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Solute transport in a shear-thinning fluid flow through porous media

The flow of non-Newtonian fluids in porous materials can be found in many industrial applications such as chemical engineering, subsurface engineering (de-contamination, energy production), and the food industry. The relation between the shear stress and viscosity in non-Newtonian fluids is not linear and it is time-dependent, making it difficult to understand their behaviour. Non-Newtonian shear-thinning fluids tend to decrease in viscosity as the shear rate increases, while non-Newtonian shear-thickening fluids tend to increase in viscosity as the shear rate increases. The process of transporting non-Newtonian fluids through porous materials is complicated and influenced by different factors. These factors include the properties of the fluid, the porous material, and the flow conditions. The fluid flow rate is impacted by the fluid's velocity, pressure gradient, and the porous medium's tortuosity. Extensive research has shown that the properties of the fluid, the porous material, and the flow conditions all play a significant role in transporting shear-thinning fluids through porous media.
The present study uses a laboratory approach to examine the flow of a non-Newtonian shear-thinning fluid in a porous media. The fluid bulk rheology was obtained from the rheometer measurement first to confirm the viscosity-shear relation for the selected non-Newtonian fluid (xanthan gum), and the results were fitted using the Meter model equation. Then, a microfluidic experiment was done using xanthan gum solution mixed with a water-based ink colour to act as a tracer in the porous medium to track the fluid movement and breakthrough path. The experiment was done using different injection flow rates. The images were recorded during the experiment and processed after each experiment to calculate the average effluent concentration versus time and estimate the dispersion coefficient using Ogata and Banks' equation. The results showed a non-monotonic behaviour for the non-Newtonian fluid flow in porous media.

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References

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