Environmentally benign bleaching of paper pulps using electron transfer mediators

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Wood pulp, must be **bleached** if it is to be used in the finer varieties of light coloured paper. Bleaching of kraft pulp is traditionally performed by sequential reaction with chlorine or chlorine dioxide and sodium hydroxide. Effluents from these conventional bleaching processes contain toxic chlorinated chemicals. Thus, environmental concerns have opened up new opportunities for biotechnology, electrochemistry and competing technologies to replace current bleaching routines.

We have recently undertaken research on a process for delignification (bleaching) of kraft pulps involving oxidative fungal enzymes and redox mediators. Chemical savings can be obtained by using a fungal culture alone but the rate of delignification is too slow for commercial application[1]. The fungal bleaching effect is accompanied by the secretion of at least two lignin-oxidizing enzymes, laccase and manganese peroxidase.

Laccase is a multi-copper oxidase that reduces oxygen to water and simultaneously performs one-electron oxidation of many aromatic substrates. Laccase alone has a limited effect on pulp bleaching due to its specificity for phenolic subunits in lignin. However, we found that the substrate range of laccase can be extended to non-phenolic subunits of lignin by inclusion of a mediator such as 2,2'-azinobis-(3 ethylbenzthiazoline-6-sulfonate) (ABTS)[2].

Since the initial report with the mediator ABTS, there has been intense research activity to discover a cost-effective laccase/mediator combination, and several nitrogen-containing aromatic compounds are now known to be at least as effective as ABTS.

We recently reported the use of transition metal complexes in combination with laccase to mediate the catalytic delignification and bleaching of kraft pulps[3,4]. The principle of the process is that a transition metal redox complex is oxidized by the enzyme laccase to a stable oxidized form, and can then diffuse within the lignocellulosic fibre to mediate selective catalytic lignin oxidation leading to cleavage reactions and solubilization of the coloured lignin. During this reversible redox process, the mediator is continuously regenerated by the enzyme following its reaction with lignin and is made available for further reaction. This novel process allows the use of small amounts of the mediator and recycling via filtration of the regenerated mediator for further pulp delignification.

We have focused much of our recent attention on attempting to unravel the sequence of reactions involved in the mediated delignification of paper pulp. Recent results on the use of electrochemical techniques[5] and the design of a novel flow-through electrolysis cell to allow studies on the mediator/pulp reactions[6] will be presented together with results of electrochemical delignification[7] using this cell.

References

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