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# Structural investigation on nanostructured lipid carriers for fish oil by small angle scattering

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Fortification of foods with essential functional lipids such as $\omega$-3 polyunsaturated fatty acids (PUFAs), $\beta$-carotene and vitamin A are of key importance for health and well-being. $\omega$-3 PUFAs are essential for the human diet to support a good brain and cardiovascular health. Furthermore, they lower the risk of other diseases such as type 2 diabetes and inflammatory disorders. Vitamin A and its precursor $\beta$-carotene are important for growth and development, good vision and immune functions. Integrating such chemically unstable compounds into food products and delivering them into the human body requires encapsulating them into a carrier system. This improves their water-dispersibility and protects them from lipid oxidation.

Recent studies [1-3] show that lipid oxidation of $\omega$-3 PUFAs reduced significantly when incorporated into a solid tristearin matrix, a so called nanostructured lipid carrier, when sufficient amounts of tristearin is added to the samples and lecithin with a high phase transition temperature and bile salts or Quillaja saponins are used as emulsifiers. From this observation it is anticipated that during the cooling process the emulsifier molecules at the lipid-water interface promote a co-crystallization of the lecithin chains with the tristearin via heterogeneous interfacial nucleation. The crystallized tristearin limits the mass transport of reactive agents which reduces lipid oxidation of the encapsulated fish oil.

However, the structural composition of such nanostructured lipid carrier particles is still unclear. Does the crystallized tristearin form a shell around a single fish oil core or is the fish oil embedded as smaller islands in the tristearin particle matrix?

Typically, these lipid particles are about 150 nm in size as measured by dynamic light scattering. Based on the sample composition (fish oil : tristearin ratios between 60:40 and 20:80) and assuming a spherical core-shell structure, we can expect thicknesses between 10 and 30 nm for a tristearin shell [3]. Thus, small-angle X-ray and neutron scattering (SAXS, SANS) and wide-angle X-ray scattering are the methods of choice to study the morphology of the particles and especially their internal structure on atomic to colloidal length scales.

In SANS and SAXS experiments we will study samples with different fish oil : tristearin ratios. Using mixtures of water and deuterated water for the dispersion medium as well as mixtures of tristearin and its fully deuterated analogue, three different neutron scattering contrasts are realized for each sample. The different contrasts allow to highlight the spatial distribution of both fish oil and tristearin alone and as a combination in the lipid particles.

After an introduction to the subject, the presentation will show first analysis results of the SAXS and SANS measurements with regard to the structural composition of the nanostructured lipid carriers containing fish oil.

References:

[1] Salminen et al., Food Chem. **190** 928-937 (2016)

[2] Salminen et al., Food Chem. **141**(3) 2934-2943 (2013)

[3] Salminen et al., J. Colloid Interface Sci. **490** 207-216 (2017)

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