Breakup dynamics of slender droplet formation in shear-thinning fluids in flow-focusing devices

Taotao Fu, Youguang Ma, Huai Z. Li

Chemical Engineering Science

www.elsevier.com/locate/ces

PII: S0009-2509(16)00030-0
DOI: http://dx.doi.org/10.1016/j.ces.2015.12.031
Reference: CES12753

To appear in: *Chemical Engineering Science*

Received date: 21 July 2015
Revised date: 16 October 2015
Accepted date: 31 December 2015

Cite this article as: Taotao Fu, Youguang Ma and Huai Z. Li, Breakup dynamics of slender droplet formation in shear-thinning fluids in flow-focusing devices *Chemical Engineering Science,* http://dx.doi.org/10.1016/j.ces.2015.12.031

Breakup dynamics of slender droplet formation in shear-thinning fluids in flow-focusing devices

Taotao Fu[a,b*], Youguang Ma[a]* and Huai Z. Li[b]

[a] State Key Laboratory of Chemical Engineering, Collaborative Innovation Center of Chemical Science and Engineering (Tianjin), School of Chemical Engineering and Technology, Tianjin University, Tianjin 300072, China

[b] Laboratory of Reactions and Process Engineering, University of Lorraine, CNRS, 1, rue Grandville, BP 20451, 54001 Nancy cedex, France

* Corresponding authors:

ttfu@tju.edu.cn (T. Fu) ; ygma@tju.edu.cn (Y. Ma)

Abstract This work reports the breakup dynamics for slender droplet formation in shear-thinning fluids in flow-focusing devices consisted of respectively 600 μm and 400 μm square microchannels. Silicon oil droplets are generated in non-Newtonian shear-thinning fluids - polyacrylamide (PAAm) aqueous solutions. The thinning of the thread of the dispersed phase during droplet formation can be characterized by a power-law relationship with the remaining time before the final pinch-off, with an exponent of 1/3 in the non-universal collapse stage, followed by an exponent of 1 in the final universal pinch-off stage. The dependence of the pre-factors on the viscosity ratio of both phases and the capillary number is discussed. A scaling law is proposed to predict the size of droplets formed in shear-thinning fluids in such devices by taking into account the rheological property of the non-Newtonian fluids as well as the hydrodynamics.

Keywords: microfluidics, complex fluids, droplet, breakup, pinch-off, hydrodynamics