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Electroenzymatic degradation of ammonia using immobilized horseradish peroxidase on conductive polymer coated electrode

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Ammonia (NH3 and NH4+) is the predominant form of inorganic nitrogen in wastewater and the most common pollutant discharged into water streams. The discharge of ammonia is generally from industrial, agricultural as well as domestic wastewater and this compound in fresh water has an undesirable effect on aquatic life and human health. Therefore, ammonia removal during wastewater treatment represents an important control strategy, since high concentrations of ammonia in wastewater effluents deplete dissolved oxygen, reduce chlorine disinfection efficiency, and exhibit acute toxicity to aquatic life. There are a wide range of technologies for ammonia removal from water and wastewater, such as biological process, ammonia stripping, ion exchange and breakpoint chlorination. However, these methods have some drawbacks, long contact time, low removal efficiency, intensive energy demands and high concentrations of chemicals, contributing to high costs and negative environmental impacts. Electroenzymatic process is an attractive alternative to traditional chemical, biological and physical processes due to its versatility and environmental compatibility and as an efficient method for removal recalcitrant contaminants since pollutants can also be effectively oxidized by electron transfer. Among a variety of distinct peroxidase enzymes, horseradish peroxidase (HRP) is considered as the most abundant enzyme. HRP has appeared as a robust catalyst for the degradation of various emerging pollutants. Some chemically synthesized conductive polymers can be used as supports enzyme immobilization. Among conductive polymers, polyaniline (PANI) and polypyrrole (PPI) are especially useful for the development of enzyme-based electrodes due to its low cost, relatively easy synthesis, excellent redox recyclability and good environmental and thermal stability. The scope of this study was the removal of ammonia by electrochemical oxidation. HRP was electrodeposited on stainless steel electrodes coated with PANI or PPI by potentiostatic electrodeposition method. The prepared electrodes were characterized by SEM-FEG, FTIR, XRD and electrochemical impedance spectroscopy. To evaluate the electroenzymatic degradation of ammonia, voltammetric and chronoamperometric study were carried out. About 65% degradation of ammonia was achieved after 20 min by using the optimized reaction conditions. The results obtained provide a potential route for electrochemical treatment of ammonia by using a HRP/PANI or HRP/PPI electrodes.