NANOROBOTICS 2015
Exercise Session 7 Solutions

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Question 1

Name and describe the two locomotion techniques shown below and point out the differences in their propulsion mechanism.

- **Self-electrophoresis versus bubble propulsion**
- In both cases Pt is used for catalyzing the decomposition of \( \text{H}_2\text{O}_2 \). However, differences occur due to:
  - Material combination
  - Shape (tubular vs. nanorod)
  - Size (self-electrophoretic nanorobots are usually much smaller than bubble propulsion microrobots)

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**Self-electrophoresis**: a mechanism often used to describe the migration of particles in a self-generated electric field.

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Maltouk, Scientific American, 72, 2009
Taken the Au/Pt nanorobot reported by Paxton et. al in Figure 2a

a) Which directionality would the rod in Figure 2a have if it moves in the axial direction toward the platinum end?

- Directionality is defined by the $\cos(\theta)$, whereas $\theta$ is the initial angle between the rod axis ($z$) and the displacement vector ($D$)

$$\theta = 0^\circ \Rightarrow \cos(0) = 1$$
b) Which directionality would you expect for a pure gold rod?

- The Au nanorod would not show any directionality
- Movement can only be due to Brownian motion, since there is no reaction for self electrophoretic propulsion

c) Discuss how locomotion would be affected if the nanorobot is made out of Au/Pt/Au (Figure 2b)

- Au/Pt/Au nanorods would show no directional movement, since an asymmetric structure is required for propulsion.

d) Why does a 100nm Pt/Au rod show only Brownian motion.

- Velocity decreases for small diameters. Hence, inertial forces will be dominating

\[ v \propto \frac{SR^2\gamma}{\mu DL} \]
Calculate the nickel electrode potential $E_{\text{Ni}^{2+}/\text{Ni}}$ immersed in a solution containing 2 mol/l of Ni(NH$_2$SO$_3$)$_2$ at 25°C ($E^{\circ}_{\text{Ni}^{2+}/\text{Ni}} = -0.25$ V).

\[ E_{\text{Ni}^{2+}/\text{Ni}} = E^{0}_{\text{Ni}^{2+}/\text{Ni}} + \frac{RT}{zF} \ln \frac{C_{\text{Ni}^{2+}}}{C^{0}_{\text{Ni}^{2+}}} \]

\[ E_{\text{Ni}^{2+}/\text{Ni}} = -0.25 + \frac{(8.31 J \cdot K^{-1} \cdot mol^{-1} \times 298 K)}{2 \times 96487 C (mol.e)^{-1}} \ln(2) \]

\[ E_{\text{Ni}^{2+}/\text{Ni}} = -0.241 V \]