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Beyond Poiseuille: Over-limiting Fluid Flows through Macroscopically Long Carbon Nanochannels[1] S. SINHA RAY, A.L. YARIN, Dept of Mech. and Industrial Engr., UIC — Nanotubes and nanochannels have tremendous potential in various fields like drug delivery, DNA segregation, capillary electrophoresis etc. Except coelectrospinning all the methods result in nanotubes sufficiently small in diameter (1-100 nm) but not longer than several micron precluding easy manipulation making them almost unsuitable for installing in nanofluidic devices for studying fluid flow characteristics. In this work we developed macroscopically long ($\sim$1 cm) carbon nanochannels and studied flow characteristics in them. Then, we demonstrated that bi-layer flows of liquid and gas can result in an over-limiting regime, where a higher flow rate of liquid can be achieved as compared to the case when the same liquid flows through the same tube subjected to the same pressure drop and occupies the whole bore. This paradoxical result is because the less viscous gas layer can flow much faster than the underlying liquid layer and entrain the latter via a significant shear stress. The present results show that the over-limiting liquid flows through nanotubes, seemingly resembling a deviation from the no-slip condition, in reality are entrained by a rapidly moving gas layer in bi-layer liquid/gas flows. This quasi-slip phenomenon happens in relatively large nanotubes ($\sim$500 nm) where the no-slip condition holds with sufficient accuracy, which can be beneficial in micro- and nanofluidics, nanoreactors and drug delivery systems, which are the current goals of this team.

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