Hydrogen enzyme electrodes in microbial conversion of cellulose containing waste into electricity with intermediate H₂ production

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As we already reported, immobilizing the enzymes hydrogenases onto carbon electrode supports, it was possible to elaborate hydrogen enzyme electrodes. The latter operated according to the mechanism of direct bioelectrocatalysis, i.e. the direct (mediator free) electron exchange between the enzyme active site and the electrode. Enzyme electrode generated hydrogen equilibrium potential in H₂ atmosphere, and displayed high current of hydrogen oxidation at positive overvoltages.

Immobilizing hydrogenase onto commercial carbon electrode supports, we have developed the electrode for fuel cells based on hydrogenase from *Thiocapsa roseopersicina*. Providing the oriented enzyme immobilization, we achieved the limiting performance characteristics of hydrogenases in electrocatalysis [1]. Moreover, in contrast to platinum or other noble metals, enzyme electrodes can catalyze hydrogen oxidation in the presence of carbon monoxide, hydrogen sulfide, and even small amounts of oxygen in a wide range of pH and temperature. Hydrogenase electrodes are capable of consuming hydrogen directly from microbial media, which ensures their use as fuel electrodes in treatment of organic wastes [2].

In present study we have combined the fuel cell based on hydrogenase electrode with bioreactor containing either phototrophic or heterotrophic hydrogen-producing microorganisms. Hydrogen produced by bacteria was consumed by enzyme electrode directly in the reactor.

Power density achieved in the model system was of 400 μW/cm², short-circuit current achieved 1.2-1.4 mA/cm² at 60°C. Fuel cell has retained 70% of its initial power after 70 hours of continuous operation [3]. It was independently shown, that hydrogen enzyme electrodes are able to operate not less than 600 hours in the media of phototrophic microorganisms, and not less, than 170 hours in the media of heterotrophic microorganisms.

References

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