

## Electrochemical Generation of Hydrogen Peroxide Using a Gas Diffusion Electrode and Proton Exchange Membrane Cell Configuration

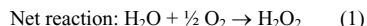
Christopher P. Rhodes, Carlos Salinas, and Tony Giletto

*Lynntech, Inc.*  
7610 Eastmark Dr., College Station, TX 77840

Hydrogen peroxide (H<sub>2</sub>O<sub>2</sub>) is a versatile oxidizer and has numerous applications including pulp and paper bleaching, wound disinfection, disinfection of medical devices, water treatment, decontamination of pathogenic agents, and destruction of environmental wastes. Since H<sub>2</sub>O<sub>2</sub> readily decomposes to water and oxygen, the use of H<sub>2</sub>O<sub>2</sub> for numerous applications is increasing based on its relative safety and environmentally friendly properties compared to other technologies. Various applications for H<sub>2</sub>O<sub>2</sub> have different requirements, but it is often beneficial to produce hydrogen peroxide on demand or at the point of use to avoid logistical, cost, and safety issues associated with transporting H<sub>2</sub>O<sub>2</sub>, particularly for concentrated solutions. A portable, safe, and efficient electrochemical reactor that can synthesize hydrogen peroxide from readily available reactants has particular advantages over transporting and storing large volumes of hydrogen peroxide.

Electrochemical generation of H<sub>2</sub>O<sub>2</sub> has been performed in both acidic and alkaline solutions where a electrical current or potential is applied between the anode and cathode of a suitable electrochemical cell.<sup>1-4</sup> Although many electrochemical designs use a “flow-through” electrochemical reactor which flows a liquid acidic or basic aqueous electrolyte to the cathode, there are specific advantages to generating hydrogen peroxide using a gas diffusion electrode which flows gas to the cathode. A gas diffusion electrode used in combination with a proton exchange membrane (PEM) allows the hydrogen peroxide to be generated and collected without additional acid or base present, which can be desirable for many applications that contain system components that would be corroded or damaged system by acidic or basic solutions. The use of a gas diffusion electrode and PEM configuration can specifically eliminate additional steps needed to isolate the H<sub>2</sub>O<sub>2</sub> from the acidic or basic solution.

Lynntech, Inc. has developed an innovative, portable, safe electrochemical cell which generates hydrogen peroxide (H<sub>2</sub>O<sub>2</sub>) on demand (patent pending). Lynntech’s cell produces hydrogen peroxide using an electrochemical process that combines oxygen, protons and electrons at a suitable cathodic electrocatalyst. At the anode, water is split into oxygen, protons, and electrons. The combined process produces hydrogen peroxide using only water, air (or oxygen), and electricity according to the net reaction presented in eq. 1.



The cell design uses a solid proton exchange membrane (PEM) that allows high concentrations of peroxide to be generated without corrosive liquid electrolytes, as is the case for many other cell designs. Using this configuration, Lynntech’s cell produces H<sub>2</sub>O<sub>2</sub> electrochemically, requires only water, electricity, and ambient air to operate, and does not use or produce any unsafe by-products.

Lynntech has demonstrated the cell’s output and longevity using either air or oxygen fed into the cell, as presented in Table 1. Using oxygen, the cells produced an average 11.7 wt. % H<sub>2</sub>O<sub>2</sub> and exhibited stable operation for more than 400 hours. High yields of up to 14.8 wt. % H<sub>2</sub>O<sub>2</sub> have been generated to date. Using air rather than high purity oxygen, the cells produced an average 3.6 wt. % H<sub>2</sub>O<sub>2</sub> and showed stable yields for over 1500 hours of testing. If required, high purity oxygen can be supplied using commercially available O<sub>2</sub> concentrators that use only air and electricity as inputs. The electrochemical cell is fully scalable to provide variable H<sub>2</sub>O<sub>2</sub> output flow rates.

Optimization of the catalyst, electrode formulation, membrane, and cell components are currently in progress to maximize the wt. % H<sub>2</sub>O<sub>2</sub> produced from the reactor and optimize the long-term stability of the cell in order to provide an on-demand H<sub>2</sub>O<sub>2</sub> generator for multiple applications.

**Table 1.** Hydrogen peroxide output and testing time of Lynntech’s electrochemical H<sub>2</sub>O<sub>2</sub>-generating cells using both air and oxygen gas inputs.

Gas Input	H <sub>2</sub> O <sub>2</sub> avg. wt %	Testing time
Air (21 % O <sub>2</sub> )	3.6 %	> 1500 hours
Oxygen (99+ % O <sub>2</sub> )	11.7 %	> 400 hours

### References

1. Tatapudi, P. and Fenton, J. M. *J. Electrochem. Soc.* **140**, L55-L57 (1993).
2. Brillas, E., Alcaide, F. and Cabot, P. L. *Electrochim. Acta* **48**, 331-340 (2002).
3. Gyenge, E. L. and Oloman, C. W. *J. Appl. Electrochem.* **33**, 665-674 (2003).
4. Gupta, N. and Oloman, C. W. *J. Appl. Electrochem.* **36**, 255-264 (2006).