O_2U

Affordable Concentrator for Low Resource Countries

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Problem & Clinical Need

COPD
- Chronic obstructive pulmonary disease
- 3rd leading cause of death in the U.S, 4th leading cause of death in the world (2015). 30 million annual death[1]
- Leads to hypoxemia: low blood oxygen level
- Deprivation of oxygen leads to tissue death and severe cerebral and organ damage
- No cure: oxygen therapy alleviates complications

Nepal
- COPD counts for 43% of chronic diseases in Nepal[1]
- Causes:
  - Severe pollution and low air quality
  - Lack of clean energy for household use: exposure to fume and smoke
  - Smoking
  - Lack of healthcare infrastructure and governmental funding

Oxygen Therapy
- Oxygen tanks
  - Cheap but bulky
  - Infeasible due to difficulties in transportation
- Central oxygen lines
  - Expensive onsite oxygen production system
  - Infeasible due to price and maintenance
- Oxygen concentrators
  - Expensive ($2000+ for single patient)

Need Statement

To design an affordable oxygen concentrator that can be used in low-resource settings to facilitate oxygen therapy in multiple patients simultaneously.

Market Analysis

- Low-resource countries and regions (Nepal and Tibet)
- Limited access to oxygen supply due to issues[2]
  - Affordability
  - Transportation
  - Unstable electric power
  - Lack of trained personnel
  - Low awareness for device maintenance
- Urgent need for devices that can facilitate oxygen therapy[2]
- Patients pass away because of a lack of reliable oxygen source
- Investor's standpoint
  - Rapid expansion in recent years
    - Increasing prevalence of respiratory diseases
    - Governmental support
  - Profit relatively small due to limitations on cost and price
    - Volume of need may be able to resolve this
    - Philanthropic

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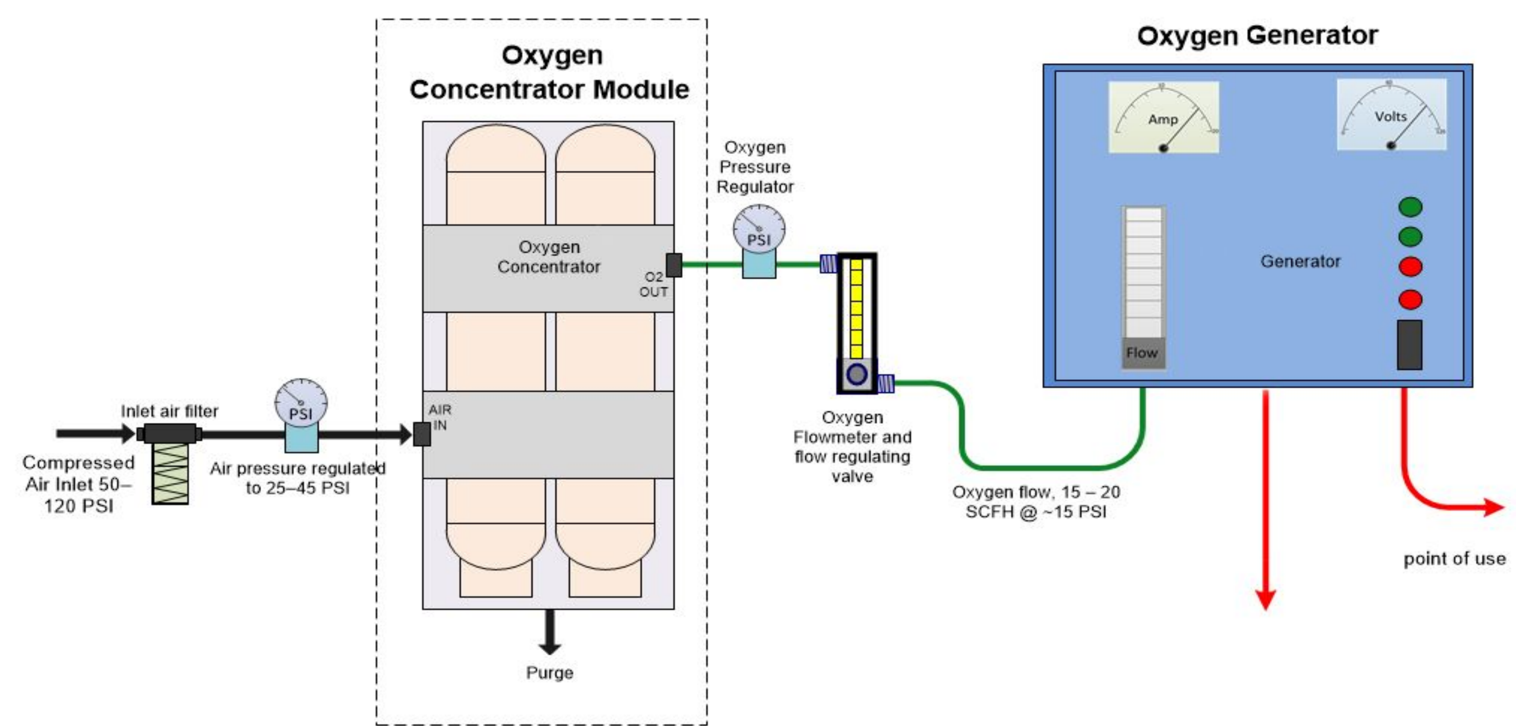
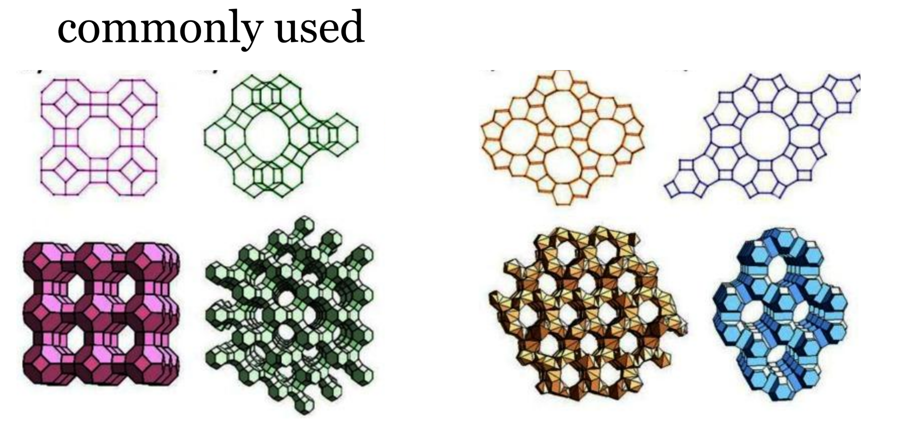
Design

Design Overview

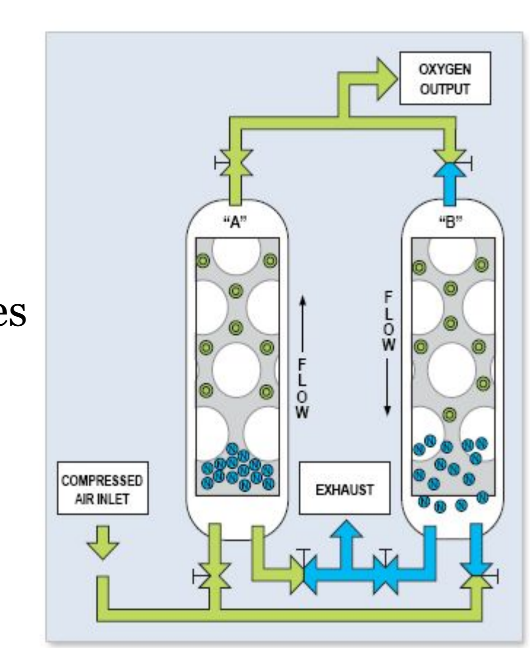


Concentrating Oxygen from Air

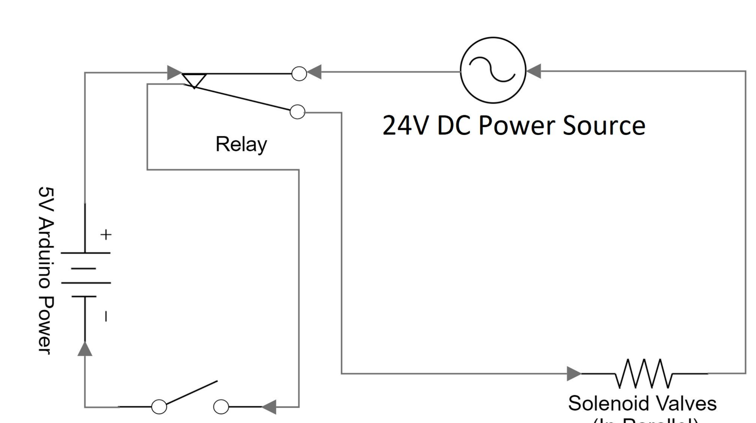
Adsorption Basics
- Adhesion of molecules and substances onto a surface[3]
- Zeolite
  - Common adsorbant, porous solid
  - Molecules attach or trapped due to ionic bonding or size
- When air flows through zeolites, N2 is trapped in the porous structure while smaller O2 passes through[2]
- For oxygen concentrating processes, zeolite 13X and zeolite 5A are commonly used



Pressure Swing Adsorption
- **Two beds**
  - Packed with zeolites
  - At any time, one bed is adsorbing, the other desorbing
- **Adsorbing bed**
  - Pressurized
  - Nitrogen trapped, concentrated oxygen leaves
  - Saturate as process progresses
- **Desorbing bed**
  - Depressurized (outlet at atmospheric pressure)
  - At lower pressure, nitrogen detaches and leaves
  - Desaturate, regenerate the zeolites

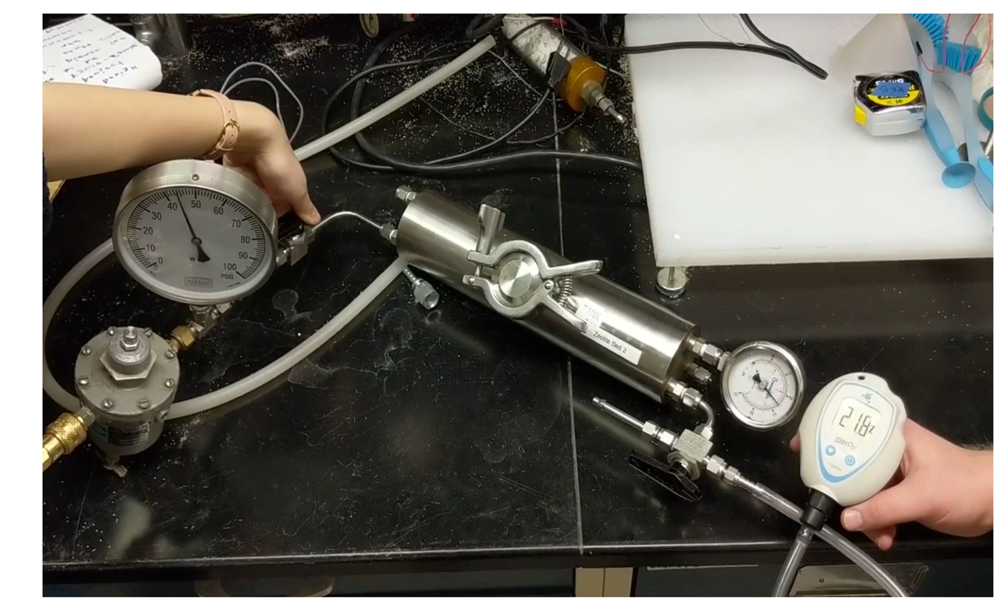


Solenoid Valves
- Electrically controlled on/off valves to control the direction of flow in PSA
- 24V DC valves controlled by an arduino relay



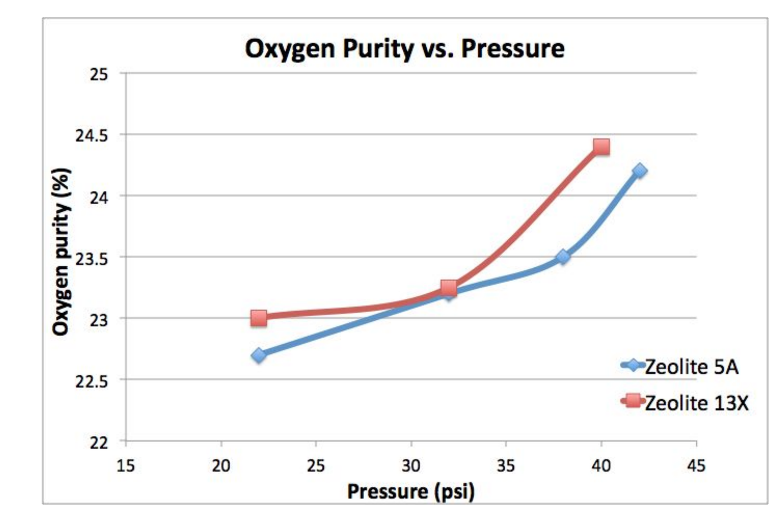
Experimentation

Single-Bed Testing
- Column packed with zeolites
- House air at different pressure flows through the system
- Oxygen purity measured at the outlet



Results

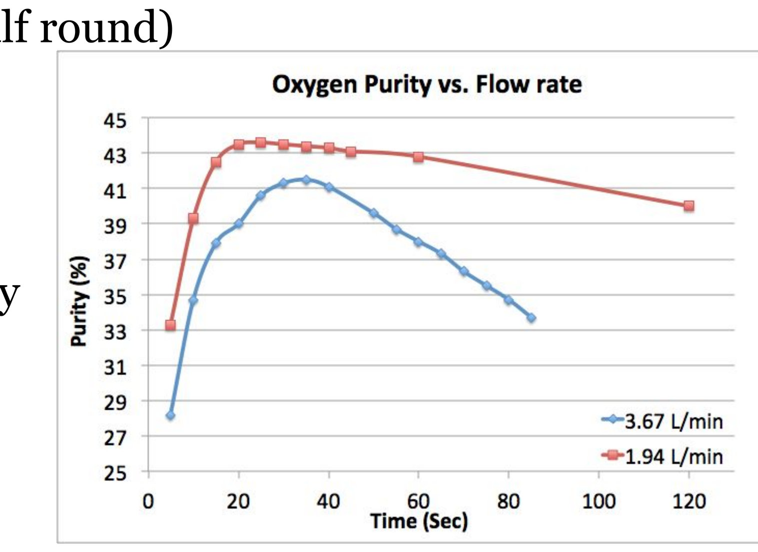
Trial 1: Zeolite 5A & 13X
- Result:
  - maximum purity 24.4%
  - zeolite 13X at 40 psi, 50 L/min
  - Mesh 6-12
- Conclusion:
  - Purity increases with pressure
- Next step: study flow rate



Trial 1: Zeolite 5A and 13X are tested at different air pressures.

Trial 2: Zeolite 13X (half ground, half round)
- Result:
  - At 4 L/min: 25.5%
  - At 1 L/min: 26.2%
- Conclusion:
  - Lower flow rate increases purity
- Next step: study particle size

Trial 3: Nitroxy SXSDM (Arkema)
- Lithium based specialty zeolite
- Mesh 20-30
- Result
  - Maximum purity: 43.6%
  - 1.9 L/min, 49 psi



Trial 3: Nitroxy zeolites are tested at different 49 psi under different flow rates

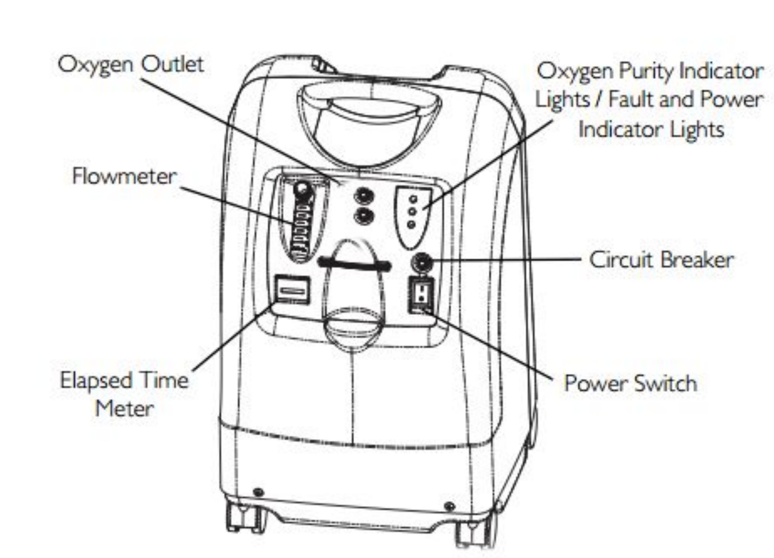
Factors that affect Adsorption
- Pressure
- Flow rate of air
- Zeolite particle size
- Dimension of the column

Future Work

Voltage Stabilizer
- Power Surges
- Electrical Outages

Portability
- Higher Storage Capacity
- Reduce Weight of Device

Higher Purity
- Explore Zeolite Alternatives
- Experiment at higher pressures



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[1] Bhandari, R., & S. (2012). Epidemiology of chronic obstructive pulmonary disease: a descriptive study in the mid-western region of Nepal. International Journal of Chronic Obstructive Pulmonary Disease, 253. doi:10.2147/copd.s28602

[2] WHO Technical Specifications for Oxygen Concentrators. <http://apps.who.int/medicinedocs/documents/s22194en/s22194en.pdf>

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Images
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