Membrane Separation of Air to Produce Oxygen

Technical Report Submitted to:
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Executive Summary

The objective of this project is to determine if the production of a ceramic oxide membrane unit for separating oxygen from air is a profitable alternative to the production of oxygen storage units. Design was based on the requirements of the 30 million Chronic Obstructive Pulmonary Disease (COPD) sufferers, for whom the unit is designed to help. The unit must be portable, provide adequate battery life, and provide 95% oxygen at a minimum of 5 Liters/minute. In addition, the unit was compared to leading competitors in the market that produced portable oxygen concentrators that yield 5 L/min flow rates. These competitors are the Inogen One, Airsep Lifestyle, and Airsep Freestyle. Based on economic analysis, it is necessary to have a happiness function near 0.75 to be profitable, where the happiness is represented by the user's preference for the dimensions and weight of the unit and the unit's noise output and power input. In the report, a design of a ceramic oxide membrane unit was designed and priced, and a risk analysis for production as well as plant design was proposed.

A compact unit measuring 12.2 inches long, 15.2 inches tall, and 9.5 inches wide at a weight of 9.94 pounds was designed for use with a 12 volt source. Based on research, a 4 hour Lithium Ion battery was the source of power in the unit. It produces a minimum of 5 L/min of oxygen with 99.9% purity at a temperature of 298.15K through the use of a BICUVOX membrane. BICUVOX ($Bi_2Cu_{0.1}V_{0.9}O_{5.35}$) is a ceramic oxide that transports oxygen through the membrane through ionic conductivity. The Copper Vandate has as an anion-deficient Perovskite-like crystal structure that is advantageous to the movement of oxygen anions through vacancies, or defects, in its crystal lattice. The selling price of the unit was determined to be $6000 using consumer pricing theory.

Risk analysis was conducted on the best of three scenarios based on the level of involvement in the production of device components in house. The scenarios are the manufacturing of all device components, manufacturing only the membranes and heat exchangers, and finally manufacturing only the heat exchangers. For each scenario a probability of 20% was assigned to all raw material prices. After conducting the scenarios, it was found that the processes of producing only the heat exchangers produced the best results. The other options were not profitable, while producing the heat exchangers and buying the other equipment showed the greatest potential for profitability. The design described above correlated to a happiness function of 0.76, and proving to be a profitable venture. It is expected that $10 million will be generated over the 10 year life of the project.

The use of ceramic oxides in oxygen generation is a new idea. It is expected that as membrane technology grows, membrane based oxygen generators will most likely seize the majority of the market from pressure swing absorption systems.