BIOFUEL CELLS

Enzymatic protection system

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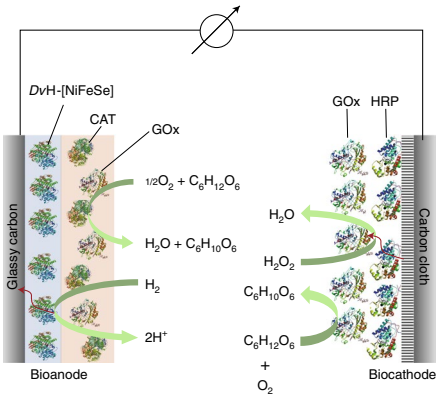

Highly active H_2-oxidation catalysts used in fuel cells usually contain noble metals such as Pt, which are rare and expensive. Hydrogenase enzymes can achieve similar activities, but use abundant metals such as Fe and/or Ni in their active sites. Hydrogen is the basic fuel, but fuel cells also require oxygen, which unfortunately inactivates the most active hydrogenases.

Previously it was found that incorporation of a hydrogenase into a redox polymer allows protection of the biocatalyst from O_2 and high potential deactivation in a biofuel cell (BFC); however, this requires not only thick films of the polymer and large amounts of hydrogenase, but also reduces the performance of the BFC by consuming electrons.

Now, Adrian Ruff, Wolfgang Schuhmann and co-workers covered a redox-polymer-supported [NiFeSe] hydrogenase from *Desulfovibrio vulgaris* Hildenborough (*Dv*H-[NiFeSe]) with a second polymer layer containing glucose oxidase (GOx) and catalase (CAT). This allowed removal of oxygen at the anode in the presence of glucose (net reaction: glucose + $0.5O_2$ → gluconolactone + H_2O). The hydrogenase bioanode was combined with an oxidase/peroxidase biocathode resulting in a BFC with an open circuit voltage value of 1.15 V, and power densities of up to 530 μW cm^{-2} at 0.85 V. In this system, glucose was not only essential to remove O_2, but also served as a sacrificial electron donor ensuring that electrons from H_2 oxidation were not consumed for O_2 reduction. This allowed an improved performance compared with previous polymer-based BFCs. Nevertheless, side products from the bi-enzymatic protection system reduced the stability of the cathode and the pH of the buffer limiting the long-term performance of the BFC. An alternative protection system based on pyranose oxidase was also tested and provided a stable pH, but showed lower oxygen protection efficiency.

Overall, the presented strategy by Ruff, Schuhmann and co-workers protects sensitive enzymes from high potential and oxygen inactivation in BFCs without consuming electrons from H_2 oxidation. However, further research is required to develop highly effective (enzymatic) protection systems that are fully compatible with high-performance BFCs in long-term use.

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