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Electro-Osmotic Peristaltic Propulsion of a PTT Fluid with Ciliary Motion in Rough-Walled Channels with Thermal Radiation: Micro-fluidic and Biomedical Applications.

Abstract:

The present study analyzes the electro-osmotic peristaltic propulsion of a Phan–Thien–Tanner (PTT) viscoelastic bio fluid in rough-walled channels with ciliary motion, incorporating the effects of thermal radiation and heat generation. The model integrates the combined influences of electro-osmosis, peristaltic pumping, and metachronal ciliary activity, which are central to many physiological and biomedical transport processes. Employing the lubrication and long wavelength approximations, the governing nonlinear equations are derived and solved to obtain closed-form expressions for velocity distribution, volumetric flow rate, pressure rise, temperature profile. The incorporation of roughness effects provides a more realistic representation of physiological conduits such as microcirculatory vessels, mucus-lined respiratory channels, and other biological ducts. The results reveal that fluid relaxation time, electro kinetic parameters, and wall roughness substantially alter the flow resistance and pumping efficiency, while thermal radiation and viscous heating significantly influence the temperature field. The findings offer insights into physiological heat and mass transport, including cilia-driven respiratory clearance, microcirculatory flows, and electro kinetically actuated microfluidic systems for drug delivery. The study highlights the importance of coupling electro-osmosis, viscoelasticity, and thermal radiation for accurate prediction of biomedical and thermal engineering transport phenomena.

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