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Liquid Crystalline Structures in Digesting Milk-like Emulsions and Their Potential for Drug Delivery Studied Using Small and Wide Angle X-ray Scattering

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Milk is nature's lipid-based formulation for delivering fat-soluble nutrients to infants and remains a mainstay of the adult diet thereafter. Commercially produced lipid-based formulations are used in the oral delivery of fat-soluble drugs, in which the emulsified lipids help to dissolve entrained drugs to promote absorption in the intestine and drug bioavailability. Critical to this absorption process is the digestion of the lipid carrier phase, in which apolar triglycerides are broken down into monoglycerides and fatty acids. Initial studies performed on the small and wide angle X-ray scattering (SAXS/WAXS) beamline of the Australian Synchrotron revealed that these amphiphilic milk fat digestion products spontaneously assemble into a progression of liquid crystalline structures over time during in vitro lipid digestion.[1] This presentation will elaborate on those initial studies, discussing the liquid crystalline structures formed in a variety of milks and milk-like emulsions and the influence of milk processing on the structures that form.[2] By utilising two camera lengths on the SAXS/WAXS beamline we have been able to correlate the extent of digestion of milk lipids with both the self-assembled liquid crystalline structures formed during digestion and the crystalline forms of drugs present in the digesting emulsion.[3,4] When combined, these data reveal the key role of the lipid digestion process in determining the fate of fat-soluble drugs co-administered with milk.

[1] Salentinig, S. et al., Formation of Highly Organized Nanostructures during the Digestion of Milk. ACS Nano 2013, 7 (12), 10904-10911.
[2] Clulow/Salim et al., A closer look at the behaviour of milk lipids during digestion. Chem. Phys. Lipids 2018, 211, 107-116.
[3] Clulow et al., The Curious Case of the OZ439 Mesylate Salt: An Amphiphilic Antimalarial Drug with Diverse Solution and Solid State Structures. Mol. Pharmaceutics 2018, 15 (5), 2027-2035.
[4] Salim et al., Interactions of Artefenomel (OZ439) with Milk during Digestion: Insights into Digestion-Driven Solubilization and Polymorphic Transformations. Mol. Pharmaceutics 2018, 15 (8), 3535-3544.

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