Title: Design of core-shell aerogel particles combining AI tools and supercritical drying for oral drug delivery

Authors: Carlos Illanes-Bordomás*, Mariana Landin, Carlos A. García-González

Afiliations: AerogelsLab, I+D Farma Group (GI-1645), Department of Pharmacology, Pharmacy and Pharmaceutical Technology, Faculty of Pharmacy, Instituto de Materiales (iMATUS) and Health Research Institute of Santiago de Compostela (IDIS), University of Santiago de Compostela, E-15782-Santiago de Compostela, Spain
*corresponding author: carlosjavier.illanes@rai.usc.es

Abstract:
Core-shell aerogels can be prepared by combination of air-assisted coaxial dripping systems with subsequent supercritical drying, obtaining particles with aerogel inherent properties and the presence of coatings [1]. This methodology involves numerous processing parameters, making Artificial Intelligence (AI) tools invaluable for optimizing and understanding the effect of each variable on the particle characteristics [2].
In this work, AI tools were employed to develop aerogel particles using alginate (Alg) solutions as drug-loaded cores and konjac glucomannan (KGM) solutions as coatings. Initially, various system variables were tested to establish the limits of the design space. Subsequently, DataForm® software was utilized to create a balanced design, incorporating variables such as Alg and KGM concentrations, airflow rate, Alg and KGM pump pressures, and different nozzle sizes at three levels. After preparing the gel particles, their Feret diameter, circularity, coating thickness, core position and nozzle blockage were analyzed. The relationship between the operational variables and the formulation characteristics was studied using FormRules® and INForm® software to identify key influencing variables and establish the optimal conditions for the intended formulation.
Results revealed that core positioning was significantly affected by nozzle configuration and the balance between pump pressures. Optimal formulations with sizes around 2 mm and coatings around 300 µm were obtained, according to the predicted results. Using these processing conditions, different gel formulations loaded with vancomycin or dexamethasone were prepared and dried with supercritical fluids.
The resulting aerogels had specific surface areas higher than 200 m^2/g, log-normal particle size distributions with average sizes of 1.77 mm, and unexpected immediate release of both drugs.

This work provides initial insights into the production process of core-shell aerogel particles via coaxial dripping for drug delivery and the use of KGM as raw material for the preparation of multiparticle aerogel formulations.

Acknowledgements:

This work was funded by MICIU [PID2023-151340OB-I00/AEI/10.13039/501100011033], Xunta de Galicia [ED431C 2024/009], Agencia Estatal de Investigación [AEI], project IBEROS+ (0072_IBEROS_MAIS_1_E, Interreg-POCTEP 2021-2027), and FEDER funds. C. I.-B. acknowledges MCINN and FSE+ for an FPI fellowship [PRE2021097177/AEI/10.13039/501100011033].

References:

[1] F. De Cicco, P. Russo, E. Reverchon, C.A. García-González, R.P. Aquino and P. Del Gaudio. Carbohydrate Polymers, 147, 482-489 (2016).

[2] C. Illanes-Bordomas, M. Landin and C.A. García-González, Polymers, 17, 1919 (2025).