About diffusion

I have based my thoughts on these notes. See p.64.

Fick's law states, that the rate of diffusion is proportional to the difference in concentration. We can write for the concentration of propane $[P]$ in inside the cell and outside the cell

$$\text{rate of flow} = D([P]_i - [P]_o),$$

where the constant D quantifies how readily propane diffuses across the membrane. It is usually represented as $D = \mu k_B T$, where k_B is Boltzmann's constant (about $1.3806488(13) \times 10^{-23}$ J/K), T is the temperature and μ is some kind of mobility value (the ratio of the particle's terminal drift velocity to an applied force, $\mu = v_d/F$; from wikipedia). Arto thought that it might be a constant value for water to be found somewhere. We will grow our bacteria in 37°C so a good value for T is 310.16 K.

We may not need the equation for the constant D. In [1] there are many diffusion constants, including a constant for propane and water, which is $0.97 \times 10^{-5} \frac{\mathrm{cm}^2}{\mathrm{s}}$. It is to be noted that this value is for 25°C.

The differential equation for concentration of propane inside the cell is

$$\frac{d}{dt}[P]_i(t) = -\frac{D([P]_i(t) - [P]_o(t))}{V},$$

where V is the volume of the cell. It can be estimated to be 1 $\mu\mathrm{m}^3$.

In our project, we want to harvest the propane for use as a fuel, so it might be reasonable assumption it is constantly taken away from the outside of the cell. Furthermore, the outside of the cell is many times bigger than the inside, so it would be quite reasonable assumption that the concentration of propane on the outside is some small constant, maybe even zero if it is taken away efficiently. In any case, we have a simple way to estimate the diffusion of propane across the cell membrane.

References

[1] E. L. Cussler, *Diffusion: Mass Transfer in Fluid Systems*, (2nd ed.). New York: Cambridge University Press, 1997. Link to the book, Wikipedia article