Effect of distribution of the electric charge density in the viscoelastic fluid towards the micro-channel flow in membrane context

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Today, the advent of micro-fabrication techniques is promoting the widespread adoption of microfluidic flow devices by a large number of industrial applications, especially those dealing with bio-fluids including environmental control and management. This study is to accurate flow control in these devices that can easily be miniaturized. An obvious candidate is electricity-related forcing taking advantage of electro-kinetic phenomena. The analytical solution is derived for the micro-channel flow of viscoelastic fluid by combined electro-osmosis and pressure gradient forcing under fully-developed conditions. The Phan-Thien-Tanner model is used to analyze these behavior with due account for the near wall layer being depleted of macromolecules and behaving the Newtonian fluid. The derived solution allows a detailed investigation of the flow characteristics due to the combined effects of fluid rheology, forcing strengths ratio, etc. The results have shown that the flow becomes dominated by the Newtonian wall layer especially when the electric double layer ($\bar{\kappa}^{-1}$) is much thinner than the layer of the depletion layer thickness ($\bar{\delta}_L$), and when the viscosity of the Newtonian fluid is much lower than the zero shear rate ($\beta >> 1$). Thus the shear-thinning nature of the viscoelastic fluid influences the flow characteristics essentially at intermediate flow conditions, i.e., $1 < \bar{\kappa}^{-1}\bar{\delta}_L < 10$ and for $1 < \beta < 10$.

Keywords: Electric charge; Viscoelastic fluid; Membrane