DIFFUSIOPHORESIS OF BLOOD CELLS AND VESICLES IN TRANSIENT CHEMICAL GRADIENTS

Saša Vrhovec Hartman, Bojan Božič and Jure Derganc
OUTLINE

• A microfluidic system with microcavities
• Migration of cells and vesicles
• Diffusiophoresis as possible explanation
• Conclusions
A MICROFLUIDIC SYSTEM WITH MICROCAVITIES

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Experimental setup
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MIGRATIONS OF CELLS AND VESICLES

GLUCOSE SOLUTION
MIGRATIONS OF CELLS AND VESICLES

Neutral phospholipid vesicles
DOPC (100%)

GLUCOSE SOLUTION

Negatively charged phospholipid vesicles
DOPC (50%)/DOPS (50%)
MIGRATIONS OF CELLS AND VESICLES

PBS BUFFER SOLUTION

Migrations towards the microcavity entrance
MIGRATIONS OF CELLS AND VESICLES

Erythrocytes

Leukocytes

Vesicles

Glucose

NaCl
MIGRATIONS OF CELLS AND VESICLES

DIFFERENT SOLUTIONS

- Sucrose
- NaCl
- KCl
- KC$_7$H$_5$O$_2$
- K$_2$SO$_4$

DIFFUSION COEFFICIENTS OF THE SOLUTES

<table>
<thead>
<tr>
<th></th>
<th>Diffusivity [10$^{-9}$ m$^2$/s]</th>
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<tbody>
<tr>
<td>Sucrose</td>
<td>0.5 (Ribeiro et al. 2006)</td>
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<tr>
<td>Glucose</td>
<td>0.6 (Ribeiro et al. 2006)</td>
</tr>
<tr>
<td>K$^+$</td>
<td>1.957 (Velegol et al. 2016)</td>
</tr>
<tr>
<td>Na$^+$</td>
<td>1.334 (Velegol et al. 2016)</td>
</tr>
<tr>
<td>Cl$^-$</td>
<td>2.032 (Velegol et al. 2016)</td>
</tr>
<tr>
<td>SO$_4^{2-}$</td>
<td>1.065 (Velegol et al. 2016)</td>
</tr>
<tr>
<td>C$_7$H$_5$O$_2^-$</td>
<td>0.9 (Noulty and Leaist 1987)</td>
</tr>
</tbody>
</table>

The exchanged solutions had the same osmolarity as the initial glucose solution.
MIGRATIONS OF CELLS AND VESICLES

DIFFUSIOPHORESIS IN TRANSIENT CHEMICAL GRADIENTS

• Migration velocity caused by the surface tension

\[ v_s = \frac{2r_0}{3\eta} \left[ \frac{\partial \gamma}{\partial c_1} \left. \frac{dc_1}{dz} \right|_{c_1,c_2=0} + \frac{\partial \gamma}{\partial c_2} \left. \frac{dc_2}{dz} \right|_{c_2,c_1=0} \right] \]

• Migration velocity caused by the electric field

\[ v_d = \frac{\varepsilon \varepsilon_0}{4\pi \eta} \left( \frac{k_B T}{Ze_0} \right)^2 \left[ \frac{D_+ - D_- Ze_0 \zeta}{D_+ + D_- k_B T} - 2 \ln \left( 1 - \tanh \left( \frac{Ze_0 \zeta}{4k_B T} \right) \right) \right] \frac{d}{dz} \ln c \]

• Migration velocity caused by the osmosis

\[ v_o = -\frac{1}{3} l N_A k_B T r_0 \frac{dc}{dz} \]

CONCLUSIONS

• A diffusive exchange of solutions can cause significant passive migration of blood cells and synthetic phospholipid vesicles in microcavity.

• This phenomenon is called diffusiophoresis.

• Migrations were observed in concentration gradients of both non–electrolyte and electrolyte solutions.
ACKNOWLEDGMENTS

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