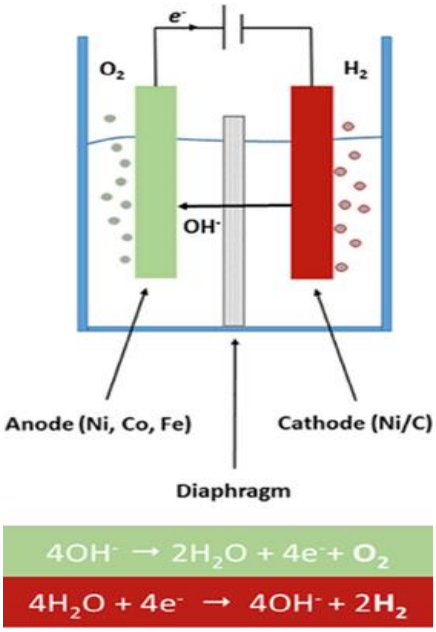
NOTE by Tata Consulting Engineers

Can We Generate Medical Oxygen from Water?

Oxygen is generally produced at commercial scale either by cryogenic air separation technology or pressure swing adsorption (PSA) technology. In principle, it is possible to produce oxygen from water using electrolysis process. In fact, oxygen is the by-product from the water electrolysis process. However, the electrolysers produce a very small quantity of oxygen. Practically, 1 LPM of oxygen would require 1.8 to 2 LPM of water. The quality of water required for electrolysis is "Demineralised Water" as the normal tap water decrease the water conductivity and will form sediment on the electrodes. The scale of oxygen generation through electrolysis cannot meet the demands of industrial or medical operations and hence practically oxygen generation through electrolysis route is limited to laboratory purpose.

Electrolyser working Principle

Typically, electrolysis of water is the process of splitting water molecules. This process is carried out in presence of alkaline solution (electrolyte) and requires electricity as an input. The electrolyser cell splits water molecule into hydrogen and oxygen. The reaction is endothermic, which requires electricity as energy input. A simple water electrolysis unit consists of an anode and a cathode, which is immersed in the electrolyte solution. The electrodes are connected through an external DC power supply. When DC power is applied to the unit, electrons flow to the cathode from the negative terminal of the DC power source. At the cathode, the electrons combine with the hydrogen protons to produce H_2. Then, H_2 ions move toward the cathode, whereas hydroxide ions move towards the anode. H_2 and oxygen gases develop at cathode and anode, respectively as shown in the Figure 1.



Overall reaction is, $2\ H_2O_{(l)} \rightarrow 2\ H_{2(g)} + O_{2(g)}$

The number of hydrogen molecules produced is thus twice the number of oxygen molecules. Assuming equal temperature and pressure for both gases, the produced hydrogen gas has therefore twice the volume of the produced oxygen gas.

Specific Energy Consumption

The energy required to split water into hydrogen and oxygen by electrolysis is about 260 kJ per mole of water. Splitting of one litre of water would take at least 16 MJ (4.4 kWh), which is an enormous expense on an industrial scale. The conventional route of oxygen just takes 0.8 kW per Nm3 of oxygen produced; whereas water electrolysis would consume 150 kWh per Nm3 of Oxygen produced. Therefore, it is simply not feasible for mass production of oxygen. This technology is used for green hydrogen production.

Purity and safety Issues

The oxygen produced by electrolysis needs secondary treatment to get rid of carryover alkalis and hydrogen. The medical grade oxygen must not contain any alkali.

Using electrolytes such as sodium or potassium hydroxide in the water electrolysis process, the alkali may be dragged along with the oxygen product as mist or fine droplets. For example, the water contains sodium chloride (common salt, NaCl), the anode bubbles will consist of not only oxygen but chlorine gas as well, which would be toxic to breathe.

The oxygen produced from the electrolysis process must be completely separated from the hydrogen produced. Any kind of contamination is not allowed in medical grade oxygen. The purity of medical grade oxygen is minimum 93% with zero hydrogen in it. The hydrogen and oxygen separation is hence an issue. The electrolyser downstream process must use suitable technologies for hydrogen separator/absorption from the oxygen product.

Lower explosive limit of hydrogen is just 4%. When mixed with oxygen, it forms an explosive mixture.

Home based set ups

Haphazard or home-based setups are matter of concern for generating medical grade oxygen. For example, if a crude setup is used and the water contains sodium chloride (common salt, NaCl), the anode bubbles will consist of not only oxygen but chlorine as well, which would be toxic to breathe. Over time, the chlorine content decreases, but some will be in the output for a long time.

Tap water quality will form sediment around the electrodes when the current is passed. The sedimentation process will decrease the productivity of electrolyser process and it may not be sustainable over a long duration to operate the cell with tap water. The oxygen produced will be contaminated by the salt precipitation from the normal tap water. Demineralised water production on continual basis is not possible in home set up. Also, in industrial set up, it will add significant costs towards raw material (Water) conditioning prior to use in electrolysis process.

Home based oxygen generation using water bottles produces too little quantity – 1 ltr bottle can produce 0.2 LPM of oxygen – That too inferior quality which would never help any patient.

There are pressure limitations as well. Even if you could produce it in sufficient quantities or at sufficient purity, you will still need equipment to pressurize it into a canister!!

Proven Medical oxygen generating Technologies

Cryogenic air separation is currently the most efficient and cost-effective technology for producing large quantities of oxygen, nitrogen, and argon as gaseous or liquid products. The energy requirement of the latest technology is about 0.5 kW h/Nm3 -O2. Oxygen purity of cryogenic process can be higher than 99 vol%. Because of the high purity requirement, oxygen for medical use is normally produced by the cryogenic process. No technology, except electrolysis, is expected to challenge cryogenic air separation to produce large quantities of oxygen, especially at high purity.

For medical oxygen in-situ generation at hospital sites, Pressure swing adsorption technology (PSA) is the most suitable technique considering scale and purity requirements.

Concluding Remarks:

The home-based water electrolysis produces inferior quality of oxygen. The quantities are very small. It is not a sustainable process and shall. There are safety hazards associated with inhaling contaminated oxygen. This method shall never be used as source of medical grade oxygen. Doctors and scientists in India are already warning of the dire hazards of trying to make medical oxygen at home.

There is a scientifically proven method to produce medical oxygen through concentrators. Any other means to try making the gas at home involves many risks like chances of toxic gases being inhaled and explosions.

TCE has released an opensource design for O2 Concentrator with specification of 20 LPM 95% oxygen concentration. We are helping MSME, start-ups / incubators and medical parks in few states along with a national consortium being led by a central GOI team to mass manufacture this device.

https://www.tce.co.in/wp-content/uploads/2021/05/O2-Concentrator.pdf

This link will continue to be updated with more FAQ's in the coming days based on queries received.

Press / Media:

Indians make oxygen at home. The results are dangerous.

https://www.livemint.com/news/india/indians-make-oxygen-at-home-the-results-are-dangerous-11619720310360.html

Experts warn Indians of dangers of trying to make oxygen at home

https://www.reuters.com/world/india/experts-warn-indians-dangers-trying-make-homemade-oxygen-2021-04-30/

CMC technician develops simple machine to produce oxygen

https://www.dtnext.in/News/TopNews/2021/05/14054335/1294099/CMC-technician-develops-simple-machine-to-produce-.vpf