# Study on LiAgX Zeolite Based Pressure Swing Adsorption Technique Employed Oxygen Concentrator

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**Abstract**

The supply of pure oxygen has always shown dominance in the healthcare sectors due to variety of respiration related health problems and one such demand and crisis was tremendously faced during *COVID-19* pandemic. The permanent ailment for such emergencies always adequate supply of oxygen concentrators and sufficient ventilator can support the hospitals to be defensive during such pandemics. This paper highlights on the design of a portable oxygen concentrator for medical usage invoking the technology Pressure Swing Adsorption (PSA). The PSA technology helps to achieve the selective air molecules and supplies oxygen at a greater selectivity ratio. A detailed study on LiAgX zeolite was performed and found that it is more effective using a layer of LiAgX zeolite as adsorbents. The LiAgX is the most suitable with better nitrogen to oxygen selectivity ratio with a flow rate of 5LPM. The sodium based zeolites were tested with 2-way solenoids and 4-way solenoids using oom202 sensor but the accuracy was found to be in the range of 85% and later the sensor was replaced to enhance the accuracy over 95% by ultrasound oxygen sensor ocs3f3.0 with UART communication.

***Keywords:*** *Oxygen Concentrator, Pressure Swing Adsorption (PSA), LiAgX Zeolite, selectivity ratio.*

## 1. Introduction

Oxygen concentrators are optimized electrical equipment's utilized at home or at healthcare centres to provide oxygen from barometrical air [1-3]. They are a favoured wellspring of home oxygen for patients on long haul consistent oxygen treatment. An oxygen concentrator comprises of a blower, strainer bed channel, oxygen tank, pressure valve and a nasal canula or breathing device. The need of these oxygen generators created huge demand in the supply during the pandemic of *Covid-19* and significance of compactness (oxygen concentrators) all through the globe, particularly in our nation, India were embarked. Compact clinical oxygen concentrators have tracked down wide use in working with locally established oxygen treatment centres for patients experiencing lung conditions including *Covid-19*, persistent obstructive aspiratory sickness, constant bronchitis and pneumonia, etc.,

In the recent past, Avian Influenza sped up the prerequisite for mechanical ventilation and during the *Covid-19*, the requirement for ventilator and oxygen concentrators developed dramatically. Ventilators is medical equipment utilized to help patients taking in breathe or to experience relaxing in breathing issues and few toxic gases in the hospital environment are to be monitored using suitable sensor devices [4-8]. They work on the pneumatic force and adsorption guideline and are principally utilized during a medical procedure, when a patient is given general sedation or during therapy for COPD (Chronic Obstructive Pulmonary Disorder). The requirement for ventilator, oxygen concentrator and oxygen chambers develop dramatically during calamities like scourge, pandemic illness, military contentions, fear based oppressor exercises. Consequently, a compact medical equipment that could create oxygen on location without extra power sources or hardware would be significant in the greater part of the crisis circumstances. This produced oxygen is put away in tanks and supplied for homes and emergency clinic purposes and this medical equipment is intended for long haul, successive use. Different method for the supply of oxygen to patients is by compacting oxygen in a chamber and oxygen chambers are accessible in different sizes such as H-sized chambers and D-sized chambers. Oxygen chambers are just method adopted for oxygen storage capacity and not for generation.

Fundamentally, oxygen concentrators provide low volumetric stream paces of exceptionally determined oxygen levels through nasal cannulas to the patients for relaxing. Blowers, sifter beds, and batteries utilized in the oxygen concentrators get more modest as POC (Portable oxygen concentrator) [9-11]. Subsequently, required measure of oxygen can be made in a specified measure of time supplied to the patient. POCs utilize beat stream conveyance to preserve oxygen as a compensatory measure and an oxygen bolus, or "heartbeat," through a nasal cannula or breathing device is recognized, when the patient pulse flow rate is determined during inhalation. During exhalation, this lessens the concentration of oxygen that is delivered into the environment and more often the POCs use pressure to determine the inhalation. As the patient breathes in, the sign of pressure, which is observed through the cannula supply tubing, is brought about by the entrainment of room air. A beat of oxygen is delivered when the pressure surpasses the POC equipment's setting off limit. As well as being exceptionally delicate to the differing attack of traditional nasal prongs inside the nostrils of individual patients, the signal of pressure is an element of inward breath stream rate. The principal qualities of an ideal oxygen concentrator are compact in size, simple to work, inexpensive and high virtue of oxygen response.

There are different methods to isolate oxygen from the encompassing air and the first oxygen division was done by focussing daylight (sunlight) on mercuric oxide utilizing a focal point (lens) after the use of chemo electrolysis technique.

Similarly, a few techniques exist for the isolating oxygen from air and one of the exceptionally results giving method is Pressure Swing Adsorption (PSA) method [12-14]. Oxygen concentrators depend on the principle technique of swing adsorption, which prompts specific adsorption of a specific gas under a high pressure followed by it's desorption under a decreased pressure to reactivate the adsorbent bed for the following cycle. The functional material - zeolite (aluminosilicate) in the oxygen concentrators is commonly known by their atomic structures with shape for various sorts of zeolites based on the material formation. Sub-atomic sifters are materials that are utilized for the detachment of particles in light of their size and shape. Oxygen concentrator use zeolite as sub-atomic strainer which signifies that the size and shape selectivity of zeolites have been broadly taken into considerations separation of various substances and synergist movement (catalytic activity). Yet, the oxygen concentrators utilize an entirely unexpected property including the quadrupolar interaction between the adsorbate and adsorbent zeolite. The zeolite particle (Na, Li) act as adsorbate and the nitrogen atom stick on surface of zeolite particle is due to higher sub-atomic size. It eliminates nitrogen from the air structure by volume (78% nitrogen, 21% oxygen, 1% argon and different gases). Thus, in Clinical grade oxygen ought to have no less than 82% of unadulterated oxygen. The decision of wellspring of oxygen relies upon a few variables including area (location), infrastructure, cost, accessibility of power, assets for support and maintenance.

As per the World Health Organization (WHO), clinical grade oxygen has oxygen concentration in the range of 90-96%, with residual of nitrogen and argon. The detection of toxic gases also plays important role in hospital and industry environment prior to the installation of oxygen concentrators to avoid any sort of contaminations. [15-17] In arrangement with these determinations, the typical oxygen obtained from adsorption based MOC (Medical Oxygen Concentrator) equipment comprises of 90-93% oxygen at a production pace of fewer than 10 L/min4. In adsorption-based MOCs, because of restricted adsorption limit, the adsorbent is occasionally recovered for proficient usage [18-20]. To work with ceaseless oxygen supply, either the product oxygen can be gathered in a surge section provided at a consistent time with average rate, or a multi-bed activity can be used.

Skarstrom-type PSA cycle arrangement is commonly used in MOCs, which comprises of creation, depressurization, cleanse and compression steps.

In light of the pressure levels of creation and cleanse steps, three distinct subclasses exist that is pressure swing adsorption (PSA), vacuum swing adsorption (VSA) and pressure vacuum swing adsorption (PVSA). MOCs influence fast cycling of adsorption segment to amplify adsorbent use and scale down the size of the activity.

Likewise, the small adsorbent molecule sizes are utilized to diminish the mass transfer resistances and upgrade the adsorption energy (kinetics) [21]. For clinical use, contingent upon the state of end-use patients and whether the patient is very still or dynamic, the necessary determinations of oxygen concentration could change flow rate and immaculateness. Moreover, a similar oxygen concentrator unit can be utilized for a few distinct patients in a clinic setting. In this manner, it is alluring to plan an adaptable and particular PSA process that can quickly switch between various working systems for on-request oxygen production while satisfying different specified details.

## 2. Materials and Methods

In oxygen concentrators, pressure swing adsorption is the best method for separating oxygen from the air and removing other gases like carbon dioxide, nitrogen, and argon. POC frequently employ this strategy. The O2 gas is separated using the crystalline zeolite and the machine receives air at a higher pressure from the PSA compressor. The different methods can be employed are as discussed below.

### i. OXYGEN SEPARATION METHODS:

For the first time ever recorded, Joseph Priestly used a lens to focus sunlight on mercuric oxide to produce oxygen gas in 1774. Electrolysis is another method that uses an electrochemical cell to remove hydrogen from water in order to separate oxygen from water. Electric field forces oxygen through the membrane was employed in this method. Only a small amount of oxygen is produced from air was able to be produced by the aforementioned method. Or on the other hand, utilizing a zeolite strainer bed and a tension differential, they separate oxygen from the air. The process of separating air to produce pure oxygen can be accomplished in a number of different ways. The most well-known methods are films, cryogenic refining, and pressure swing adsorption method.

The two primary methods of POC are to separate oxygen from air with a membrane or a molecular sieve tube. Tubes filled with zeolite molecules are used in a molecular sieve. They have positive outcomes. Currently, its purity is between 96% and 98 %. However, only 40% pure oxygen is produced by the membrane oxygen concentrator. It is essential to consider all methods when creating a fully developed POC.

Some methods are too expensive, inefficient, or large, and they also need feed materials like water or POC molecules or temperatures or pressures that are too high or low.

### ii. OXYGEN MEMBRANES:

Through their "molecular barriers," oxygen membranes remove argon and nitrogen from the environment. Although the method is inexpensive, it uses surface area to screen the air that is passing by and typically uses modules that are larger than what is considered to be as portable—the modules can be a few feet long. Oxygen is typically produced using this method at low concentrations, around 40%. The majority of commercial membrane gas separation devices are used to separate nitrogen from the surrounding air rather than oxygen.

### iii. CRYOGENIC AIR SEPARATION:

The most widely used method for producing 99% oxygen in bulk supply are processes for cryogenic air separation. This procedure separates the various components after cooling the air to a liquid state. The component gases are produced in a dense state, making them suitable for transportation and confinement, which makes this advantageous. However, the procedure requires expensive, bulky equipment and is only suitable for large-scale production and distribution. Similar to oxygen membranes, this technology is too small for a POC application.

### iv. PRESSURE SWING ADSORPTION:

By selectively adsorbing nitrogen from the air under pressure, medical oxygen concentrators produce oxygen-enriched breathing air using pressure swing adsorption (PSA) technology. It selectively adsorbs nitrogen from the air into their molecular sieves owing to the strong quadrupole interaction between the adsorbed nitrogen and the electrical field of the charge-balancing non-framework exchangeable cations of alumina-silicate zeolites. In an oxygen concentrator, two zeolite-filled adsorbent vessels work in opposite directions in a cyclic process to produce oxygen-rich air almost continuously.

A PSA oxygen concentrator consists of a compressor, a number of valves to control the pressure cycling and flow sequence of the system's atmospheric air pump, and one or more adsorption columns. The device's compressor and adsorption columns are its two primary weight and size contributors. The primary impediments to reducing weight and size are the miniaturization of the compressor and the adsorption column.

They are a trustworthy and savvy source that can be used in clinics. A PSA system presses air through a chamber filled with zeolite. The climatic air keeps down, primarily nitrogen and argon, are adsorbed on the external layer of the zeolite. These units have two zeolite sifter filled tank that adsorb nitrogen from the pressed air. The tank operates differently, as the first tank removes oxygen from the air and adsorbs nitrogen, the second tank regenerates by releasing adsorbed nitrogen into the air. The air is purified in one tank, and nitrogen is desorbed and released in the other. The tanks work in opposite directions producing the oxygen consistently using this method with a purity of 94–96.2% and complete model is as depicted in the figure 1.

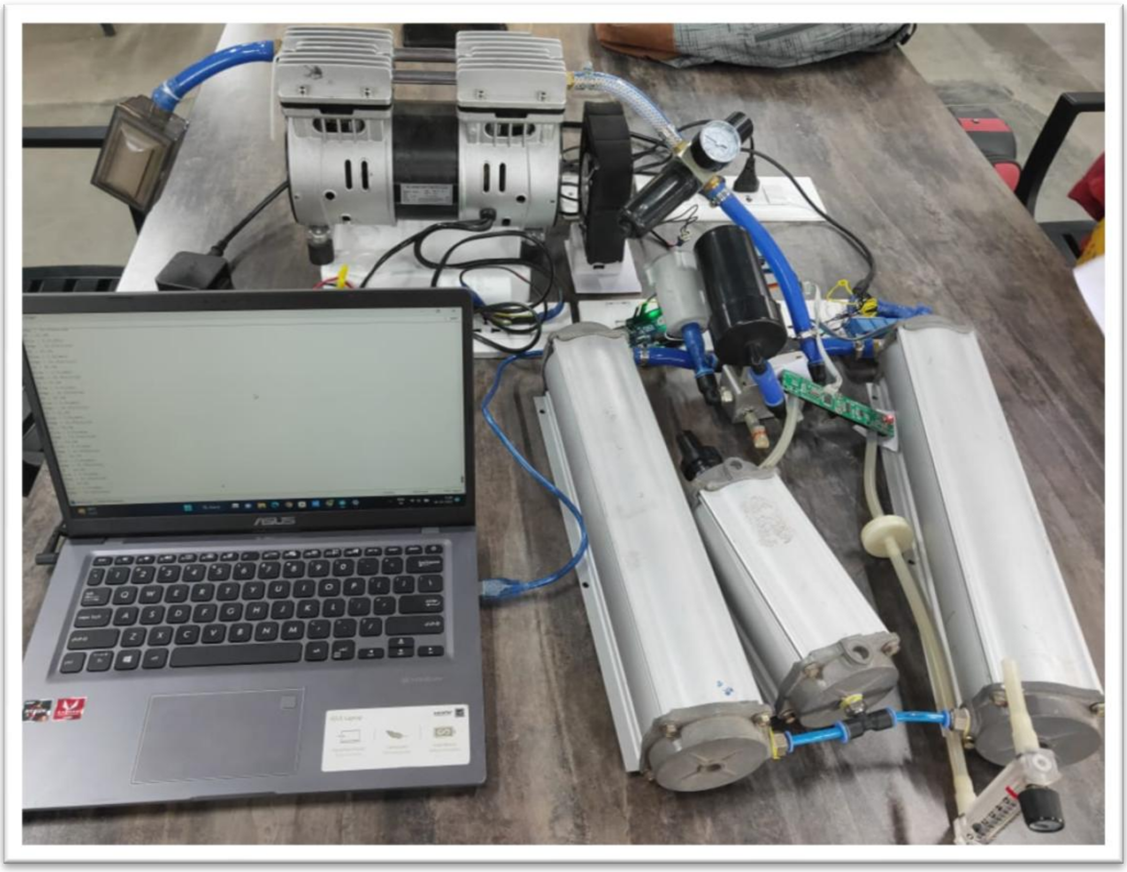

***Figure 1:*** *The prototype working model of portable oxygen concentrator with complete setup.*

The different materials which can be employed are as discussed below:

**i. ZEOLITE:**

Zeolites are mostly made up of silicon or aluminate materials. There are various assortments of zeolites available such as natural zeolite and synthetic zeolite. Typically, aluminium and silicon together forms the crystalline material known as zeolites. Depending on how they are used in the adsorption bed, the zeolites that are utilized in PSA systems typically take the form of beads and can be any size. Purity is significantly affected by the size of the pores. The pore size of zeolite is very important because zeolite is the one which filters air for nitrogen and oxygen. Pore sizes ought to be somewhere in the range of 4 and 3 A°. Zeolite materials are used in a PSA system, each designed to better adsorb specific gas molecules. Because of their shape-selective properties, zeolites are used in molecular adsorption. The ability to selectively adsorb some molecules while excluding others has led to the development of a wide range of molecular sieving applications. After the zeolite absorbs nitrogen and other gases, oxygen is released. Peter Scott explains the two-step adsorption process of zeolite. Nitrogen is drawn to zeolite by the crystal's exposed cations, triggering the first step. Since nitrogen is more polarizable than oxygen, the zeolite specifically adsorbs nitrogen because of the development of a dipole.

Zeolite's cage-like structures exclude the larger nitrogen molecules that have attracted the nitrogen to them and allow only oxygen to enter their interiors. The chosen zeolites are layered within a PSA column to get the most out of the available volume. Narrow adsorption of the component gases is more effective than a mixed arrangement. Argon is more challenging to adsorb because nitrogen is less selective and will adsorb to areas of the zeolite intended to collect argon. For instance, found that a PSA system with a layer of LiAgX zeolite, which is better at separating nitrogen, and then a layer of AgA zeolite, which is better at separating argon, was better than simply mixing the two zeolites in an adsorption bed. This was done with the intention of determining the optimal ratio of selective zeolite materials.

**ii. SOLINOID VALUE:**

The majority of the time, the value is used to direct the flow; since we utilize two sifter beds, we need to change the wind current like clockwork. Because it puts more pressure on the compressor, using a value for a two-way pneumatic solenoid won't give you the right output. Because nitrogen will also pass through zeolite, its purity will decrease and the pressure in the sieve bed will drop.

It does not use a 4-way mechanical solenoid value to regulate the pressure; Instead, only the zeolite tank experiences pressure, which improves filtering efficiency and accuracy. As the nitrogen moves from the tank to the air, it also helps to flesh it out.

### iii. ZEOLITE TANK:

The purpose of the study was to determine whether modifying the design parameters of an existing proof of concept (POC) would improve its performance. Our POC makes use of aluminum zeolite tanks rather than zeolite tanks because the latter are lighter and less reactive. The tank plays a significant role because it accounts for nearly half of the POC's weight. We employ a 1.5-foot-high 2-inch tank. The compressor determines the tank's dimensions. The tank has a water- and air-tight compartment; any hole will affect the virtue. For this investigation project, it was different in existing public help declaration structure its bay and outlet settings rather than fostering a by and large new open assistance declaration system.

A zeolite tank is a specialized filtration system that uses zeolite crystal to remove other gases from the air. Zeolites are naturally occurring minerals which are able to capture and remove specific airborne particles due to their distinctive, porous structure [25-26]. These minerals are frequently used in a variety of industrial and environmental settings to separate air.

In a zeolite tank, air flows through a bed of zeolite minerals, trapping and removing gases and heavy metals. One of the benefits of a zeolite tank is its ability to function as a PSA system. In addition to being simple to regenerate, the zeolite crystal can be cleaned and repurposed in a zeolite tank. The zeolite bed is rinsed through a filtration process as part of the regeneration process to remove impurities that have gotten stuck in the minerals and restore their ability to remove pollutants from the air. In conclusion, a zeolite tank is a specialized air filter that uses zeolite minerals to filter the air.

### iv. OXYGEN SENSOR:

The sensor with better sensitivity and selectivity always plays a major role in understanding and analytes of the sensor characteristics [22-24]. The present work uses the ultrasonic oxygen sensor 7500 serious (OCS 3f) to measure the air's oxygen level. Pass the ultrasound and determine the reflection's wavelength. The OCS 3F is an ultrasound oxygen sensor that is used in a number of applications where it is crucial to accurately and reliably measure the oxygen concentration. This sensor can be used for monitoring in the medical, industrial, and environmental sectors because it is designed to measure the partial pressure of oxygen in a gas or liquid. Before being picked up by a receiver, the OCS 3F sensor uses ultrasonic waves that travel through a gas or liquid. When compared to other gases or fluids, oxygen particles have a unique acoustic impedance, which indicates that they disperse or reflect ultrasound waves in a particular manner. The OCS 3F sensor is able to precisely quantify the convergence of oxygen in a gas or fluid by looking at the changes in ultrasound waves caused by oxygen.

The OCS 3F ultrasound oxygen sensor's precision and constancy are one of its benefits. This sensor is ideal for use in applications that require precise measurements due to its high sensitivity and capacity to detect even minute changes in oxygen concentration. Additionally, the OCS 3F sensor is designed to withstand interference from other gases, ensuring accurate measurements even in challenging conditions. Also, the OCS 3F ultrasound oxygen sensor is made to be enduring and strong. Because it is made of high-quality materials that resist corrosion and wear, it can be used in harsh environments. Additionally, the sensor is designed to be simple to maintain, lowering its total cost of ownership and guaranteeing its continued dependability over time.

**v. PRESSURE:**

The pressure is creating the high impact over purity. The amount of pressure applied also has an impact on the accuracy of the output. We utilize a medium tension, which is generally somewhere in the range of 1.2 and 1.5 bar, for improved yield precision. As the pressure rises, the nitrogen molecule moves through the zeolite molecule. As a result, we want to use a medium strain to achieve greater precision.

**vi. SOURCE TANK:**

The oxygen is kept in the source tank, where it is used to ensure that the patient receives a constant supply of oxygen air. Because the source tank pressure stays at 0.8 bar, the accuracy ranges from 95% to 98%. The flow meter that controls how much oxygen is given to the patient. The patient's condition and age will alter the oxygen flow.

## 3. Results and Discussions

A heavy metal filter is used for filtering the air as part of our POC working process. The zeolite tank's air flow is controlled by the four-way solenoid value, which receives the filtered air in further stage. After passing through the zeolite tank, the tank separates the molecules of oxygen and nitrogen and when air is added to the tank, the nitrogen cannot escape through the zeolite molecule. Only the oxygen molecule is transported and stored in the source tank during the process, the molecule of zeolite blocks the nitrogen, raising the tank's entry (inward) pressure.

An earlier report says that, a zeolite tank once had a complete obstruction that prevented oxygen from passing through it. As a result, we must elaborate on the nitrogen air's re-entry into the atmosphere. Thus two different tanks are utilized in the present proposed system, when nitrogen air is present in the first tank; it flows to the second tank, which is in the dead-sorb state, where it is re-absorbed by the system. The procedure is carried out in a different manner, and the timing plays a very crucial role as the tank's air flow will switch to another tank after five seconds. In addition, the pressure does not rise above 1.5 bar and remains constant letting only the oxygen out of zeolite tank during the process. The tiny reducer, which is anchored between the source and the tank, is maintained by the zeolite tank's output air. The channel air is stored in the source tank at a pressure of 0.8 bar, where it is used to provide a patient with oxygen after passing through the oxygen sensor where the oxygen content and temperature of the air will be measured. The passing of sound, the bandwidth of the reflected sound wave, the oxygen percentage, and the temperature of the air were all checked using an ultrasound technique. After the air has passed through the regulator, it will control the flow of air from the source tank to the patient and with use of flow meter rate of delivery to the patient can be adjusted. A detailed testing process of the oxygen concentrator's operation is as explained in further section.

At first, zeolite with a lithium base was used under 1.5 bar tension with 1 kg of lithium zeolite for a 0.5-second free stream and the results that were obtained as depicted in table1.

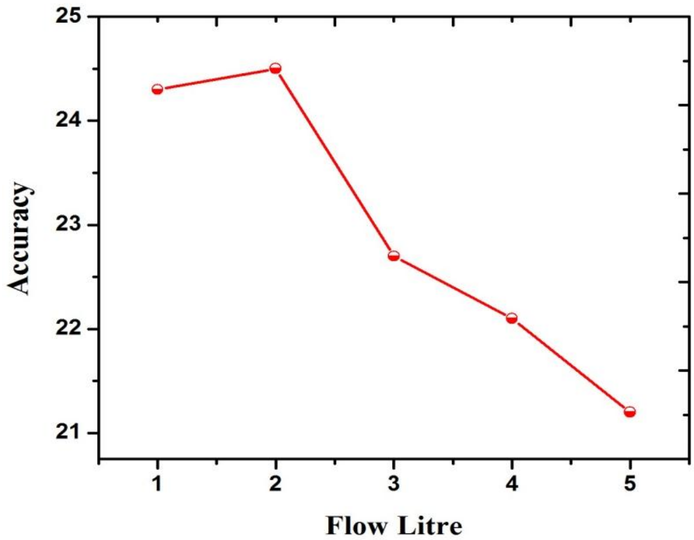


*Table 1*

| FLOW LITRE | ACCURACY |
|---|---|
| 1 | 24.3 |
| 2 | 24.5 |
| 3 | 22.7 |
| 4 | 22.1 |
| 5 | 21.2 |

***Figure 2 (a):*** *depicts the graphical representation of Accuracy vs the flow litre (lithium based zeolite) and data (table-1) respectively at 1.5bar pressure.*

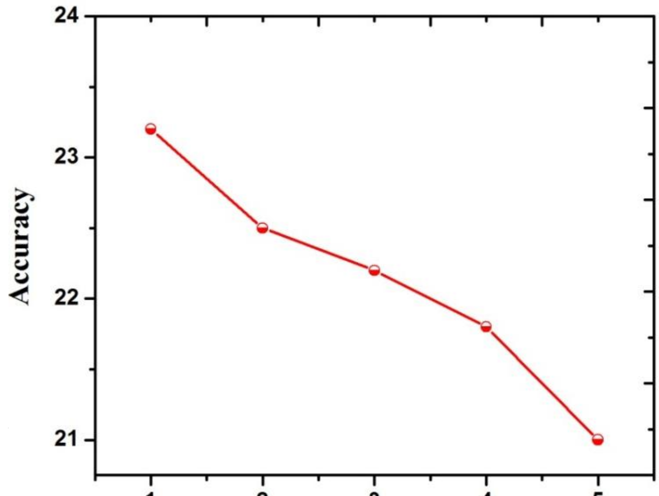


*Table 2*

| FLOW LITRE | ACCURACY |
|---|---|
| 1 | 23.2 |

| | |
|---|---|
| 2 | 22.5 |
| 3 | 22.2 |
| 4 | 21.8 |
| 5 | 21.0 |

***Figure 3(a):*** *depicts the graphical representation of Accuracy vs the flow litre (lithium based zeolite) and data (table-2) respectively at 2bar pressure.*

When the pressure was increased to 2 bar the change in the curve can be seen as depicted in the figure 3 (a) & table 2.

When the pressure was further increased to 2.5 bar pressure the change in curve plot is seen in figure 4(a) & table 3.

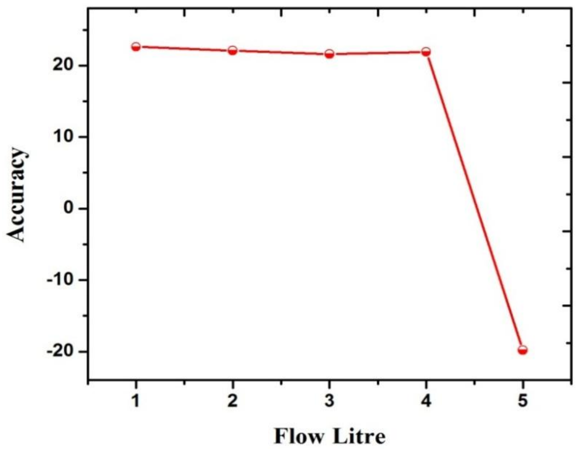


*Table 3*

| FLOW LITRE | ACCURACY |
|---|---|
| 1 | 22.6 |
| 2 | 22.1 |
| 3 | 21.6 |
| 4 | 21.9 |
| 5 | -19.8 |

***Figure 4(a):*** *depicts the graphical representation of Accuracy vs the flow litre (lithium based zeolite) and data (table-3) respectively at 2bar pressure.*

**i. PHASE THREE TESTING:**

By adjusting the pressure, we employ a sodium-based zeoli -way solenoid value in the phase. To achieve the desired purity, the following scenarios were used to repeat the testing multiple times. **SODIUM BASED ZEOLITE TESTING:**

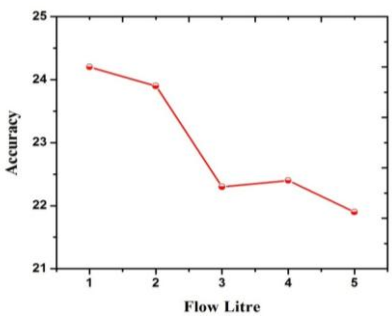


*Table 4*

| FLOW LITRE | ACCURACY |
|---|---|
| 1 | 24.2 |
| 2 | 23.9 |
| 3 | 22.3 |
| 4 | 22.4 |
| 5 | 21.9 |

***Figure 5(a):*** *depicts the graphical representation of Accuracy vs the flow litre (Sodium based Zeolite) and data (table-4) respectively at 2bar pressure.*

Sodium zeolite was tested under 2 bar pressure the change in curve plot is seen in figure 5(a) & table 4.

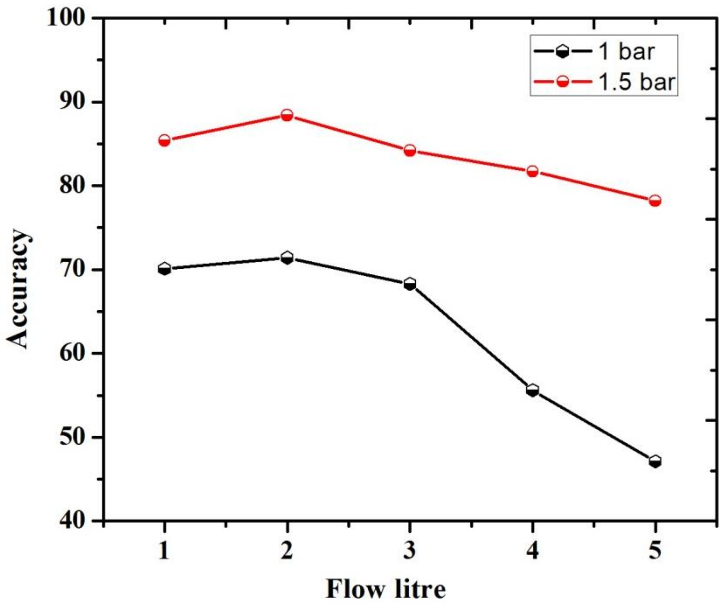


*Table 5*

| Flow Litre | Accuracy (1bar Pressure) | Accuracy (1.5 Bar Pressure) |
|---|---|---|
| 1 | 70.1 | 85.4 |
| 2 | 71.4 | 88.4 |
| 3 | 68.3 | 84.2 |
| 4 | 55.6 | 81.7 |
| 5 | 47.1 | 78.2 |

***Figure 6(a):*** *depicts the graphical representation of Accuracy vs the flow litre (Sodium based Zeolite) and data (table-5) respectively at 1 and 1.5bar pressure.*

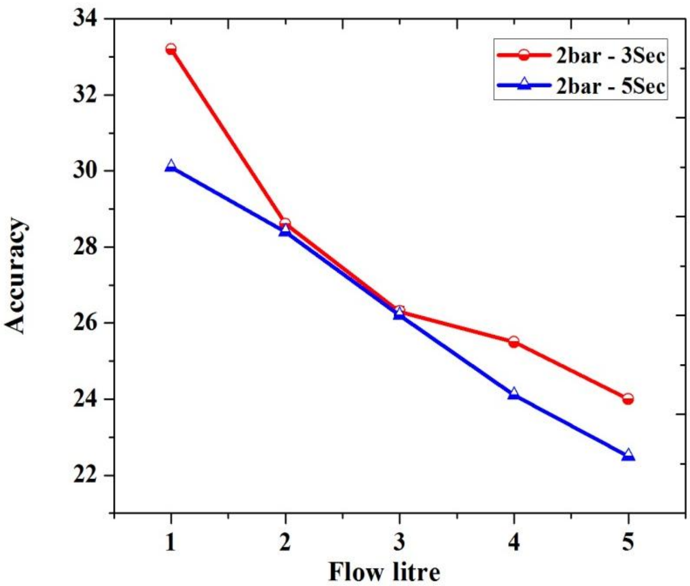


*Table 6*

| FLOW LITRE | ACCURACY (2bar Pressure 3 Sec) | ACCURACY (2bar Pressure 5 Sec) |
|---|---|---|
| 1 | 30.1 | 33.2 |
| 2 | 28.4 | 28.6 |
| 3 | 26.2 | 26.3 |
| 4 | 24.1 | 25.5 |
| 5 | 22.5 | 24.0 |

***Figure 7(a):*** *depicts the graphical representation of Accuracy vs the flow litre (Sodium based Zeolite) and data (table-6) respectively at 2 bar pressure for 3 and 5 seconds respectively.*

The zeolite filled tanked was now inserted to a working machine with working compressor pressure and applied 2.9 bar pressure for 5 seconds.

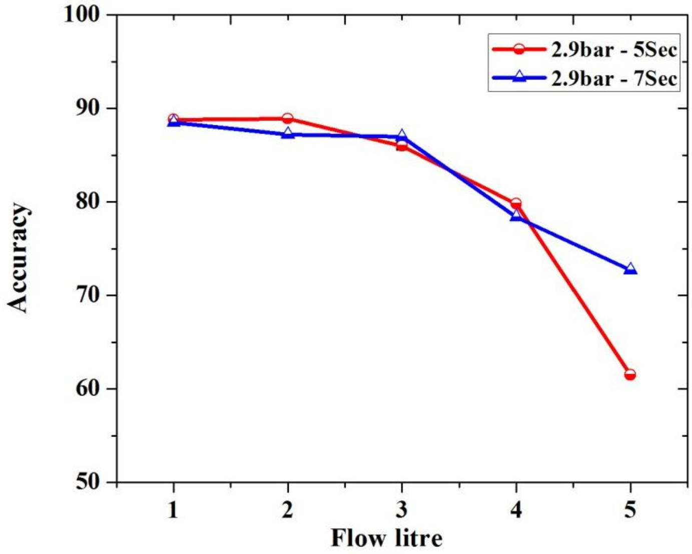


*Table 7*

| Flow Litre | Accuracy (2.9 bar pressure 5 sec) | Accuracy (2.9 bar pressure 7 sec) |
|---|---|---|
| 1 | 88.8 | 88.5 |
| 2 | 88.9 | 87.2 |
| 3 | 86.0 | 87.0 |
| 4 | 79.8 | 78.4 |
| 5 | 61.5 | 72.7 |

***Figure 8(a):*** *depicts the graphical representation of Accuracy vs the flow litre and data (table-7) respectively at 2.9 bar pressure for 5 and 7 seconds respectively.*

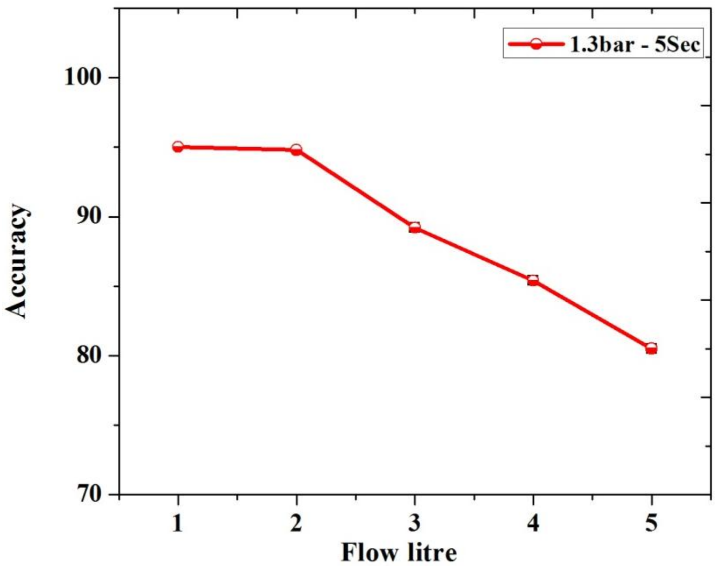


*Table 8*

| Flow Litre | Accuracy at 1.3 bar pressure (5 sec) |
|---|---|
| 1 | 95.02 |
| 2 | 94.8 |
| 3 | 89.2 |
| 4 | 85.4 |
| 5 | 80.5 |

***Figure 9(a):*** *depicts the graphical representation of Accuracy vs the flow litre and data (table-8) respectively at 1.3 bar pressure for 5 seconds respectively.*

**Discussion**

**ii. TESTING:**

- **PHASE ONE TESTING:**

The oxygen purity was tested in phase 1 with a two-way solenoid value and a lithium-based zeolite. The output accuracy was found to be in the range of 20% to 25% owing to the two-way solenoid value, which adds pressure to the compressor as the air flows freely through a zeolite bed and the pressure in the tank is reduced.

- **PHASE TWO TESTING:**

Phase two testing was carried out with a lithium-based zeolite and a four-way mechanical solenoid value in which the purity of lithium-based zeolite produced was almost identical (60-70%). As a result, it is also capable of passing nitrogen air during this phase; we verify that the tank's pressure is extremely low conditions. As a result, the pressure and zeolite must be altered as follows:

• Lithium-based zeolite - served as the initial testing material.

• On lithium-based zeolite, a variety of pressures were tested.

• Second, using sodium-based zeolite under a variety of pressure conditions.

• The size of the zeolite used was also tinkered with in order to get the desired result.

Sensors were installed and the equipment was turned on to affirm the flow rate and the readings from the outlet gauge were very close. As the system began to separate oxygen gas from the air in the atmosphere, the concentration of oxygen began to rise.

The sensor was then tested for the accuracy *vs* flow litre with the pressure range of 0.6 to 2 bar pressure which was in direct contact with source tank was found to be 70%, the sensor we used was oom202 sensor, the data sheet of the sensor was pre-checked to adjust the pressure range to which the sensor could withstand. In high pressure the accuracy reached to 45 but the high pressure was not maintained for a long time as there was a chance for the sensor to breakdown.

Under this condition 85% was achieved in 1 litre and 78.2% in 5 litres which was the standard output accuracy. Further the assumption of pressure increase is directly proportional to the accuracy was tested.

So, the pressure was increased to 3bar to affirm the relationship but surprisingly, output reached to 100% but then the values threw an error after that. Later the solenoid valve from a working machine was employed to confirm the accuracy. The accuracy reached up to a level of 82 in free flow check. In the new tank the free flow almost reached a level of 23% at 2bar pressure for 3 sec.

Later, the 4-way solenoid valve was used instead of 2-way solenoid valve and maintained 2.9bar pressure (5 sec). This 4-way solenoid valve enhanced the accuracy with the selected zeolite at 2.9 bar pressure (5 sec). Finally, the ultrasound oxygen sensor ocs3f3.0 with UART communication was used instead of oom202 sensor at 1.3 bar pressure (5 sec) to obtain the accuracy of 95.02%.

## 4. Conclusion

The portable oxygen concentrator using pressure swing adsorption (PSA) is demonstrated. The PSA technology helps to achieve the selective air molecules and supplies oxygen at a greater selectivity ratio. A detailed study on LiAgX zeolite was performed and found that it is more effective using a layer of LiAgX zeolite as adsorbents. Results show LiAgX is the most suitable with better nitrogen to oxygen selectivity ratio with a flow rate of 5LPM. The sodium based zeolites were tested with 2-way solenoids and 4-way solenoids using oom202 sensor but the accuracy was found to be in the range of 85% and later the sensor was replaced to enhance the accuracy over 95% by ultrasound oxygen sensor ocs3f3.0 with UART communication. The proposed system can be commercialized with much economical way owing to their advantages and limitations.

## List of Abbreviations

1. PSA - Pressure Swing Adsorption
2. COPD - Chronic Obstructive Pulmonary Disorder
3. POC - Portable Oxygen Concentrator
4. MOC - Medical Oxygen Concentrator
5. WHO - World Health Organization
6. PVSA - Pressure Vacuum Swing Adsorption
7. VSA - Vacuum Swing Adsorption

## Declarations

- **Ethics approval and consent to participate**
  Not Applicable

- **Consent for publication**
  Not Applicable
- **Availability of data and material**
  Not Applicable
- **Competing interests**
  "The authors declare that they have no competing interests"

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