Advancing Drug Delivery Systems: Building a Model for Thin Film Double-Layer Polyurethanes

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Research Question

Can the shape/release exponent (n) be controlled in a double-layer film system for drug delivery applications by varying two different material properties: diffusion coefficients and film depths?

Background

What is n? Release exponent associated with the drug release shape

n ⟶ 0	drug release is more exponential
n ⟶ 0.53	standard diffusion
n ⟶ 1	drug release is more linear and constant

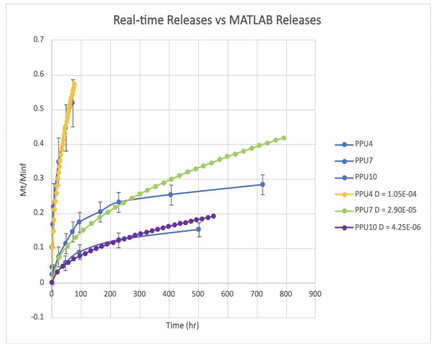
Korsmeyer-Peppas Model [1]: $\frac{M_t}{M_\infty} = kt^n$

Methods

1. Use diffusion coefficients of polymers from experimental data of single-layer-films [2].

   i. Governing principle: Fick's 2nd Law with single layer boundary conditions

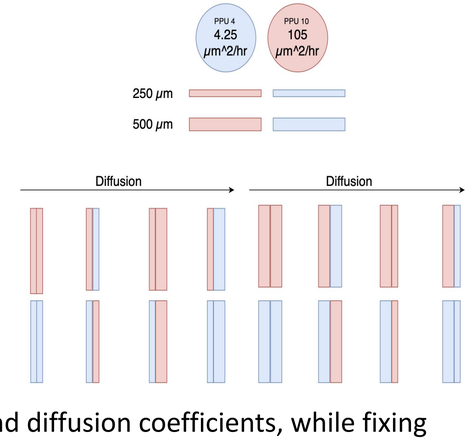
   ii. Use the Partial Differential Equation (PDE) and Least Squares Method (LSM) via MATLAB.



Fick's Second Law of Diffusion (planar) [3]:

$$\frac{dC}{dt} = D\frac{d^2C}{dx^2}$$

2. Set up a DOE with multiple combinations of diffusion coefficients, thicknesses, and layer location (16 total).

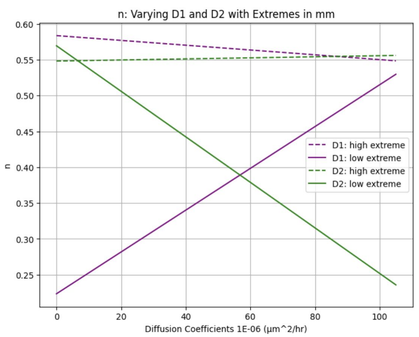


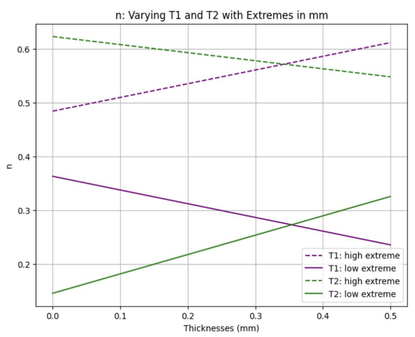
3. Use Fick's 2nd Law again, but with changed boundary conditions and parameter patterns for double-layer-films

4. Analyze data on JMP Pro® 16

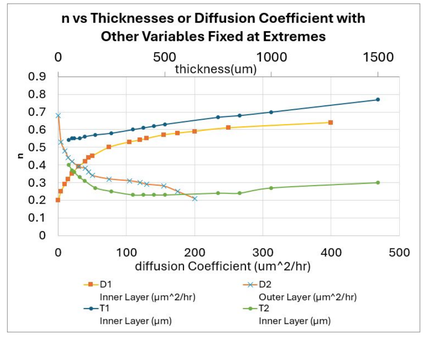
5. Vary ranges of thicknesses and diffusion coefficients, while fixing the other variables at their high or low extreme.
   - Plot from prediction expressions in JMP for n

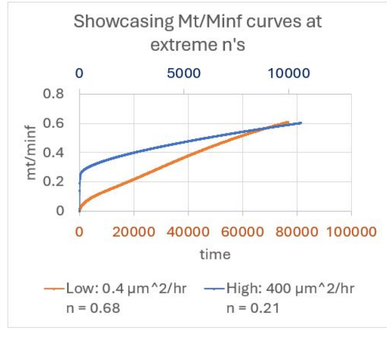
n	D1 (μm²/hr)	D2 (μm²/hr)	T1 (μm)	T2 (μm)
High Extreme	105	4.25	0.25	0.5
Low Extreme	4.25	105	0.5	0.25





Results





Conclusion

Varying both diffusion coefficients and the thicknesses of the inner and outer layers can affect the diffusional release exponents.

Future Work

Honors Thesis: Comparing experimental releases from double-layer films with MATLAB's theoretical release.

References

[1] R. W. Korsmeyer, R. Gurny, E. Doelker, P. Buri, and N. A. Peppas, "Mechanisms of solute release from porous hydrophilic polymers," *Int. J. Pharm.*, vol. 15, no. 1, pp. 25-35, 1983. [Online]. Available: https://doi.org/10.1016/0378-5173(83)90064-9
[2] Gerdes, M.; Vernon, B.; Pal, A. tech.
[3] Ueber Diffusion - Fick - 1855 - Annalen Der Physik - Wiley Online Library. https://onlinelibrary.wiley.com/doi/10.1002/andp.18551700105. Accessed 2 Apr. 2024.

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