


SEM images kindly provided by Jason Morehouse and Leah Worrel, University of Texas at Austin.


www.nafigate.com. Food and Beverages. 7th October 2014, 12.40pm.


LIST OF PUBLICATIONS AND AWARDS

PUBLICATIONS:


AWARDS:

**Mac 2014**
: National Innovation and Invention Competition through Exhibition (i-CompEx)

**April 2014**
: International Engineering Invention & Innovation Exhibition (i-ENVEX)
  : Achievements
    - Gold Prize
    - Special Award Romanian Inventors Forum

**May 2014**
: 25th International Invention, Innovation & Technology Exhibition (ITEX)
  : Achievement
    - Gold Medal

**November 2014**
: Orally presented the paper in the 5th International Chemical & Environmental Engineering Conference (ICEEC) 2014 at Royal Hotel, Kuala Lumpur

**February 2015**
: Orally presented the paper in the International Postgraduate Conference on Industrial Technology 2015 at Langkawi Seaview Hotel, Kedah.

: Orally presented the paper in the International Conference on Applied Sciences & Industrial technology 2015 (Chemistry & Environment Symposium) at Grand Lexis, Port Dickson, Negeri Sembilan.
A.1: Preparation 1 L of 0.5 M Sodium Phosphate Buffer (pH 7.2)

<table>
<thead>
<tr>
<th>Chemicals</th>
<th>Concentration</th>
<th>Molecular Mass, M_r (g/mol)</th>
<th>Manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Na₂HPO₄·2H₂O</td>
<td>1 M</td>
<td>141.96</td>
<td>HmbG Chemicals</td>
</tr>
<tr>
<td>NaH₂PO₄·2H₂O</td>
<td>1 M</td>
<td>156.02</td>
<td>Merck</td>
</tr>
</tbody>
</table>

Solution A: 1 M disodium phosphate dehydrate (Na₂HPO₄·2H₂O)

\[ g = M \times M \times L \]
\[ = 141.96 \text{ g/mol} \times 1 \text{ M} \times 1 \text{ L} \]
\[ = 141.96 \text{ g (dissolved in 1 L distilled water)} \]

Solution B: 1 M sodium dihydrogen phosphate dihydrate (NaH₂PO₄·2H₂O)

\[ g = M \times M \times L \]
\[ = 156.02 \text{ g/mol} \times 1 \text{ M} \times 1 \text{ L} \]
\[ = 156.02 \text{ g (dissolved in 1 L distilled water)} \]

Mixed solution A and B for 1 L of Sodium Phosphate Buffer (0.5 M, pH 7.2) as follows:

Solution A : 342 mL  
Solution B : 158 mL  
Distilled H₂O : 500 mL
## B.1: Calculation of PWP

<table>
<thead>
<tr>
<th>Membrane</th>
<th>Pressure (kPa)</th>
<th>50</th>
<th>100</th>
<th>150</th>
<th>200</th>
<th>250</th>
<th>300</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Time (s)</td>
<td>120</td>
<td>84</td>
<td>82</td>
<td>80</td>
<td>79</td>
<td>77</td>
</tr>
<tr>
<td>PN1</td>
<td>Time (h)</td>
<td>0.0333</td>
<td>0.0233</td>
<td>0.0228</td>
<td>0.0222</td>
<td>0.0219</td>
<td>0.0214</td>
</tr>
<tr>
<td></td>
<td>PWP (Lm⁻²h⁻¹)</td>
<td>216.51</td>
<td>309.30</td>
<td>316.85</td>
<td>324.77</td>
<td>328.88</td>
<td>337.42</td>
</tr>
<tr>
<td></td>
<td>Time (s)</td>
<td>173</td>
<td>107</td>
<td>80</td>
<td>69</td>
<td>65</td>
<td>62</td>
</tr>
<tr>
<td>PN2</td>
<td>Time (h)</td>
<td>0.0481</td>
<td>0.0297</td>
<td>0.0222</td>
<td>0.0192</td>
<td>0.0181</td>
<td>0.0172</td>
</tr>
<tr>
<td></td>
<td>PWP (Lm⁻²h⁻¹)</td>
<td>150.18</td>
<td>242.82</td>
<td>324.77</td>
<td>376.54</td>
<td>399.72</td>
<td>419.06</td>
</tr>
<tr>
<td></td>
<td>Time (s)</td>
<td>229</td>
<td>144</td>
<td>79</td>
<td>67</td>
<td>62</td>
<td>57</td>
</tr>
<tr>
<td>PN3</td>
<td>Time (h)</td>
<td>0.0636</td>
<td>0.0400</td>
<td>0.0219</td>
<td>0.0186</td>
<td>0.0172</td>
<td>0.0158</td>
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<tr>
<td></td>
<td>PWP (Lm⁻²h⁻¹)</td>
<td>112.46</td>
<td>180.43</td>
<td>328.88</td>
<td>387.78</td>
<td>419.06</td>
<td>455.82</td>
</tr>
<tr>
<td></td>
<td>Time (s)</td>
<td>309</td>
<td>205</td>
<td>150</td>
<td>126</td>
<td>119</td>
<td>115</td>
</tr>
<tr>
<td>PN4</td>
<td>Time (h)</td>
<td>0.0858</td>
<td>0.0569</td>
<td>0.0417</td>
<td>0.0350</td>
<td>0.0331</td>
<td>0.0314</td>
</tr>
<tr>
<td></td>
<td>PWP (Lm⁻²h⁻¹)</td>
<td>84.08</td>
<td>126.74</td>
<td>173.21</td>
<td>206.20</td>
<td>218.33</td>
<td>229.92</td>
</tr>
</tbody>
</table>

\[
PWP, J_v = \frac{Volume \ permeation \ rate, L}{Membrane \ area \ (m^2) \times \ time \ (h)}
\]

\[
= \frac{0.01 \ L}{0.0013856 \times 0.0333}
\]

\[
= 216.51 \ \text{Lm}^{-2}\text{h}^{-1}
\]
### B.2: Calculation of Permeate Flux

<table>
<thead>
<tr>
<th>Membrane</th>
<th>1.0 bar</th>
<th>Cf (g/mL)</th>
<th>Cp (g/mL)</th>
<th>BSA Rejection (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PN1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time (s)</td>
<td>30</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time (h)</td>
<td>0.0083</td>
<td>1.0000</td>
<td>0.2285</td>
<td>77</td>
</tr>
<tr>
<td>Flux (Lm⁻²h⁻¹)</td>
<td>519.63</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PN2</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time (s)</td>
<td>116</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time (h)</td>
<td>0.0322</td>
<td>1.0000</td>
<td>0.2045</td>
<td>80</td>
</tr>
<tr>
<td>Flux (Lm⁻²h⁻¹)</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PN3</td>
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</tr>
<tr>
<td>Time (s)</td>
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<td></td>
</tr>
<tr>
<td>Time (h)</td>
<td>0.0722</td>
<td>1.0000</td>
<td>0.1636</td>
<td>84</td>
</tr>
<tr>
<td>Flux (Lm⁻²h⁻¹)</td>
<td>59.96</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PN4</td>
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<td></td>
</tr>
<tr>
<td>Time (s)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Time (h)</td>
<td>0.0433</td>
<td>1.0000</td>
<td>0.1796</td>
<td>82</td>
</tr>
<tr>
<td>Flux (Lm⁻²h⁻¹)</td>
<td>99.93</td>
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</tr>
</tbody>
</table>

Permeate Flux = \[
\frac{\text{Volume permeation rate, } L}{\text{Membrane area (m}^2\text{)} \times \text{time (h)}}
\]

\[
= \frac{0.006 \text{ L}}{0.0013856 \times 0.0083}
\]

\[
= 519.63 \text{ Lm}^{-2}\text{h}^{-1}
\]
B.3: Calculation of Protein Rejection

<table>
<thead>
<tr>
<th>Membrane</th>
<th>1.0 bar</th>
<th>$C_f$ (g/mL)</th>
<th>$C_p$ (g/mL)</th>
<th>BSA Rejection (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PN1</td>
<td>30</td>
<td>1.0000</td>
<td>0.2285</td>
<td>77</td>
</tr>
<tr>
<td></td>
<td>Time (s)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Time (h)</td>
<td>0.0083</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Flux (Lm⁻²h⁻¹)</td>
<td>519.63</td>
<td></td>
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</tr>
<tr>
<td>PN2</td>
<td>116</td>
<td>1.0000</td>
<td>0.2045</td>
<td>80</td>
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<td></td>
<td>Time (s)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Time (h)</td>
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<td></td>
</tr>
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<td>Flux (Lm⁻²h⁻¹)</td>
<td>134.39</td>
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<td>1.0000</td>
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<tr>
<td></td>
<td>Time (s)</td>
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<td>Time (h)</td>
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<td>Time (h)</td>
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<tr>
<td></td>
<td>Flux (Lm⁻²h⁻¹)</td>
<td>99.93</td>
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</tr>
</tbody>
</table>

$$R(\%) = \left(1 - \frac{C_p (g/mL)}{C_f (g/mL)}\right) \times 100$$

$$= \left(1 - \frac{0.2285}{1.000}\right) \times 100$$

$$= 77 \%$$