A COMPUTATIONAL BIO-RHEOLOGY STUDY ON BIO-FLUIDS UNDER EXTENSIONAL DEFORMATION

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The main focus of the present computational modelling work is to determine the rheological response of some biofluids to aid experimentally-based analyses and clinical practice. This may be accomplished through advanced rheological parameterisation and characterisation of samples, particularly when considering extensional deformation flow situations – as in filament stretching and contraction flows.

Here, two biological flow systems within the human body are of interest: *(i)* sputum in the lung-airways, where stretchiness of sputum in situ is vital; with clinical focus on chronic obstructive pulmonary disease (COPD/sputum) (filament stretching); and *(ii)* bile-flow in the biliary system: with clinical focus on primary sclerosis cholangitis, and common bile duct narrowing (contraction flow). Both sputum and bile samples are represented and characterised through kinetic theory rheological fluid modelling, with capability to represent material structure (entanglement, branching, anisotropy). This is practically achieved by appealing to the class of pom-pom differential models, using the Single Extended pompom (SXPP) approximation. This class of models exhibits the desired viscoelastic response (memory), with strain-hardening/softening and shear-thinning properties.

Under filament-stretching considerations, the filament stretching rheometer has recently emerged as a candidate apparatus for measuring the extensional properties of highly-mobile low-medium viscosity fluids. Typically, the dynamic development of the mid-filament diameter is monitored, under step-strain mode (*CaBER -FiSER)*), during the process of necking and failure, from which the appropriate rheological calculations are performed (providing Trouton ratio, extensional viscosity and relaxation time). This is precisely the modelling procedure adopted in the present study, where trends of increasing apparent extensional viscosity in time are derived over acceptable ranges of deformation rate. The aim is to link this type of data with that emerging from experimental/clinical trials to reveal insight on disorder treatment.

Furthermore under contraction flow, the well established 4:1 contraction and 4:1:4 contraction/expansion benchmark problems are appealing and representative of confined flow settings encountered in the biliary system (mixed shear-extensional flow). Here, accurate determination of flow structures and pressure-drops is vital under clinical procedures (to avoid or avert constrictions/blockage in the bile system – as with gallstones), and as a direct consequence of the bio-sample rheological properties. In addition to represent bile fluid properties, we take this further to explore the viscoplastic regime via a viscous regularisation procedure, implemented through a Bingham-Papanastasiou model. This allows assess to prediction for shear-thinning/thickening behaviour with a yield stress response. This approach may then be developed into the visco-elastoplastic regime.