SESSION 9: BIOANALYTICS THROUGH THE MEASUREMENT OF THE CHARGE ON SOLID/LIQUID INTERFACES

Exercise 1.

Estimation of the density of target molecules on the sensor and potential shift:

The exercise focuses on paper: Jürgen Fritz, et al., PNAS 99-22, pp 14142-14146, 2002

1.a How is the density of hybridized DNA molecules calculated?

1.b Considering the Grahame equation on page 14145, calculate the potential shift due to DNA hybridization.

Exercise 2.

Surface-charge density in pH environment:

2.a At solid liquid interfaces, the charged species are redistributed due to formation of electrical double layer. Hence, the concentration at the surface differs from that in bulk. For pH solutions at equilibrium with solid surface, hydrogen ion concentration at the liquid/solid interface is not same as the bulk hydrogen ion concentration. The relation between two is given by Boltzmann distribution:

$$\frac{[H^+]}{[H_\infty^+]} = \exp\left(\frac{-e\Psi_0}{kT}\right)$$

Where Ψ_0: Surface potential drop.

$[H^+]$: Aqueous hydrogen ion concentration at the silicon dioxide surface.

$[H_\infty^+]$: Aqueous hydrogen ion concentration in the bulk electrolyte.

e: Elementary charge of an electron = 1.6 x 10^{-19} C.

k: Boltzmann constant = 1.38 x 10^{-23} JK^{-1}.

Hence for a solution with bulk pH = 7 at room temperature (298 K), that produces a surface potential is 0.005V, calculate the pH seen by the solid interface.

2.b Silicon dioxide surface consist of dangling $SiO-$bonds that at a time can be in either neutral ($SiOH$), protonated ($SiOH_2^+$) or deprotonated (SiO^-). Total number of sites though remains constant and depending upon the pH of the electrolyte, they distribute themselves among these three states. In such a case, the surface charge density on Silicon dioxide is given as follows:

$$\sigma_0 = eN_s\left(\frac{[H^+]^2 - K_1.K_2}{[H^+]^2 + [H^+].K_2 + K_1.K_2}\right)$$

Where N_s: total number of surface sites

$[H^+]$: Aqueous hydrogen ion concentration at the silicon dioxide surface

K_1: Deprotonation equilibrium constant.

K_2: Protonation equilibrium constant.

Considering $N_s = 5 \times 10^{18}\ m^{-2}$, $K_1 = 10^{-6.8} M$, $K_2 = 10^{-0.5} M$ calculate surface charge density at surface $pH = 7$.