GREEN HYDROGEN PRODUCTION BY MEC

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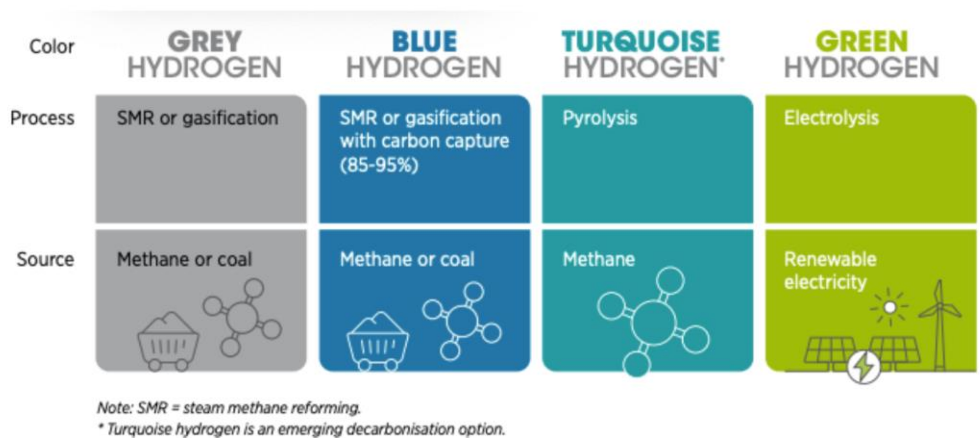
ABSTRACT

The study discusses option of producing hydrogen from wastewater by microbial electrolysis cell (MEC) technology. Hydrogen is used in many industries and has been produced in large scales for over two centuries. Conventional methods are steam reforming of natural gas, coal gasification which still produce as much as 95% of demand.

Only recently hydrogen has been considered a replacement for hydrocarbon fuels in transport and industry to reduce CO_2 emissions. Especially to utilize electricity from intermittent renewable sources such as solar and wind hydrogen is a potential energy storage alternative to batteries. Although hydrogen is carbon-free fuel but how hydrogen is produced has effect on its overall emission contribution, thus a terminology grey, blue, turquoise, and green is devised based on the source and method of its production (Figure 1).



Hydrogen production methods based on carbon contribution [1]

To move to carbon free economy and to replace the equivalent quantity of energy produced by fossil fuels, currently we need to produce 4 billion tonnes of green hydrogen per year [2]. Thus, to meet this target, efficiency of conventional methods must improve. New methods such as use of algæ, photosynthesis to produce hydrogen from water are also investigated. MEC is an emerging method which was discovered in 2005 by two independent research groups, one at Penn State University and the second a Patent at Wageningen University in the Netherlands [3, 4]. An attractive feature of MEC is that it uses wastewater to produce hydrogen thereby helps waste minimization and wastewater treatment industry reduce carbon footprint. Electrochemically active bacteria naturally present in wastewater oxidize organic matter present in wastewater and generate CO2, electrons, and hydrogen protons (Figure 2) and electrical potential of about 0.3V is produced.

In a conventional MFC, this voltage is used to extract electrical power, and water is produced at cathode. Whereas additional voltage is supplied from an outside source to MEC to produce hydrogen. The whole cell reaction for acetate can be written as,
$CH_3COO^- + 2H_2O + H^+ \rightarrow 2CO_2 + \mathbf{4H_2}$.

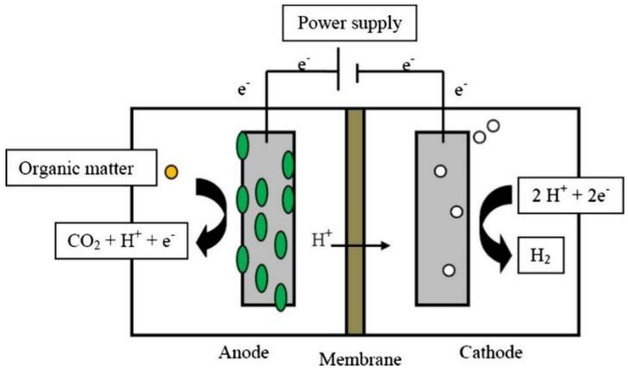


Figure 2 Schematic of MEC [5]

This technology is in its initial stages of development and only few pilot scale studies are reported [5,6] and pathways to scale-up and benchmarking of performance parameters are still unclear. The critical components of MEC are anode, cathode, and membrane which together with design and operating parameters need to be optimised for cost effectiveness and hydrogen output at real scales. Maintaining high current densities is critical factor in scaling-up. Increasing the surface area of anode and reducing the internal resistance within the cell by considering suitable electrode design and materials is the first step in this direction. Anode should be biocompatible to support the biofilm for oxidation of organic matter. Cathode surface area is directly correlated with the hydrogen production rate. Reaction at cathode is slow and requires high overpotential to drive hydrogen production, and to enhance the reaction platinum is usually used as catalyst in fuel cells, which is expensive. Biocathode is an option which many researchers are investigating. Another issue is methanogenesis, as hydrogen favors growth of methanogens which reduce the production of hydrogen or contaminate the gas. In our research group, we are investigating these factors particularly, modifying electrode materials and design to improve the hydrogen production by MEC technology. The experimental results using single cell will be presented to demonstrate the performance improvement.

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