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Degradation of N-heterocyclic indole by a novel endophytic fungus *Phomopsis liquidambari*

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HIGHLIGHTS

- ▶ With litter addition, 99.1% of 100 mg L^{-1} indole was degraded within 60 h.
- ▶ Indole oxidation to oxindole and isatin were the key to limit indole degradation.
- ▶ Litter induce *P. liquidambari* to produce laccase and LiP to oxidize indole.
- ▶ Indole metabolic pathway was similar with endophytic metabolism of IAA in plant.

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ABSTRACT

A broad-spectrum endophytic *Phomopsis liquidambari*, was used to degrade environmental pollutant indole. In the condition of using indole as sole carbon and nitrogen source, the optimum concentration of indole supplied was determined to be 100 mg L^{-1}, with 41.7% ratio of indole degradation within 120 h. Exogenous addition of plant litter significantly increased indole degradation to 99.1% within 60 h. Indole oxidation to oxindole and isatin were the key steps limiting indole degradation. Plant litter addition induced fungus to produce laccase and LiP to non-specific oxidize indole. The results of fungal metabolites pathway through HPLC–MS and NMR analysis showed that indole was firstly oxidized to oxindole and isatin, and deoxidated to indolenie-2-dione, then hydroxylated to 2-dioxindole, which pyridine ring were cleaved through C–N position and changed to 2-aminobenzoic acid. Such metabolic pathway was similar with bacterial degradation of indole-3-acetic acid in plant.

1. Introduction

A typical N-heterocyclic compound, indole which is widely present in the natural environment due to it as well as its derivatives is important plant hormone precursor and microbial signal molecule (Blom et al., 2011; Frey et al., 2000). However, with the development of industry for various applications, including pharmaceuticals, fuel, cosmetics, pesticides, disinfectants and dyestuffs, indole and its derivatives are now considered pollutants, since they are released into the environment through cigarette smoke, coal-tar, sewage, coking and dye-stuff wastewater (Hong et al., 2010; He et al., 2011).

Some researches try to photocatalytic degradation or electrochemical oxidation of indole (Gai et al., 2010; Merabet et al., 2009). Although the removal efficiency of physical catalysis is high, considering the expensive investment and high energy consumption of physical reactor, it is not suitable for extensive application in environment. Chemical disinfection is another way to control indole release, but it can result in the formation of other aromatic products, which are known the potential of toxic, and carcinogenic (Lin and Carlson, 1984). Information regarding the capabilities of microbes to degrade N-heterocyclic aromatic compounds is useful in determining the fate of these chemicals in the environment (Fetzner, 1998). However, as high concentration of indole inhibits microbial growth, most reports concerning microbial degradation initial concentration was less than 50 mg L^{-1}(Gu and Berry, 1991; Hong et al., 2010; Kamath and Vaidyanathan, 1990). Hence, screening appropriate microbial strain and optimizing its degrading condition for environmental indole degradation will benefit for natural ecology bioremediation.

As a large and novel microbial resource, endophytic fungi have been paid more attention in their ecological functions. Besides their biocontrol and growth promotion to host plants, their strong capabilities to decompose organic matter were also continuously

Abbreviations: MnP, manganese peroxidase; LiP, lignin peroxidase.

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