The Macha Oxygen Concentrator Project:
Prolonging medical device lifespans in a rural care facility

Poster by: Jilean Schutz

Introduction

The project is currently engaged in troubleshooting early failures experienced with oxygen concentrators, devices which replace conventional tanked oxygen for patients with respiratory issues. These devices take ambient air in and separate the oxygen from the other gases in the air via a material called zeolite.

They have been focusing their efforts on designing an alternate intake filter for the concentrators that can adequately reduce the amount of humidity and dust the zeolite is exposed to. The team has plans to send a team to Macha Mission Hospital in January of 2015.

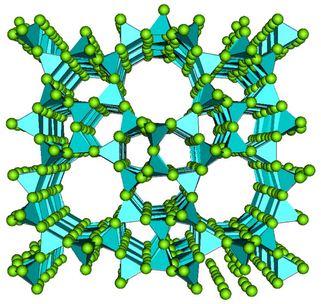
Client

The Macha Oxygen Concentrator project works in conjunction with the Macha Mission Hospital in Zambia, Africa. Our contacts there include Dr. John Spurrier, Mr. Melvin Mabeta, Dr. Phil Thuma, and Nathan Siastibole.

Results

How the concentrator works:

Two sieve beds containing zeolite allow oxygen to pass through unrestricted while trapping other gases through a process called pressure swing adsorbtion.



Zeolite's structure allows nitrogen to physically adsorb to the outside of the crystal as well as pass into the cage-like inner structure.

When one sieve becomes saturated with nitrogen, the zeolite material is then regenerated by depressurization, thus exhausting the nitrogen that was adsorbed. The sieves are alternately pressurized and depressurized, allowing a constant flow of oxygen to be supplied to the patient.

Our problem:

Symptom	Potential Causes
Low oxygen concentration	Leak in system Defective sieve bed check valve Defective compressor reed valve Defective compressor Rotary valve not operating correctly Occluded filters Contaminated sieve beds

Although the zeolite's purpose is to trap nitrogen, it is also sensitive to water molecules. When the zeolite material is exposed to moisture, the moisture is also adsorbed, causing clumping in the sieve beds. This clumping impedes the concentrator's ability to supply high quality oxygen to the patient.

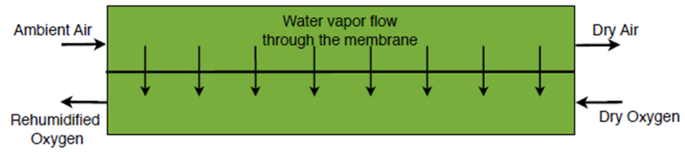
Further Information

For more information, please visit the Collaboratory Wiki under the Disabilities Resources Application Group. All group members would love to answer questions as well. Feel free to email Jilean Schutz at js1682@messiah.edu.

Results

Our solution:

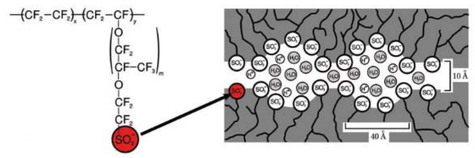
The implementation of a water permeable Nafion membrane that will pull water vapor out of ambient air before entering the concentrator unit.



How the membrane works

Sulfonic acid groups are responsible for Nafion being an excellent drying material because of the high amount of water it takes to hydrate each acid group.

- The sulfonic acid groups form ion channels through the membrane
- The water is able to transport through the hydrophilic channels
- Sulfonic acid groups deeper within the membrane have a higher affinity for water, thus transporting the water through the channels
- The driving potential is simply the humidity gradient across the membrane



Conclusions

The project has started testing with the membrane this semester and will continue testing in the fall. Work was done to successfully create a humid environment chamber to be controlled by an Arduino. Designing and prototyping were also done to create a membrane housing for testing purposes. The project intends to create a prototype to be used for the concentrators in Macha to be implemented in January 2015.

Acknowledgements

Special thanks goes to DeVilbiss Healthcare, Pentair and Porous Media, Dr. Filburn, and Dr. Vader for their advice and support.

Also thanks to our client, the Macha Mission Hospital. Thank you to our advisor Dr. Swartz and group members Wyatt Albert, Michael Madea, Erik Listor, and Christopher Scheib for their contributions.

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