DEVELOPMENT OF AN OXYGEN CONCENTRATOR FOR FUTURE EXPLORATION MISSIONS

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ABSTRACT

Future space missions will take astronauts beyond Earth's orbit. These exploration missions may be long in duration (e.g. 36 months), which requires that medical support be available for the crew. This medical support will include advanced life support equipment, which includes supplemental O_2 and patient ventilation with oxygen. The current medical oxygen aboard ISS is from 100% oxygen tanks, which enriches the ambient oxygen concentration, which in turn increases the risk of fire. This risk is exacerbated in smaller exploration vehicles. Providing a method of oxygen therapy that keeps the oxygen levels below the vehicle fire limit, will allow extended duration of oxygen therapy without intervention required to reduce the cabin oxygen levels.

Two technologies for the oxygen concentrator are being evaluated. The first technology is based on the Pressure Swing Adsorption (PSA) method, and the second technology is based on a catalytic electrochemical nanocomposite proton exchange membrane stack. The PSA method extracts oxygen from the air by molecular separation of the nitrogen and oxygen within the zeolite beds, and then providing the oxygen to the patient. Most PSA systems have multiple packed beds that operate in sequence to provide a constant flow of oxygen. The electrochemical membrane stack relies on liquid water and produces oxygen. The water is electrolysized into oxygen and hydrogen, the oxygen is extracted, and the hydrogen formed flows to a catalyst, where it reacts with atmospheric oxygen to form water which flows back to the proton-conducting membrane for further electrolysis.

Based on Integrated Medical Model Likelihood predictions, the most probable scenario for medical oxygen need is the treatment of smoke inhalation. Since an oxygen concentrator uses cabin air as the source of oxygen, the air must be filtered to remove smoke, carbon monoxide, and other trace contaminants to avoid concentrating these as part of the oxygen stream and exacerbating the patient's condition. To address this scenario, a smoke filter similar to that currently used on ISS for fire events would be attached to the inlet of the oxygen concentrator.

For patients requiring mechanical ventilation, a closed-loop controller using feedback from a pulse oximeter can maintain the blood oxygen saturation levels via well studied ventilation protocols. This automated control and monitoring system simplifies the caregiver's role in ventilation, and provides data for remote monitoring of the patient's condition by flight medical personnel on the ground.

In addition to treating medical conditions, the oxygen concentrator could be an option for pre-breathing protocol by the crew in preparation for Extravehicular Activities (EVA). The portability of the system could allow the astronaut the ability to move around and perform other activities while completing the pre-breathing protocol. It could also be used for atmospheric contamination events such as spills or a fire to avoid smoke inhalation. The replaceable inlet filter on the unit would remove toxic gases from the oxygen delivery stream, allowing the user to breathe in oxygen free of smoke, dust, or other contaminates.