Membrane Filtration Processes
Concentration Polarization

Concentration polarization is the natural phenomenon that occurs during membrane filtration where the concentration of the solute near the membrane surface is greater than that of the bulk feed solution. This bulletin explains this phenomenon and best practices for mitigating its effects.

CONCENTRATION POLARIZATION

During crossflow membrane filtration, the solute is generally retained by the membrane, while the solvent passes through the membrane to the permeate side. Since the permeation rate of the solvent is greater than that of the solute, the concentration of the solute begins to build up in the area near the membrane surface. The concentration in this area near the membrane surface is greater than that of the bulk feed solution, forming a boundary layer. Figure 1 below illustrates this concept.

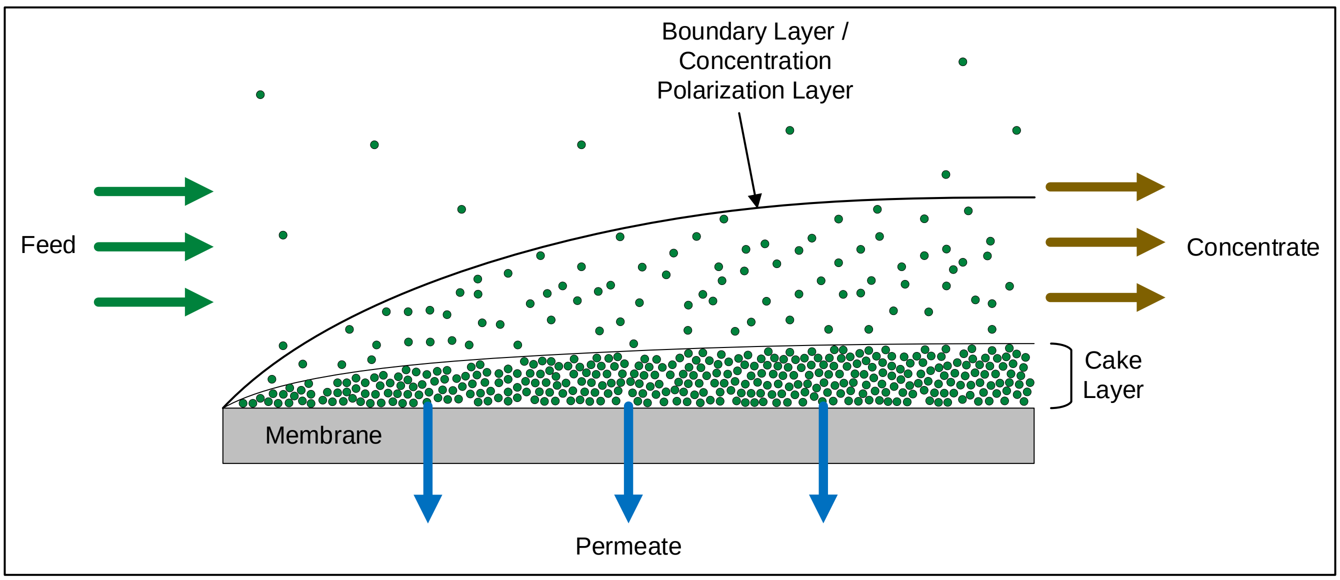

Figure 1. The concentration of solute near the membrane surface is greater than that of the bulk feed solution.

REDUCING CONCENTRATION POLARIZATION

The overall rejection performance of a membrane system can be significantly affected by concentration polarization. As the size of and concentration within the boundary layer increases, there is more solute available near the membrane surface to pass through the membrane, and thus the membrane rejection decreases. Therefore, it is important to design membrane systems with concentration polarization in mind. The effects of concentration polarization can be reduced by promoting turbulent flow for better mixing of the bulk feed with the boundary layer. The most effective technique for promoting turbulence in a membrane system is to increase the fluid velocity along the membrane surface. This is done by maintaining an appropriate crossflow through the membrane elements. For example, a general rule of thumb for water desalination systems is to ensure at least 4.5 m^3/hr (20 gpm) of concentrate flow per 8" membrane pressure vessel and at least 1.1 m^3/hr (5 gpm) of concentrate flow per 4" membrane pressure vessel. Different feed spacer geometries and thicknesses used in different membrane system types can also promote turbulent flow.

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