Quantized effective viscosity of dense monodisperse emulsions in microchannels

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The rheology of pressure-driven flows of dense monodisperse emulsions in microchannels is investigated by means of mesoscopic lattice Boltzmann simulations, capable of handling large collections of droplets, in the order of several hundreds. The simulations reveal that the fluidisation of the emulsion isquantized, i.e. it proceeds through a sequence of discrete steps, characterized by yielding events whereby layers of droplets start rolling over each other, thus leading to sudden drops of the effective viscosity. It is shown that such a discrete fluidisation is robust against loss of confinement, namely it persists also in the regime of small ratios of the droplet diameter over the microchannel width. We also develop a simple phenomenological model which predicts a linear relation between the effective viscosity of the emulsion and the product of the confinement parameter (global size of the device over droplet radius) and the viscosity ratio between the disperse and continuum phases. The model shows excellent agreement with the numerical simulations.

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