



Pole for Doctoral Studies
Center for Doctoral Studies Sciences, Technologies, and Medical Sciences

ANNOUNCEMENT OF DOCTORAL THESIS DEFENSE



Ms. BENKIRANE Lina

**Will present their research work with the aim of earning a
Doctorate**

**Doctoral program: Science and Technique Engineering
Discipline: Chemistry-Physics
Specialty: Materials Engineering**

**On 14/02/2026 at 11H00 at the “G” Hall of the Faculty of Sciences
and Techniques of Tangier, UAE
Under the Theme**

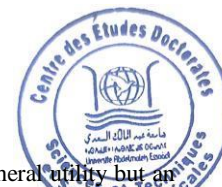
**Investigation of Scaling Up Medical Oxygen Production Unit
based on PSA Process : Modeling and Techno-economic
Assessment**

Front of the jury composed of :

| First Name & Last Name | Establishment | Designation |
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| Pr. DRAOUI Khalid | FS of Tetouan, UAE | Examiner |
| Pr. CHAFIK Tarik | FST of Tangier, UAE | Supervisor |

Host Research Structure: Chemical Engineering for Resources Valorization Group

Abstract



The COVID-19 pandemic demonstrated with unprecedented clarity that medical oxygen is not a peripheral utility but an essential therapeutic intervention whose availability directly determines survival. Oxygen therapy remains indispensable not only for the management of acute respiratory distress syndrome (ARDS), pneumonia, and COVID-19, but also for surgical anesthesia, neonatal care, trauma management, and chronic respiratory conditions such as chronic obstructive pulmonary disease (COPD). Yet, despite this universal importance, access to medical oxygen remains profoundly unequal, with low- and middle-income countries (LMICs) such as Morocco facing persistent shortages. During the pandemic, oxygen demand in Moroccan hospitals increased by more than 300%, overwhelming supply chains and highlighting vulnerabilities linked to dependence on imported cryogenic oxygen and logistical bottlenecks in distribution. Against this backdrop, decentralized production technologies such as Pressure Swing Adsorption (PSA) offer a promising pathway to strengthen national oxygen resilience.

This thesis presents a comprehensive evaluation of PSA technology for medical oxygen production in Morocco, integrating global and national context analysis, process modeling, system scale-up, and techno-economic assessment. The research begins with an extensive review of oxygen production methods, ranging from conventional cryogenic separation to adsorption-based processes (PSA, VSA, VPSA) and emerging technologies such as membranes, electrolysis, and chemical generators. Particular emphasis is placed on sorbent materials—zeolites, carbon molecular sieves (CMS), and metal-organic frameworks (MOFs)—whose adsorption properties fundamentally determine the efficiency and scalability of PSA systems. This literature review identifies both technological opportunities and research gaps, especially regarding scale-up in LMIC contexts.

Building on this foundation, a small-scale PSA oxygen concentrator was modeled using Aspen Adsorption and validated with experimental data from hospital concentrators. The unit achieved oxygen purities of 94% at flow rates of up to 3.8 L/min. Sensitivity analysis highlighted adsorption pressure (1–9 bar), cycle duration, and adsorbent particle size as the most influential parameters, with optimal recovery rates exceeding 45% and specific energy consumption of ~ 0.35 kWh/Nm³ O₂. These results confirmed the technical reliability of PSA units under real-world hospital conditions. The validated model was subsequently scaled to an industrial hospital-level unit designed to produce 500 t/year of oxygen, maintaining purity above 96% and stable cyclic performance across a range of operating scenarios. Comparative performance analysis confirmed that PSA systems can provide continuous, high-purity oxygen supply while avoiding dependence on liquid oxygen imports and mitigating logistical delays in cylinder transport.

A techno-economic assessment was then carried out to compare the scaled 500 t/year PSA system with a conventional 1000 t/year cryogenic separation plant. For the PSA plant, capital expenditure (CAPEX) was estimated at USD 9.07 million and operating expenditure (OPEX) at USD 2.05 million/year, yielding equivalent annual cash flow of USD 7.94 million. The financial indicators were strongly favorable: a payback period of only 1.14 years, a net present value (NPV) of USD 21.05 million at a 10% discount rate, and a return on investment (ROI) exceeding 437.87%. In contrast, the cryogenic plant required a higher CAPEX of USD 15.67 million, with annual cash flows of USD 4.88 million, resulting in a payback period of 3.21 years and an NPV of USD 2.84 million. Sensitivity analysis further revealed that PSA economics are highly dependent on electricity price and oxygen selling price, while cryogenic systems are primarily constrained by capital intensity.

The findings of this thesis provide robust evidence that PSA technology constitutes a technically feasible, economically competitive, and context-appropriate solution for decentralized medical oxygen production in Moroccan hospitals. The integration of modeling, validation, scale-up, and financial analysis not only advances the scientific understanding of PSA systems but also delivers policy-relevant insights for national healthcare planning. More broadly, the results underscore the potential of PSA deployment across LMICs, where strengthening oxygen infrastructure is both a medical necessity and a public health priority. By demonstrating that PSA units can be optimized to balance purity, efficiency, and affordability, this work contributes to the long-term goal of building resilient and equitable oxygen ecosystems, in alignment with World Health Organization (WHO) strategies for global health security.

Keywords : pressure swing adsorption process, cryogenic separation, process modelling, techno-economic assessment, medical oxygen production, large scale oxygen generation unit, small scale oxygen production unit, sensitivity analysis.