11/30/23

Stationary Liquid Method:

⓪ Clean & Dry

① Sat. with W phase (100%)

$\rightarrow K_{abs}$

② Inject nW $\rightarrow$ Displace W until $S_{w,irr}$

$\rightsquigarrow$ Calculate $S_{w,irr}$, S_{nw}

$\rightsquigarrow$ $\Delta P_{\text{steady state}}$, q_{nw}

$\rightsquigarrow$ $K_{rnw} = \dfrac{\mu_{nw} q_{nw} L}{K A \Delta P}$ at $S_{w,irr}$

③ Inject a mixture $\dfrac{q_w}{q_{nw}}$ at low values

$\rightarrow \Delta P, q \rightsquigarrow K_{rw}$ & K_{rnw}

S_w, S_{nw}

Unsteady-State Method:

① Sat. sample with nw phase at $S_{w,irr}$

② Inject w phase → Displace nw

③ w phase breaks through at outlet

$$\underbrace{f_w\ ,\ f_{nw}\ ,\ \Delta P}_{K_r}$$

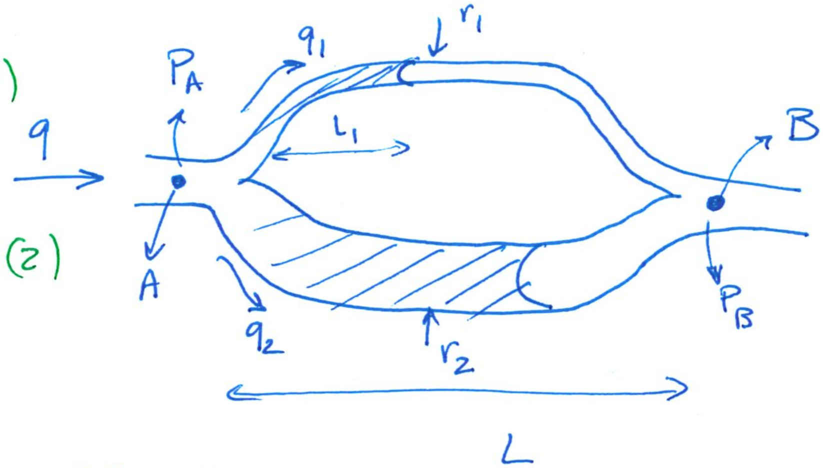
Capillary Trapping in Porous Media:

$$P_A - P_B = P_A - P_w + P_w - P_{nw} + P_{nw} - P_B \qquad (*)$$

H-P's Law:

$$q_1 = \frac{\pi r_1^4}{8\mu}\,\frac{P_A - P_w}{L_1} \qquad (1)$$

$$q_2 = \frac{\pi r_1^4}{8\mu}\,\frac{P_{nw} - P_B}{(L - L_1)} \qquad (2)$$



$$\xrightarrow[(1),(2)]{*} \qquad \left.\begin{aligned} P_A - P_B &= \frac{8 q_1 \mu L}{\pi r_1^4} - P_{c_1} \\ P_A - P_B &= \frac{8 q_2 \mu L}{\pi r_2^4} - P_{c_2} \end{aligned}\right\} \Rightarrow$$

$\frac{2\sigma\cos\theta}{r_2}$ $\qquad$ $\frac{2\sigma\cos\theta}{r_1}$

$$\Rightarrow -\left(\frac{8\mu L}{\pi r_1^4}\right) q_1 + \left(\frac{8\mu L}{\pi r_2^4}\right) q_2 = (P_{c_2} - P_{c_1}) \qquad (**)$$

$$= 2\sigma\cos\theta\left(\frac{1}{r_2} - \frac{1}{r_1}\right)$$

From Laplaces eq.

$$\left.\begin{aligned} q_1 + q_2 &= q \\ &(**) \end{aligned}\right\} \Rightarrow$$

$$q_1 = \frac{\left(\frac{8\mu L}{\pi r_2^4}\right) q - 2\sigma\cos\theta\left(\frac{1}{r_2} - \frac{1}{r_1}\right)}{\left(\frac{8\mu L}{\pi r_1^4}\right) + \left(\frac{8\mu L}{\pi r_2^4}\right)}$$

$$q_2 = \frac{\left(\frac{8\mu L}{\pi r_1^4}\right) q + 2\sigma\cos\theta\left(\frac{1}{r_2} - \frac{1}{r_1}\right)}{\left(\frac{8\mu L}{\pi r_1^4}\right) + \left(\frac{8\mu L}{\pi r_2^4}\right)}$$

$$\Longrightarrow \quad \frac{q_2}{q_1} = \frac{\left(\frac{r_2}{r_1}\right)^4 q + \frac{\pi r_2^4 \sigma \cos\theta}{4\mu L}\left(\frac{1}{r_2} - \frac{1}{r_1}\right)}{q - \frac{\pi r_2^4 \sigma \cos\theta}{4\mu L}\left(\frac{1}{r_2} - \frac{1}{r_1}\right)}$$

let $\begin{cases} v_1 = \dfrac{q_1}{\pi r_1^2}, & v_2 = \dfrac{q_2}{\pi r_2^2} \\ \beta = \left(\dfrac{r_2}{r_1}\right), & N_{vcap} = \dfrac{q\mu L}{\pi r_1^3 \sigma \cos\theta} \end{cases}$

$q\mu L \rightarrow$ viscous force

$\pi r_1^3 \sigma \cos\theta \rightarrow$ capillary force

$$\Longrightarrow \quad \frac{v_2}{v_1} = \frac{4N_{vcap} + \left(\frac{1}{\beta} - 1\right)}{\frac{4N_{vcap}}{\beta^2} - \beta^2\left(\frac{1}{\beta} - 1\right)}$$

$\dfrac{v_2}{v_1} > 1 \rightsquigarrow$ Trap in smaller pores

$$\equiv \quad N_{vcap} > \frac{\beta(\beta^2+1)}{4(\beta+1)}$$

$\dfrac{v_2}{v_1} < 1 \rightsquigarrow$ Trap in larger pore

$$\equiv \quad N_{vcap} < \frac{\beta(\beta^2+1)}{4(\beta+1)}$$

low $q \rightarrow$ displacement will be dominated by cap. force

$\rightarrow$ Trap in large pore $\Longrightarrow$ low displacement efficiency

high $q \rightarrow$ " " " " " viscous force

$\rightarrow$ Trap in small pores $\Longrightarrow$ high disp. eff.