disciplines.

നമ്പർ 28688 പേര് രജിസ്ട്രാർ കണ്ണൂർ സർവ്വകലാശാല
തിരൂർ കണ്ണൂർ
തീയതി 24-06-15
കണ്ണൂർ താലൂക്ക് ആഫീസ് ആക്ടിങ്ങ്
വെണ്ടർ കെ.പി. ജാഫിക്

ATTESTED

Dr.Gangadhara Somayaji K.S.
Registrar
Yenepoya(Deemed to be University)
University Road, Deralakatte
Mangalore- 575 018, Karnataka

DISTRICT TREASURY
24 JUN 2015
KANNUR

3. And whereas, Kannur University and Yenepoya University, of which the Medical and other colleges are now part, wish to continue the common interests of the two universities and further develop and enrich the academic and research exchanges.

A.

NOW THIS MEMORANDUM OF UNDERSTANDING (MOU) WITNESSES AS FOLLOWS:

i. Collaborative research, instructions, cultural and extension programmes
ii. Exchange of research information
iii. Exchange of students
iv. Exchange of faculty and staff

B. Each of the above activities will be governed by specific norms to be established between parties.

C. The above activities will be carried out in such a manner so as not to digress from the established traditions and regulations of each party.

D. The terms of this MOU may be modified and amended from time to time upon agreement between the parties.

E. This MOU shall be valid initially for a period of Five years and be renewed automatically thereafter for a further period of Five years unless notified thereto by either party within three months of expiry thereof.

These presents shall be signed by the respective registrars on two sets of originals and signed copies shall be exchanged thereafter.

Signed and delivered on 30th day of June 2015 at Kannur.

Registrar

Yenepoya University
University Road
Deralakatte
Mangalore-575018

Registrar
Yenepoya University
University Road, Deralakatte

Registrar

Kannur University
Thavakkara Campus
Civil Station PO
Kannur 670002.

ATTESTED

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frontiers in Microbiology

PERSPECTIVE
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Trichoderma viride Laccase Plays a Crucial Role in Defense Mechanism against Antagonistic Organisms

Divya Lakshmanan†* and *C. Sadasivan**

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Fungal laccases are involved in a variety of physiological functions such as delignification, morphogenesis, and parasitism. In addition to these functions, we suggest that fungal laccases are involved in defense mechanisms. When the laccase secreting *Trichoderma viride* was grown in the presence of a range of microorganisms including bacteria and fungi, laccase secretion was enhanced in response to antagonistic organisms alone. In addition, growth of antagonistic microbes was restricted by the secreting fungi. Besides, our study for the first time shows the inability of the secreting fungi (*T. viride*) to compete with antagonistic organism when laccase activity is inhibited, further emphasizing its involvement in rendering a survival advantage to the secreting organism. When laccase inhibitor was added to the media, the zone of inhibition exerted by the antagonist organism was more pronounced and consequently growth of *T. viride* was significantly restricted. Based on these observations we accentuate that, laccase plays an important role in defense mechanism and provides endurance to the organism when encountered with an antagonistic organism in its surrounding.

Keywords: antifungal, defense mechanism, inter-specific interaction, laccase, *Trichoderma* sp.

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INTRODUCTION

Laccases (E.C.1.10.3.2) are oxidoreductases that contain copper ions at the catalytic center (Kiiskinen et al., 2002) and are one of the few microbial enzymes employed in number of industrial applications (Abadulla et al., 2000; Cuoto and Herrera, 2006; Kidwai et al., 2012; Sole et al., 2012; Divya et al., 2013). Fungal laccases are unique in that they exhibit low substrate specificity and strong oxidative abilities and are involved in a variety of physiological functions such as delignification, morphogenesis, and parasitism (Worrall et al., 1986; Williamson, 1997; Missall et al., 2005; Camarero et al., 2007). In addition to these functions, our study suggests that fungal laccases are involved in conferring the secreting organism a resistance to antagonistic microorganisms.

Besides directly oxidizing a variety of phenolic compounds, laccases catalyze the indirect oxidation of chemicals that are not phenols or amines in the presence of a redox mediator or Laccase-mediator system (LMS), which can be of natural or synthetic origin (Eggert et al., 1998). The combination of the laccase with low molecular weight mediators not only lead to higher rates and yields in the transformation of laccase substrates but also add new oxidative reactions to the laccase repertory toward substrates in which the enzyme alone had no or only marginal activity. Thus, LMS enlarges substrate range being able to oxidize compounds with redox potential (E°) higher than that of laccase.

DEPT. OF BIOTECHNOLOGY AND MICROBIOLOGY
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Date 9-12-2019

From,

HOD

Department of Biotechnology & Microbiology

Kannur University

Thalassery Campus, Palayad

To,

The Director

Yenepoya Research Centre

Yenepoya University Road, Deralakatte

Mangalore

Sir,

This is to certify that Ms. Haritha K is a bonafide student of the Department Of Biotechnology and Microbiology ,Kannur University. She aspires to pursue her MSc project in your esteemed institute under Dr.Divya Lakshmanan M . Kindly consider her request favourably.

Thank You

Regards

Dr.Anu Augustine

Dr. ANU AUGUSTINE, Ph.D
Associate Professor & HOD
Dept. of Biotechnology & Microbiology
School of Life Sciences
Kannur University, Thalassery Campus
Palayad (P.O.), Kerala, India-670 661

Copy to: Dr.Divya Lakshmanan M

Permitted
Relieve A.O
30/12/2019

ATTESTED

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Bisphenol-A carbonate dimer is a more preferred substrate for laccase mediated degradation than the Biphenol-A in its monomeric and dimeric forms

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ABSTRACT

Bisphenol A (BPA), a known endocrine disrupting chemical is used as a primary monomer in most of the day to day consumables. Though enzyme laccase secreted by certain microbes are known to catalyze the removal of BPA, their mode of interaction remains unresolved. Here we propose a mechanism underlying the interaction between laccase and the three forms of BPA; BPA carbonate dimer and BPA monomer which easily leach out from polycarbonate plastic, and BPA dimer formed by laccase mediated BPA oxidation. The result indicated that there is a high degree of propensity for the carbonate dimeric form of BPA to interact with laccase when compared to BPA monomer and dimer (formed by laccase mediated BPA oxidation), owing to the tunnel like arrangement of the active site, which is large enough to accommodate dimeric or higher forms of BPA and due to the flexible confirmation of BPA carbonate dimer. Besides carbonate dimer is less stable than BPA dimer and has more number of H- bonds, with the key catalytic residues within the active site of the laccase, than monomers and dimers and hence has more chances of getting cleaved and degraded faster. Laccase catalyzed BPA dimers on other hand are less flexible and more stable and hence has more probability to form nontoxic polymers, which can be sieved out later after treatment process. Our proposed mechanisms on BPA-Laccase interaction provide explanation to the previous observations on the laccase catalyzed removal of BPA and formation of its oxidative products.

1. Introduction

Bisphenol A (BPA), identified as a ubiquitous endocrine disrupting chemical (Lee et al., 2007; Murray et al., 2007; Zsarnovszky et al., 2006; Sargis et al., 2010; WHO/UNEP et al., 2012), is used as a primary monomer in polycarbonate plastic, epoxy resins, as a polymerization inhibitor in polyvinyl chloride and as color developer in thermal papers (Sheehan, 2000; Divya et al., 2013). It has been reported that enzyme laccases secreted by certain microbes can oxidize BPA to other compounds and thereby detoxify it (Beck et al., 2018; Barrios-Estrada et al., 2018; Daâssi et al., 2016; Divya et al., 2013; Eio et al., 2016; Kim and Nicell, 2006; Modaressi et al., 2005; Orozco et al., 2013; Takao et al., 2004; Uchida et al., 2001; Yang et al., 2013; Zdarta et al., 2018; Zeng et al., 2017; Zhao et al., 2018).

Laccases (E.C.1.10.3.2) belong to a family of multi-copper oxidases and are widespread in nature. The functional units of the enzyme laccase comprises three cupredoxin-like domains A, B and C and they are about equal in size and equally important for the catalytic activity (Bertrand et al., 2002; Ducros et al., 1998; Piontek et al., 2002). The substrate-binding site is located in a cleft between domains B and C, a mononuclear copper center is located in domain C, and a trinuclear copper center is located at the interface between domains A and C (Hakulinen et al., 2002; Messerschmidt, 1997). The mononuclear copper center contains one type-1 (T1) copper that is trigonally coordinated to two histidines and a cysteine (His- Cys- His motif). T1 has also a distant axial ligand, usually a Leu or Phe residue in fungal laccases (Ducros et al., 1998; Piontek et al., 2002) and a Met residue in the *Bacillus subtilis* CotA laccase and in other multicopper oxidases (Enguita et al., 2003). The trinuclear cluster contains one type-2 (T2) and two type-3 (T3) coppers (Messerschmidt, 1997). The T2 copper is coordinated by two and the T3 copper by six conserved histidines (Bertrand et al., 2002; Piontek et al., 2002). When oxidized by a laccase, the substrate loses a single electron and usually forms a free radical (Kersten et al., 1990). The unstable radical may undergo further

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