doi:10.1017/S1431927611002650
Microsc. Microanal. 17 (Suppl 2), 2011

Characterization of the Microstructure and Lipid Oxidation of Fish Oil Emulsions

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Addition of fish oil to industrially prepared food products is attractive to both consumers and the food industry for reasons such as health benefits from omega-3 fatty acids in the fish oil and the possibility to add additional commercial value to the food products. However, fish oil is highly susceptible to oxidation because of the large number of double bonds in the long chain omega-3 fatty acids. Oxidation affects both the nutritional value and the taste and smell of the products. Strategies for limiting oxidation are thus very important.

One strategy for limiting lipid oxidation is the emulsification of the fish oil before addition to the food products. It has been suggested that addition of emulsified oil droplets surrounded by food grade emulsifiers rather than addition of the neat oil might protect the fish oil from oxidation to some extent. Studies so far have indicated that the emulsification of the fish oil changes the products' oxidative stability but whether emulsification is an advantage seems to be dependent on the food matrix to which the emulsion is added [1, 2]. It is therefore of interest to look at the emulsions themselves to assess what determines the oxidation. It has been proposed that oxidation is to some extent dependent on the structure of the emulsion; including oil droplet sizes, size distribution and the thickness of the interface between oil and water. This interface can be stabilized by food grade emulsifiers such as proteins and phospholipids from milk. The main objective of this study is to characterize fish oil in water emulsions with respect to oil droplet size, size distribution, and ultimately to view the thickness, structure and morphology of the water / emulsion and emulsion / oil interface layers.

Cryo electron microscopy methods such as freeze fracture, cryo Scanning (and Transmission) Electron Microscopy, cryo-SEM (and cryo-TEM) have been chosen to explore whether there are structural differences between different emulsifiers and if there is any relationship between the oxidation of the emulsions and their structure. We have so far compared 70% fish oil-in-water emulsions prepared with emulsifiers having either a high protein content or a high content of phospholipids using cryo-SEM.

It has been found that there is some dependency on droplet size with the concentration of emulsifier. Hence, a high emulsifier concentration resulted in smaller oil droplets (see Figure 1 a-b). There seem to be structural differences between protein rich emulsifiers and phospholipid rich emulsifiers (Figure 1 a-c vs d) with a high content of phospholipid, leading to rough surfaces of the oil droplets. It seems that there are multiple layers of emulsifier surrounding the oil droplets in emulsions prepared with a high concentration of phospholipids and that they also seem to break along the interface much more frequently compared to the protein based emulsions that tend to fracture directly across the droplets and not along the interfacial layers [3, 4].

References

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[2] M.B. Let et al., *J. Agric.Food Chem.* 55 (19) (2007) 7802.
[3] This research was supported by the Danish Food Industry Agency under the Ministry of Food, Agriculture and Fisheries.
[4] All micrographs were produced at the Center for Electron Nanoscopy, DTU Cen, Denmark.

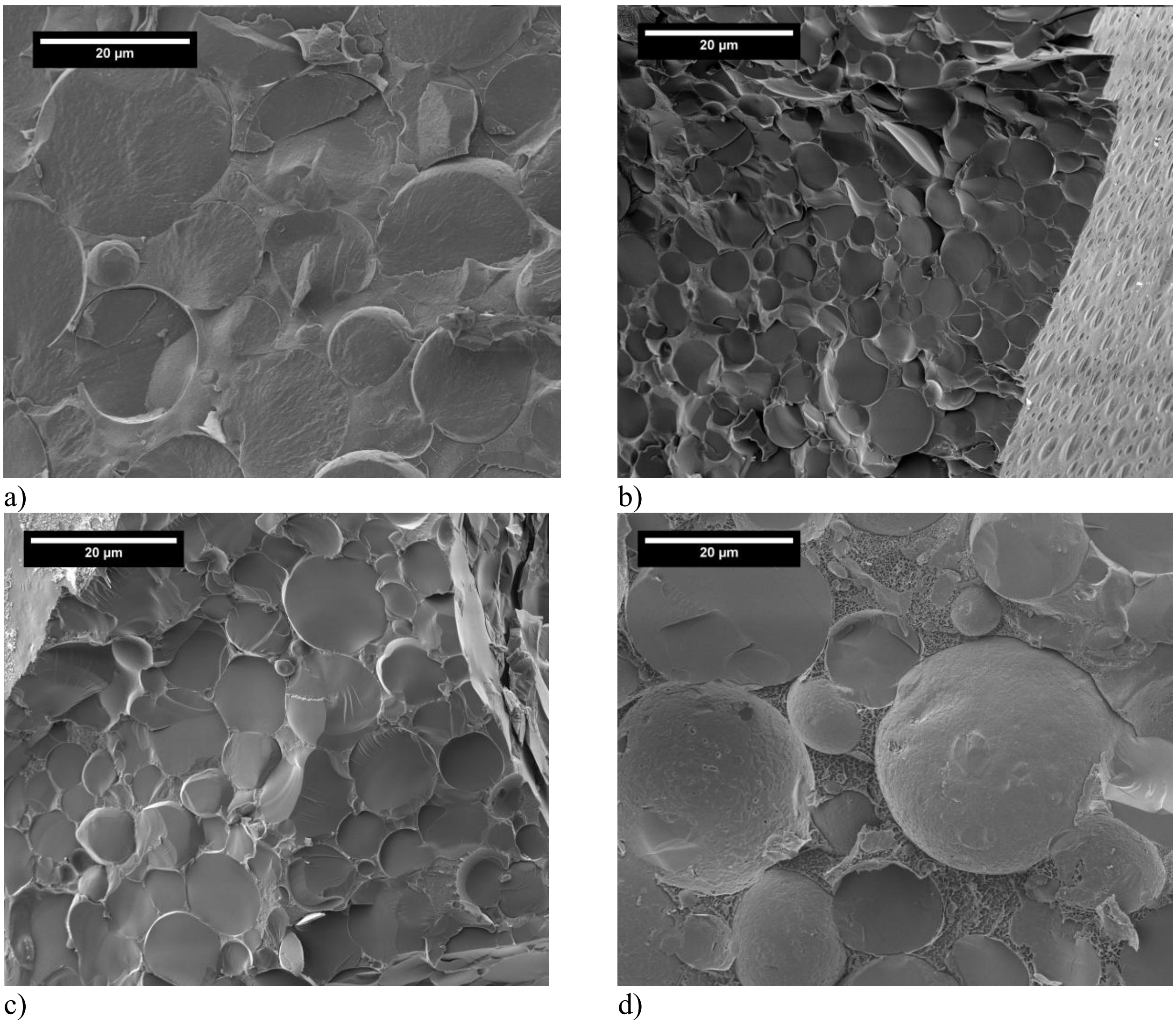

FIG. 1. Cryo-SEM of freeze fractured emulsions containing 70% fish oil. a) Sodium caseinate 1.4 %, b) Sodium caseinate 2.8 %, c) Milk phospholipid (20%) based emulsifier 2.8%, d) Milk phospholipid (75%) based emulsifier 2.8%.