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Advances in Fungal Removal of Polycyclic Aromatic Hydrocarbons

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Abstract: Many studies on the bioremediation of PAHs-contaminated soils have shown that fungi are often more effective than bacteria for PAHs depletion. Fungi can survive better in contaminated environments because their mycelial growth can penetrate the soil layer and get close to the source of contamination, which can improve the bioavailability of soil organic pollutants; and have better tolerance to toxins. field et al reported in their study eight strains of white rot fungi that all had the ability to degrade PAHs, including strain Bjerkandera sp. BOS55 showed a 28-day removal rate of 99.2% and 83% for anthracene and benzo[a]pyrene, respectively.

Keywords: PAHs, Removal, Pollution.

1. Fungal Removal of Polycyclic Aromatic Hydrocarbons

The removal of organic pollution by fungi takes many forms, including adsorption, degradation and adsorption-degradation together. Biosorption can remove PAHs from the environment quickly, but still attached to the sorbent, prone to secondary pollution; biodegradation is through various enzymes catalyzed degradation of PAHs into less toxic or non-toxic compounds, but the treatment cycle is long; while the combination of biosorption and degradation first adsorbed a large number of PAHs in a short period of time, retaining them in the microorganism, and then using microbial enzymes to completely degrade PAHs, no The biosorption and degradation combination first adsorbs a large amount of PAHs in a short period of time and then uses microbial enzymes to completely degrade them without secondary contamination. The adsorption of phenanthrene and pyrene by white rot fungi reached 53% and 86% respectively within 7 d, but PAHs decreased gradually with increasing incubation time. The PAHs adsorbed in the cells of white rot fungi are only temporary and will eventually be consumed by their degradation and transformed into non-toxic or small molecule compounds. In contrast, Cladosporium sphaerospermum was found to degrade 30% of the 5- and 6-ring PAHs in soil. a variety of fungi, which act on PAHs by secreting their own intracellular and extracellular enzymes and extracellular polymer systems. This indicates that fungi still remove PAHs from the environment by degradation, achieving complete elimination.

2. Mechanism of Fungal Degradation of Polycyclic Aromatic Hydrocarbons

Unlike bacterial degradation, fungi use their oxidative capacity to degrade PAHs. two degradation mechanisms are distinguished: the intracellular pigment P450 oxidase system as shown in Figure 1, and the extracellular lignin hydrolase system[1] (Figure 1). Cytochrome P450 is the collective name for a class of enzymes used by many plants, animals and microorganisms to catalyse the oxidation of organic matter. The first step is the oxidation of the aromatic ring in cytochrome P450 monooxygenases to produce aromatic oxides. In contrast to the oxidation of the aromatic ring by dioxygenases to form cis-dihydrodiols, monooxygenases incorporate only one oxygen atom into the ring to form the aromatic oxides. In a hydration-catalyzed reaction by an epoxide hydrolase to form trans-dihydrodiols. Alternatively, phenol derivatives can be produced from non-enzymatic aromatic oxides The rearrangement of this compound can be used as a substrate for subsequent sulphation/methylation, or in combination with glucose, xylose or glucuronide[2]. Most cytochrome P450-degrading fungi are unable to complete the mineralisation of PAHs, and these PAHs couples are usually less toxic and more soluble than their respective parent compounds. For example, the most potent one, the filamentous fungus Cyclothyrium sp, converts 48% of pyrene to derivatives such as pyrene trans-4,5-dihydrodiol via cytochrome P450 monooxygenase and epoxide hydrolase[3]. Similarly there is the small gram silverhamella (Cunning-hamella) and others[4], all of which have similar metabolic activation of PAHs as mammals.

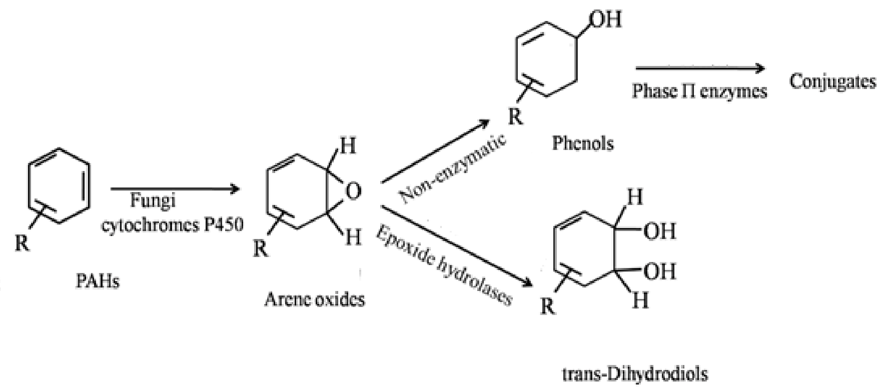

Figure 1. Transformation pathways of PAHs by Fungal P450 enzyme

There are two types of lignin hydrolase systems: peroxidase and laccase peroxidase. These enzymes are secreted extracellularly and are free radical-based reactions specific to oxidised organic matter. There are two main types of peroxidase, depending on the type of substrate they reduce, lignin peroxidase (Lip) and manganese peroxidase (MnP), both of which are capable of oxidising PAHs, while laccase, a phenol oxidase, is also capable of oxidising PAHs[5]. Ligninolytic enzymes can convert PAHs by generating hydroxyl radicals to donate an electron to oxidise the PAHs ring to form PAHs-quinones and acids[6]. Lignin peroxidase and manganese peroxidase have been reported by white rot fungi to oxidise pyrene, anthracene, fluorene and BaP to the corresponding quinones[7, 8]. The yellow spore protochlorophyllum and variegated embryonic bacteria, capable of mineralizing PAHs, observed complete decomposition of PAHs [9].

In contrast to bacterial PAHs degrading enzymes, lignin degrading enzymes have broad substrate specificity and are a unique mechanism for fungal degradation of PAHs. Thus being able to modify a wide range of substrates, even the most recalcitrant ones[10, 11]. Most fungi degrade contaminants by secreting extracellular enzymes in order to avoid overloading the contaminants and poisoning the cells. Therefore, fungi have a good potential for both extended and practical applications.

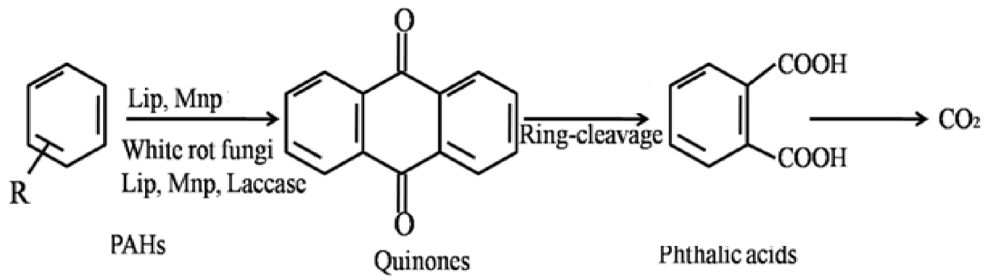

Figure 2. Transformation pathways of PAHs by Fungal lignin oxidase enzyme

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