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Taylor Dispersion in a Pulsatile Flow of a Maxwell Fluid through an Eccentric Annular Tube

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Extended Abstract

In the present work, the Taylor dispersion of a solute into a pulsatile flow of a Maxwell fluid through an eccentric annulus is studied. To determine the dispersion coefficient, we use the multiple-scale analysis together with the homogenization method [1]. To achieve this, the first step is to obtain the solution for the velocity profile, which characterizes the nature of biological flows, exhibiting both viscoelasticity (described for Maxwell upper-convected model) and the pulsating behaviour. This pulsation is expressed by the equation $dP/dz = dP0/dz\ (1+\varepsilon sen(\omega t))$, where ε is the amplitude of the pressure oscillation and ω is the angular frequency. By combining the Cauchy equation with the Maxwell constitutive equation, we obtain a hyperbolic partial differential equation. To solve numerically the momentum equation, we transform the equation from Cartesian to bipolar coordinates, which maps the physical domain into a rectangular computational domain. Once the solution for the velocity profile is obtained, we can solve the advection-diffusion equation using the homogenization method. However, we obtain a partial differential equation (PDE) with variable coefficients, due to coordinate transformation. This problem must be solved semi-analytically; we derive PDEs for different orders analytically, but these equations are then solved numerically using the Alternating Direction Implicit (ADI) method. The governing equation is controlled by dimensionless parameters such as the Womersley number, the Deborah number and the eccentricity of the tube; the first characterizes the competition between the inertial forces and viscous forces and the second the ratio between the retardation time of the fluid and the time of the flow. The results evidence that eccentricity and viscoelasticity increase the dispersion of the solute along the tube.

References

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