Development of a Predictive Model for the Sauter Mean Diameter in Emulsion-Based Processes for Food and Nutraceutical Applications

Chiara Bufalini [a], Raffaella Griffo [b], Claudia Carotenuto [b], Giulio Armando Angiolani [a], Jan Oscar Pralits [a] & Roberta Campardelli [a]

[a] Department of Civil, Chemical and Environmental Engineering, University of Genoa, Genoa, Italy
[b] Department of Engineering, University of Campania "Luigi Vanvitelli", Aversa, Caserta, Italy

E-mail: *chiara.bufalini@edu.unige.it*

Emulsion-based processes are widely used for the encapsulation and the controlled delivery of several active principles for food and nutraceutical applications. In these processes, the selection of operating conditions is crucial for generating products with dimensions suitable for specific applications. As such, predictive models play a key role in production process optimizing, minimizing the number of experiments required to identify optimal conditions. This study presents a novel predictive model for estimating the Sauter mean diameter of emulsion droplets and polymeric particles. This approach addresses a significant gap in literature, in fact predictive models for these systems are currently lacking.

In this work, the oil phase of the emulsion consisted of a polymeric solution. Commonly used polymers, such as polycaprolactone with varying molecular weights and polylactic acid, and solvents, such as chloroform and dichloromethane, were selected for particle production. Regarding the production process, emulsions were prepared using a rotor-stator emulsifier, and the polymeric particles were produced through the emulsion solvent evaporation technique. The collected data was used to develop a predictive model based on the Buckingham Π-theorem. Through dimensional analysis and appropriate simplifications, a model equation was derived that expresses the Sauter mean diameter as a function of four dimensionless parameters: Reynolds number, Weber number, mass ratio of polymer to total oil phase, dimensionless time. Each of these was raised to an exponent, calibrated experimentally using the generalized reduced gradient method. Two versions of the model were developed: one for predicting emulsion droplet size and another for polymeric particle size.

From the obtained results, the root mean square errors were particularly low, highlighting the accuracy of the proposed models. Therefore, the used methodology allowed to develop an accurate predictive model for droplets and particles.

Keywords: *emulsion-based processes, Sauter mean diameter, emulsions, polymeric particles, predictive modelling, dimensional analysis.*