French Polytech network form for PhD Research Grants from the China Scholarship Council

This document describes one of the PhD subjects proposed by the French Polytech network. The network is composed of 15 engineering schools/universities. The document also provides information about the supervisor. Please contact the PhD supervisor by email for further information regarding your application.

Supervisor information	
Family name	Tarlet
First name	Dominique
Email	dominique.tarlet@univ-nantes.fr
Web reference	https://polytech.univ-nantes.fr/fr/dominique-tarlet
Lab name	Laboratoire de Thermique et Energie de Nantes – LTeN UMR CNRS 6607
Lab web site	http://www.polytech.univ-nantes.fr/ltn/en/
Polytech name	Polytech Nantes
University name	Nantes Université
Country	France

PhD information	
Title	Transport phenomena of carbon capture process in microfluidics through in-situ investigations
Main topics regards to CSC list (3 topics at maximum)	V-4, V-12, V-14

Required skills in science and engineering	Image treatment using matlab, Optical test bench (camera), English written and spoken, advanced Fluid dynamics, two-phase flow (gas-liquid)

Subject description (two pages maximum including biblio)

Carbon dioxide (CO_2), as a major greenhouse gas, has raised great concerns in terms of global warming and climate change. Therefore, Carbon Capture, Storage and further Utilization (CCSU) is considered as a crucial strategy for meeting CO2 emission reduction targets as defined in COP21 in 2015, and in the Paris agreement signed in 2016 [1]. Different technologies are actually available for removing large amounts of CO2 from natural, refinery and synthesis gas streams [2]. Among them, the most mature and widely used technique is the chemical absorption/desorption process using alkanolamine-based solvents [3, 4].

In terms of equipment needed for CO_2 capture and storage, current chemical absorption process usually involves towers or packed columns having huge volumes and low efficiencies in heat and mass transfer. They usually occupy large spaces, are difficult to control and not energy-efficient. Furthermore, they bring safety and reliability issues to the industrial facilities. One of the routes to realize the CO_2 absorption/desorption process intensification is through the miniaturization, more precisely the employment of microfluidic devices [5, 6], providing a largely reduced required volume, enhanced mass and heat transfer through a dramatic increase in interfacial area, cleaner, safer, higher productivity and more efficient use of energy.

The general objective of this PhD is to enhance the absorption efficiency of such a miniaturized process, whithin two-phase flows designed to break and fold gas-liquid interfaces [7] and boundary layers while keeping an acceptable pressure drop. In addition to well-known optical measurements, the means of non-intrusive optical investigation to determine the field of pH [8], then the gradient of dissolved CO_2 concentration, are new in this field and particularly developed in our research team and network. They (i) bring an explanation to the improved absorption efficiency, (ii) enable further optimization of the two-phase flow and (iii) open the way to a precise comparison to CFD results.

Globally, this Ph.D. topic and research environment at LTeN lab is the opportunity to work for sustainable development through an improved CCUS process [9], to develop and publish cutting-edge results about chemical absorption of CO_2 within a miniaturized, industrially-efficient gas-liquid flow [10] by means of innovative optical measurements.

LITTERATURE REFERENCES

[1] Paris Agreement". United Nations Treaty Collection. 8 July 2016.
[2] Leung, D.Y.C., Caramanna, G., Maroto-Valer, M.M. An overview of current status of carbon dioxide capture and storage technologies (2014) Renewable and Sustainable Energy Reviews, 39, pp. 426-443. DOI: 10.1016/j.rser.2014.07.093

[3] Vega, F., Baena-Moreno, F.M., Gallego Fernández, L.M., Portillo, E., Navarrete, B., Zhang, Z. Current status of CO2 chemical absorption research applied to CCS: Towards full deployment at industrial scale (2020) Applied Energy, 260, art. no. 114313. DOI: 10.1016/j.apenergy.2019.114313
[4] Zhang, Z., Wang, T., Blunt, M.J., Anthony, E.J., Park, A.-H.A., Hughes, R.W., Webley, P.A., Yan, J. Advances in carbon capture, utilization and storage
(2020) Applied Energy, 278, art. no. 115627. DOI: 10.1016/j.apenergy.2020.115627
[5] Ganapathy, H., Steinmayer, S., Shooshtari, A., Dessiatoun, S., Ohadi, M.M., Alshehhi, M. Process intensification characteristics of a microreactor absorber for enhanced CO2 capture (2016) Applied Energy, 162, pp. 416-427. DOI: 10.1016/j.apenergy.2015.10.010
[6] Aghel, B., Heidaryan, E., Sahraie, S., Mir, S. Application of the microchannel reactor to carbon dioxide absorption (2019) Journal of Cleaner Production, 231, pp. 723-732. DOI: 10.1016/j.jclepro.2019.05.265
[7] Hao Cheng, Dominique Tarlet, Yilin Fan, Lingai Luo, Mass transfer enhancement for CO2 chemical absorption in a spiral baffle embedded microchannel, Chemical Engineering Science, Vol. 280, 2023, https://www.sciencedirect.com/science/article/pii/S0009250923005249
[8] M. Wang, M. Stiti, H. Chaynes, S. Becker, E. Berrocal, F. Lemoine, G. Castanet, Two-photon fluorescence lifetime imaging applied to the mixing of two non-isothermal sprays: temperature and mixing fraction measurements, Experiments in Fluids, 2022, 63 (11), pp.172.
[9] Hao Cheng, Yilin Fan, Dominique Tarlet, Lingai Luo, Zhiwei Fan, Microfluidic-based chemical absorption technology for CO2 capture: Mass transfer dynamics, operating factors and performance intensification, Renewable and Sustainable Energy Reviews, Vol. 181, 2023, https://www.sciencedirect.com/science/article/pii/S1364032123002149
[10] H. Cheng, D. Tarlet, Y. Fan, L. Luo, Enhancement of carbon dioxide chemical absorption in microchannel with structured baffle, 8th European Process Intensification Conference (EPIC), May-June 2023, Warsaw, Poland.