

Title:

Development of a Rheo-NMR System to Study the Crystallisation of Bulk Lipids under Shear Flow

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The properties of edible crystallized fats are determined by the combination of solid fat content (SFC) and fractal structure. Both SFC and the structures are dramatically affected by shear flow during crystallization. We developed a mini-Couette cell to crystallize samples under shear flow. Initial tests used canola stearin (CS) in canola oil (CO) in a 20MHz NMR spectrometer. The blends were, melted in the cell at 80 °C, and then crystallized under different shear rates (58 s^{-1} to 460 s^{-1}) at 40 °C inside the spectrometer for 4 hours. Time averaged NMR free induction decay (FID) curves were captured at 20 s intervals. SFC values were calculated using parameters determined by a calibration procedure.

The SFC values determined by the direct method with and without the shaft of the Couette device were reasonably close. Similar results were observed with and without shear in the Couette device. The FID curves did not show a significant difference either. The system is thus accurate for in-situ time-resolved determination of SFC under rheological conditions. Furthermore, a combination of the direct and the indirect methods was used to estimate the temperature increase due to viscous heating. A special temperature control system was later developed for the system and SFC values for crystallization of cocoa butter under controlled shear flow (45 to 720 s^{-1} , 17.5 to 22.5 °C) were obtained for the first time. These results were correlated to synchrotron x-ray diffraction measurements in a system with the same geometry. To further illustrate its application, we will present also selected results from experiments conducted with other commercial fats.

The system developed will help in understanding the effects of shear flow on SFC of nanostructured lipid multicomponent systems. Our aim is to contribute to optimize the design of manufacturing processes.