267a Barrier Membranes: How Good Are Geometric Estimates for Flux and Lag Time?

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In our daily lives we are surrounded by barrier membranes, quite literally. Our ability to live on land depends on the ability of our skin to minimize water loss. Barrier films keep our food fresh and protect everyday inanimate objects from corrosion and weathering. The effectiveness of many barrier films, both man-made and natural, depends on the significant amount of nearly impermeable material that is dispersed throughout a more permeable continuous phase. Over the past century Maxwell, Aris, Cussler and others have proposed simple geometric-based models to describe the effect of shape, spacing, alignment and orientation of the dispersed material on steady-state flux through composite materials. Cussler and a few others have also proposed models for estimating the increased lag time of the composite membrane compared to the homogeneous membrane. For some conditions, these various published equations predict different results, which provokes the questions of which to use and under what conditions. Experimental verification of the flux and lag time estimates is qualitative at best, because the distribution of the impermeable material within the experimental membranes is more random than considered in the models. Until now, computer simulated experiments have been limited. Recently we have developed a robust finite element model to simulate steady and unsteady-state diffusion in two dimensions, through layers of regularly spaced impermeable ribbons. Using this model, we have calculated the relative steady-state flux and lag time as a function of the ribbon aspect ratio, as well as the alignment and spacing of the ribbon layers. We have also examined how many layers are required for estimates of flux and lag time to become independent of the number of layers. The results of these studies will be presented and compared with predictions from previously published simple equations. Based upon these new results, we recommend which equations to use and the limits of applicability.