THE SOLUTION OF THE INVERSE LIGHT-SCATTERING PROBLEM FOR PRECISE MORPHOLOGICAL CHARACTERIZATION OF MILK FAT GLOBULES

Konokhova A.I.*, Gilev K.V., Strokotov D.I., Yurkin M.A.,Maltsev V.P.
Institute of Chemical Kinetics and Combustion SB RAS, Novosibirsk, Russia
e-mail: konokhova_a@mail.ru
**Corresponding author*

Key words: inverse light-scattering problem, global optimization, milk fat globules

Motivation and Aim: Scanning flow cytometry proved itself as a method able to characterize single particles of different shapes by their morphology from light scattering [1]. The method is based on measurement of angle-resolved light-scattering patterns (LSPs) of individual particles and on the solution of the inverse light-scattering (ILS) problem. The ILS problem in its turn requires theoretical simulation of light scattering by a particle described by a proper optical model. The latter is a crucial factor for precise characterization.

Morphological characterization of milk fat globules (MFGs) is an important problem due to their function as a major carrier of bioactive molecules in milk. Thus, their characteristics play an important role in manufacturing of various dairy products. Usually modeled by spheres they nevertheless have a weak asphericity and can also be modeled as oblate spheroids. Our goal is to test different models for MFGs and develop an enhanced characterization method of the MFG population by their sizes and refractive indices.

Methods and Algorithm: LSPs of individual MFGs were measured with the Scanning Flow Cytometer. We used T-matrix method to simulate LSPs for the model of an oblate spheroid, and the Mie theory – for a homogeneous sphere. The ILS problem was solved through the global minimization and was performed by using DiRect algorithm for spherical model and nearest-neighbor interpolation with precalculated database of LSPs for spheroidal one. Both models were applied to each MFG, and the best one was chosen by applying the F-test.

Results: The inversion algorithm allowed us to separate measured MFGs into two fractions: those well-modeled by a sphere and those requiring a spheroidal model. While the spherical model was sufficient for large part of MFGs, spheroidal model was still required for the largest MFGs. This separation improved the accuracy of particle characterization over the whole sample in comparison with the results based on a single model.

Conclusion: We have demonstrated an advanced performance of the scanning flow cytometry in characterization of individual particles from light scattering. For the first time the shape of MFGs was modeled by an oblate spheroid to agree with sensitive measurement of angle-resolved light scattering. The solution of the ILS problem for individual MFGs allowed us to construct the distributions over MFG characteristics of the milk samples. This precise quantitative characterization of milk samples can be used to control manufacturing processes.

References:

1. V. Maltsev, A. Chernyshev, D. Strokotov. (2013) Light-Scattering Flow Cytometry: Advanced Characterization of Individual Particle Morphology. In: *Flow Cytometry: Principles, Methodology and Applications,* S. Papandreou (Ed.), 79–103 (Nova Science Publishers).