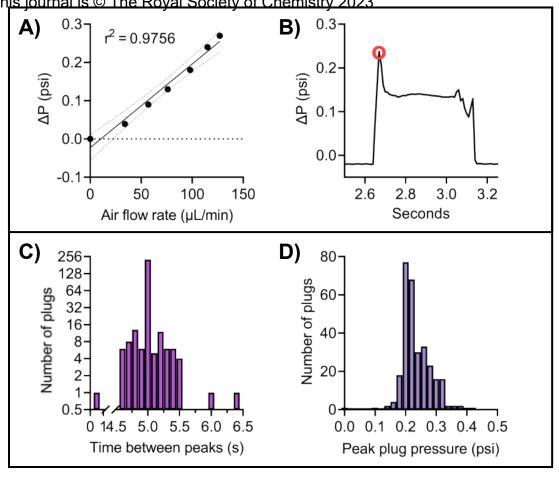
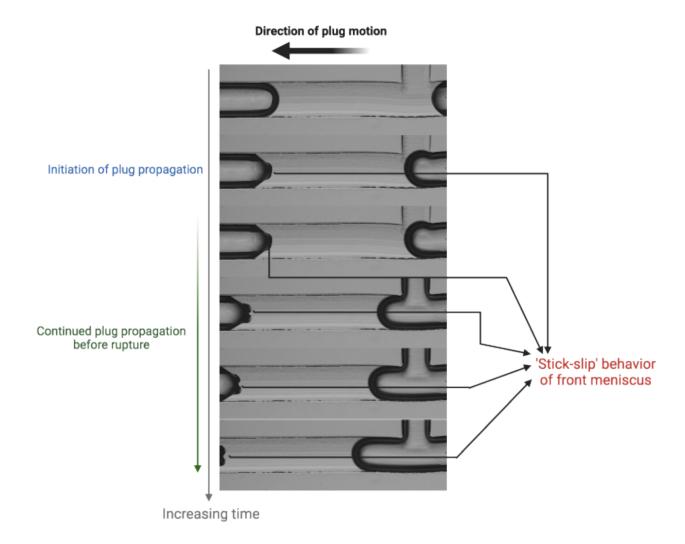
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Supplemental Figure 1. Liquid plug characterization and viscosity effects A) Calibration curve of air flow rate vs. measured pressure drop confirms functionality of the pressure transducer. B) Typical pressure vs. time profile for a single liquid plug C) The distribution of times between plug initiation for 297 plugs generated sequentially under identical conditions. D) The distribution of peak pressure differentials for 297 plugs generated under identical conditions.



Supplemental Figure 2. Liquid plug stick-slip phenomenon. These image captures taken from Supplemental Video 1 demonstrate the visualization of stick-slip dynamics during the initiation of plug motion. The front meniscus experiences stick-slip motion as labeled by red font.

$$arepsilon_{
m r} = rac{h_{
m r}}{a} = rac{1.34 C a_{
m r}^{2/3}}{1+1.34 imes 2.5 C a_{
m r}^{2/3}},$$

$$arepsilon_{ ext{r}} = rac{h_{ ext{r}}}{a} = rac{1.34 C a_{ ext{r}}^{2/3}}{1+1.34 imes 2.5 C a_{ ext{r}}^{2/3}}, \qquad R_{ ext{r}} = rac{\mu}{\pi a^3 (1-arepsilon_{ ext{r}})^2} \Big(rac{2 imes 1.79 imes 2^{2/3} C a_{ ext{r}}^{-1/3}}{1+1.41 C a_{ ext{r}}^{1/3}} + 1.1 \Big)$$

Supplemental Eq. 1

$$R_{
m f} = rac{\mu}{\pi a^3 (1-arepsilon_{
m f})^2} \Big(-2 imes 3^{2/3} f C a_{
m f}^{-1/3} \Big), \qquad f = \sum_{k=0}^5 C_k (\log_{10}lpha)^k + rac{1.02 arepsilon_{
m f}^{0.348} lpha^{-0.594}}{1+0.0778 lpha^{-0.594}}$$

Supplemental Eq. 2

where $Ca_{\rm f}=\mu U_{\rm f}/\sigma$, $U_{\rm f}$ is the velocity of the front bubble, $\varepsilon_{\rm f}=h_{\rm f}/a$, $\alpha = \varepsilon_{\rm f}/(3Ca_{\rm f})^{2/3}$, $C_0 = -0.149$, $C_1 = 2.04$, $C_2 = 0.570$, $C_3 = 0.233$, $C_4 = 0.064$, and $C_5 = 0.00689$.

$$R_{
m c} = rac{\mu L_{
m p}}{2\pi a^4} iggl[16 + 77.\,9725 \Big(rac{L_{
m p}}{a} + 0.\,5546 \Big)^{-1.7670} iggr]$$

Supplemental **Eq.** 3