Appendix

Sample HETP calculation for immunoaffinity sorbent performance

The experimental HETP correlation (Snyder et al.) is provided as:

\[
HETP = \frac{L}{N} = \frac{L}{\left(\frac{t_R}{W_h}\right)^2} \left(\frac{5.54}{10 mm}\right)^2 = 2.89 \text{ mm}
\]

Where L is the column bed length (cm), N is the number of theoretical plates, \( t_R \) is the retention of the sample within the column and \( W_h \) is the peak width at half peak height.

L = 1 cm (10 mm)
\( t_R = 15 \) sec.
\( W_h = 19 \) sec.

\[
HETP = \frac{L}{N} = \frac{L}{\left(\frac{15 \text{ sec}}{19 \text{ sec}}\right)^2} = 2.89 \text{ mm}
\]
The theoretical HETP correlation (Mikes et al.) is provided as:

\[ \text{HETP} = H_{\text{particle size}} + H_{\text{particle diffusion}} + H_{\text{film diffusion}} \]

\[ H_{\text{particle size}} = 1.64r \]

\[ H_{\text{particle diffusion}} = \frac{D_v}{(D_v + \epsilon) D_s} \left( 0.142 \frac{r^2 F}{D_v} D_s \right) \]

\[ H_{\text{film diffusion}} = \left( \frac{D_v}{D_v + \epsilon} \right)^2 \left( 0.266 \frac{r^2 F}{D_L (1 + 70rF)} \right) \]

Where \( r \) is the particle radius, \( D_v \) is the mg solute bound per ml column bed/mg solute per ml solution, \( F \) is the superficial velocity, \( D_s \) is the diffusion coefficient within the support particle, \( D_L \) is the diffusion coefficient in the solvent and \( \epsilon \) is the volume void fraction of the particle.

Particle radius, \( r = 0.25 \text{ mm} \) (average bead particle diameter: 500 \( \mu \text{m} \))
Superficial linear velocity, \( F = 38 \text{ mm/min} \)
Column length, \( L = 10 \text{ mm} \)
Void volume fraction, \( \epsilon = 0.4 \)
Bound mg hPC/ml support: 0.4 mg hPC/ml support
Feed solution, mg hPC/ml: 1 mg hPC/ml
\( D_v = 0.4 \)
\( D_s = D_L = 1 \times 10^{-7} \text{ cm}^2/\text{sec} \) (6 \( \times 10^{-4} \text{ mm}^2/\text{sec} \))
\[
\text{HETP} = H_{\text{particle size}} + H_{\text{particle diffusion}} + H_{\text{film diffusion}}
\]

\[
H_{\text{particle size}} = 1.64r = 1.64(0.25) = 0.41 \text{ mm}
\]

\[
H_{\text{particle diffusion}} = \frac{D_v}{\left(D_v + \varepsilon\right)^2} \frac{0.142 r^2 F}{D_s} = \frac{0.4}{\left(0.4 + 0.4\right)^2} \frac{0.142(0.25)^2}{6 \times 10^{-4}}
\]

\[
H_{\text{particle diffusion}} = 1412 \text{ mm}
\]

\[
H_{\text{film diffusion}} = \left(\frac{D_v}{D_v + \varepsilon}\right)^2 \frac{0.266 r^2 F}{D_L \left(1 + 70 r F\right)} = \frac{0.4}{\left(0.4 + 0.4\right)} \frac{0.266(0.25)^2}{\left(6 \times 10^{-4}\right)\left(1 + 70(0.25)(38)\right)}
\]

\[
H_{\text{film diffusion}} = 0.39 \text{ mm}
\]

\[
\text{HETP} = 0.41 + 1412 + 0.39 = 1412.8 \text{ mm}
\]