Solute dispersion of electroosmotic flow of micropolar fluid with inhomogeneous reaction

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1. INTRODUCTION & OBJECTIVE

The present study explores the two-dimensional concentration distribution of an electroosmotic flow of micropolar fluid in a rectangular microchannel in the presence of inhomogeneous reactions. The dispersion coefficient and concentration distribution are obtained up to second order using Mei's homogenization approach. This study discusses the influence of an inhomogeneous reaction on the concentration distribution by considering the boundary absorption at both walls. This study also includes the importance and significance of electric field and micropolar fluid parameters. The non-Newtonian fluid parameters, electric double layer thickness parameter, and inhomogeneous reaction parameter show significant influences on the solute transport. Our study reveals that when boundary absorption is applied at one or both boundaries it reduces the solute transport and also increases the nonuniformity. This work's findings have broad applications in chemical, biological, and medical sciences.

2. FORMULATION AND RESULTS

The non-dimensional form of governing equation for the considered problem with initial and boundary conditions is,

$$\frac{\partial C}{\partial t}+Pe\,\varepsilon\,U\frac{\partial C}{\partial x}=\varepsilon^2\frac{\partial^2 C}{\partial x^2}+\frac{\partial^2 C}{\partial y^2},\quad -1\le y\le 1 \tag{1}$$

$$C(x,y,t)\big|_{t=0}=\delta\left(\frac{x}{\varepsilon}\right) \tag{2}$$

$$\left.\frac{\partial C}{\partial y}\right|_{y=1}=-\varepsilon\,\beta_1' C \tag{3}$$

$$\left.\frac{\partial C}{\partial y}\right|_{y=-1}=\varepsilon\,\beta_2' C \tag{4}$$

$$C(x,y,t)\big|_{x=\pm\infty}=0 \tag{5}$$

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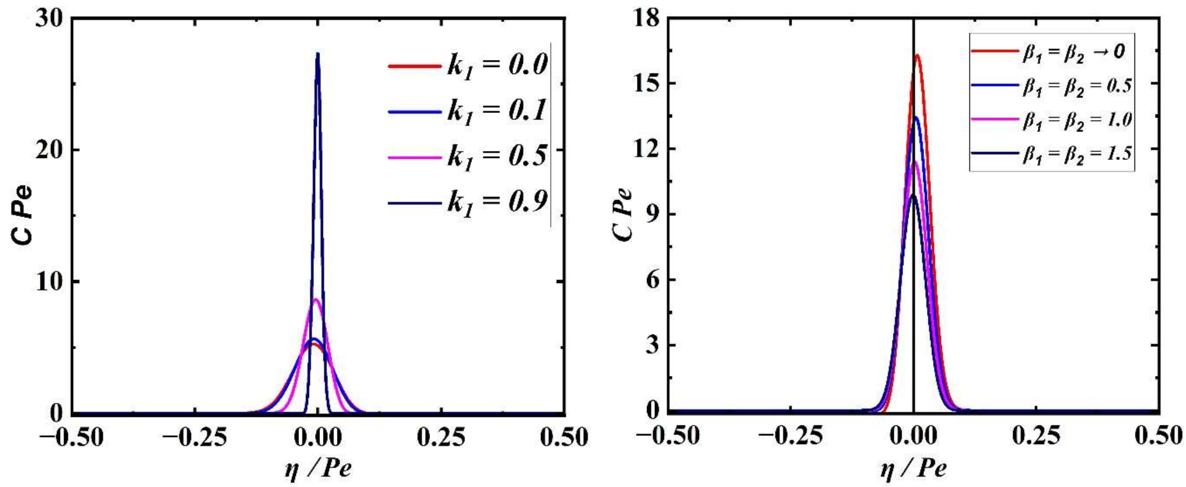

(a) (b)

Fig. 1. Response of transversal real concentration distribution for various (a) k_1 and (b) β_1, β_2.

Fig. 1(a) is representing the impact of coupling number k_1 to the transverse real concentration distribution. From the Fig. 1(a), it is noticed that transverse real concentration distribution peak increases and spreads slowly in the flow with coupling number k_1. This type of behavior is due to micro rotational nature of the polar fluid, which opposes the flow as a result, the spreading reduces but it mixes the solute well in the flow, so the peak rises. It is important to mention that when $k_1 = 0,$ the micropolar nature of the fluid will show the nature of the Newtonian viscous fluid. Figure 1(b) is representing the influence of boundary absorption parameters on transverse concentration distribution when applied in both the boundaries. From the Fig. 1(b), it is observed that the solute concentration peak is more when boundary absorption is absent (i.e., $\beta_1 \to 0$ and $\beta_2 \to 0$) near the channel bed. It is also noticed that initially the solute concentration is downstream once the boundary absorption occurs at both the boundary of the channel the peak decreases and shifts towards the core region of the channel. This is because of the absorption parameters which soaks up the concentration towards the channel boundary.

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