



**HAL**  
open science

# **Structure-Process-Property Relationships in HDPE Microfoams: Impact of Supercritical Nitrogen on Morphology, Creep Behavior, and Predictive Modeling**

Achref Elhasni, Mohamed Yousfi, Jannick Duchet-Rumeau, Abderrahim Maazouz

## ► To cite this version:

Achref Elhasni, Mohamed Yousfi, Jannick Duchet-Rumeau, Abderrahim Maazouz. Structure-Process-Property Relationships in HDPE Microfoams: Impact of Supercritical Nitrogen on Morphology, Creep Behavior, and Predictive Modeling. SPE FOAMS® 2025, Sep 2025, Naples, Italy. <ujm-05280802>

**HAL Id: ujm-05280802**

**<https://ujm.hal.science/ujm-05280802v1>**

Submitted on 30 Sep 2025

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



HAL Authorization

# Structure–Process–Property Relationships in HDPE Micro foams : Impact of Supercritical Nitrogen on Morphology, Creep Behavior, and Predictive Modeling



Achref Elhasni <sup>1</sup>, Mohamed Yousfi, Jannick Duchet-Rumeau <sup>1</sup>, Abderrahim Maazouz <sup>1,2</sup>

<sup>1</sup> Université de Lyon, CNRS, UMR 5223, Ingénierie des Matériaux Polymères, Université Claude Bernard Lyon 1, INSA Lyon, Université Jean Monnet, F-69621 Villeurbanne Cedex, France

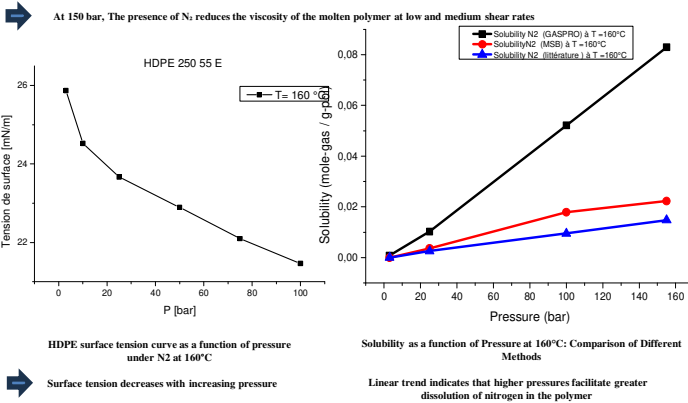
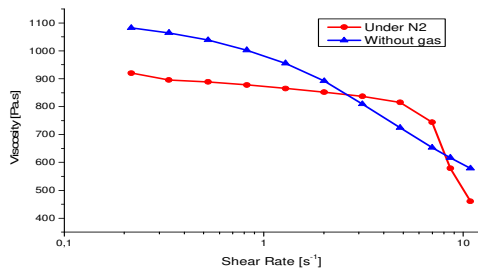
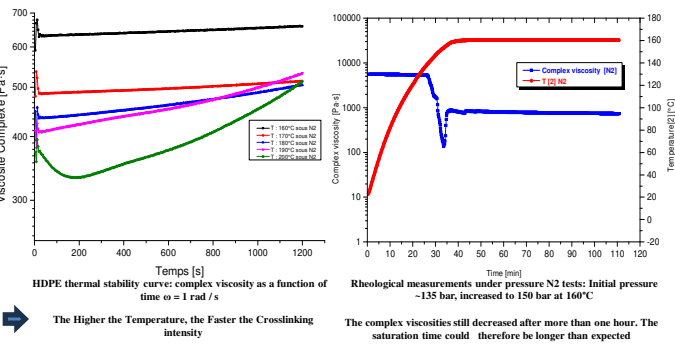
<sup>2</sup> Hassan II Academy of Science and Technology, Rabat, Morocco



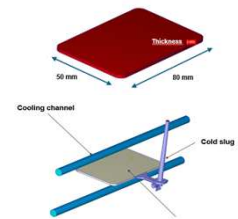
## Introduction

The production of lightweight polymer foams is a key challenge for industry. The MuCell® process with supercritical nitrogen (Sc.N<sub>2</sub>) enables control of the cellular structure in high-density polyethylene (HDPE). In this study, high-pressure rheological and physicochemical measurements, together with mechanical tests, were combined with microscopic observations and numerical models to investigate the effect of gas content on foam morphology and performance.

## Rheological and Physicochemical Characterization



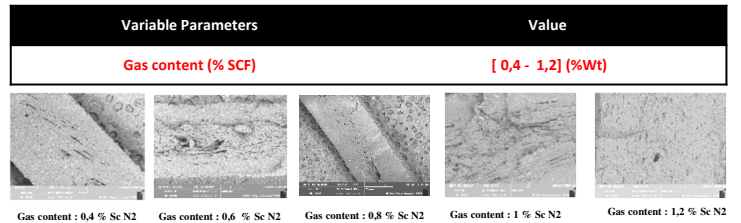
## Foaming processes ( MuCell )



## Reference :

- Ding, Y., Vyas, C., Bakker, O., Hinduja, S., & Bartolo, P., Modelling and simulation of MuCell®: The effect of key processing parameters on cell size and weight reduction, *Polymers*, 14(19), 4215, 2022.
- Raps, D., Goodarzi Hosseiniabadi, H., Heymann, L., Köppl, T., & Altstädt, V., Rheological Properties of Thermoplastic Polymers with Dissolved Gases for Foaming Applications, arXiv preprint arXiv:1804.07956, 2018.

## Morphological observations (SEM)



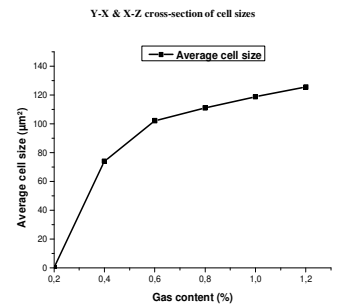
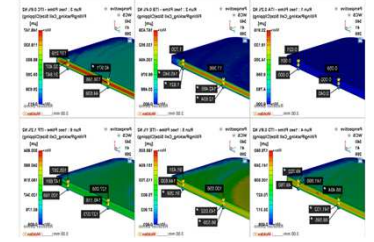
SEM images show a typical sandwich structure: a solid skin and a foamed core. In the core, pores are elongated, while near the surface, they become smaller and more circular.

## Numerical modeling

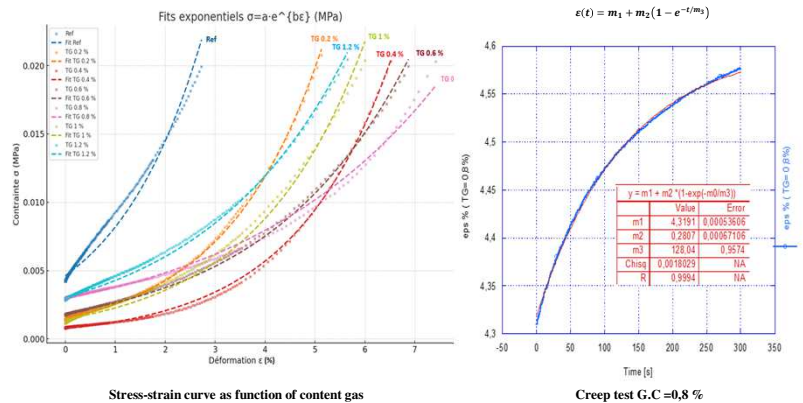
### Modified Han and Yoo Model

$$\frac{dP_D}{dt} = \frac{1}{R^2} \frac{6D (R_p T) (\bar{c} - c_0)}{1 + \left[ \frac{Z/R^3}{R_p T} \frac{P_D R^2 - P_{D0} R^2}{\text{sgn}(\bar{c} - c_0)} (\bar{c} - c_0) \right]^{1/2}} - \frac{3P_D dR}{R dt}$$

Modified Han and Yoo model is considered a good compromise, as it provides realistic growth while accounting for bubble shrinkage phases.



## Mechanical results



## Conclusion

The Sc.N<sub>2</sub> content influences the cellular structure and mechanical behavior of HDPE foams. The combined experimental and simulation approach helps identify key parameters to optimize lightweight design and performance. In the future, the goal is to establish more precise correlations between physicochemical properties, processing conditions, morphology, and mechanical performance, in order to further improve the design of lightweight and high-performance polymer parts.