URE P

CSM

Research Proposal

Modeling the Effect of Osmotic Pressure on Diffusion in Nano-Porous Matrix

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Problem Statement

- Osmosis is one of the possible mechanisms of transport in nano-porous systems
- In heterogeneous, nano-porous formations below bubble point, different fluid compositions prevail in adjacent pores
- The system tries to restore equilibrium by either self-diffusion (large throats) or osmosis (narrow throats)
- We will incorporate osmosis into flow models for nano-porous unconventional reservoirs and estimate its contribution to flow

Importance

- Self-diffusion is well known and traditionally incorporated into flow models for conventional reservoirs
- Osmosis is possible only in nano-scale pores
- Modeling osmosis in unconventional reservoirs and incorporating into flow models is important to assess its relative contribution to flow and phase behavior

Background

Fluid composition vs. pore size

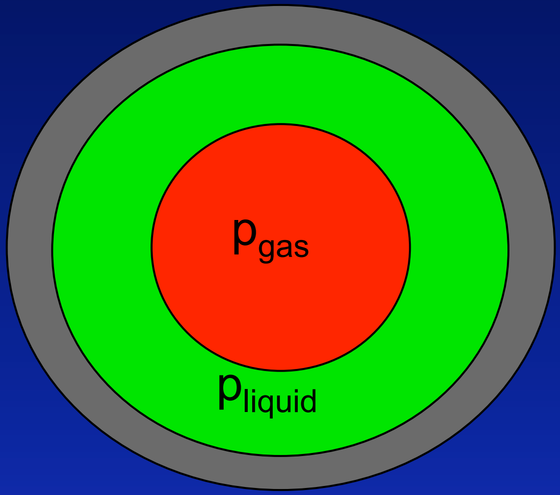
Phase behavior in nano-pores depends on capillary pressure and surface forces; thus, it depends on the sizes and the distribution of pores

In Confined Environment

The interface is curved

$$p_{gas} - p_{liquid} = p_c + \Pi_{surface}$$

$$p_c = \frac{2\sigma}{r}$$

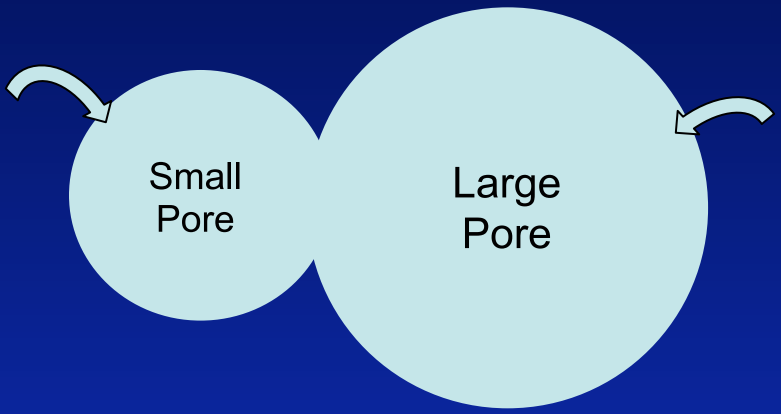


Note: Capillary pressure is negligible in large pores

Fluid composition vs. pore size

In heterogeneous, nano-porous formations below bubble point, different fluid compositions prevail in adjacent pores

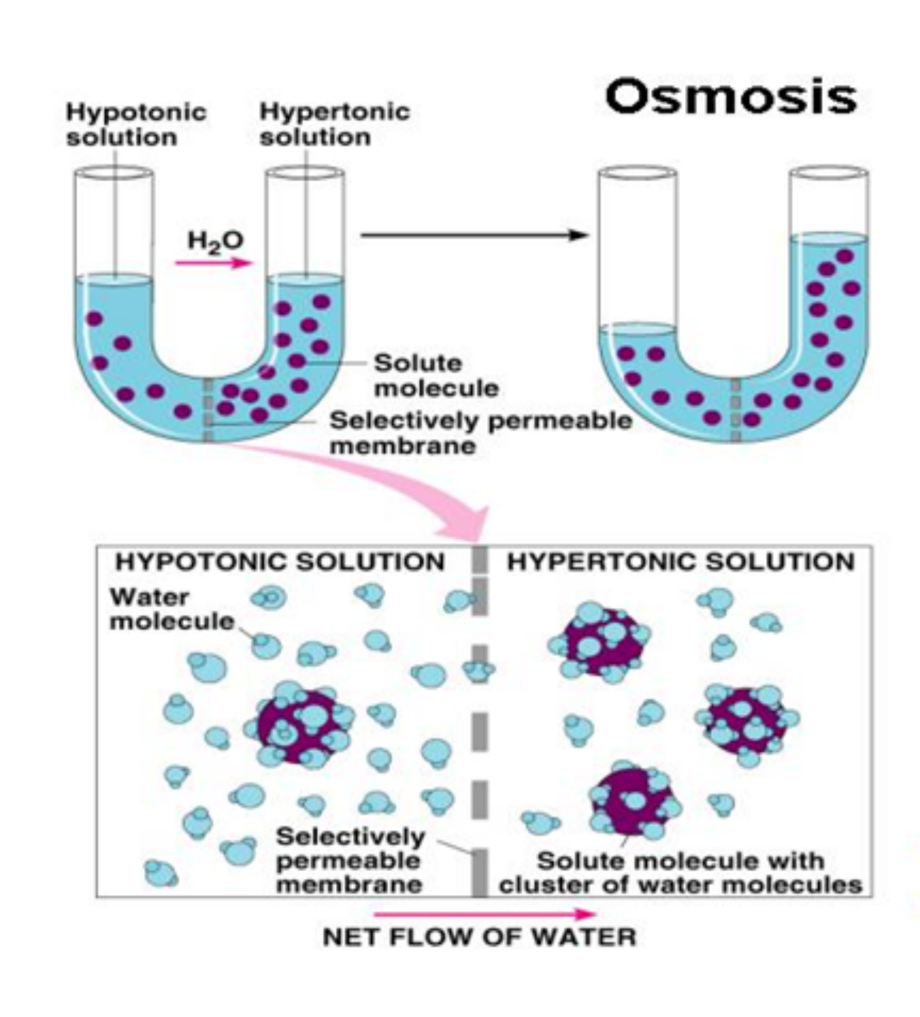
Lighter components (smaller molecules) still in liquid phase



Lighter components (smaller molecules) mostly in the gas phase

Liquid phase consists of heavier components (larger molecules)

Background



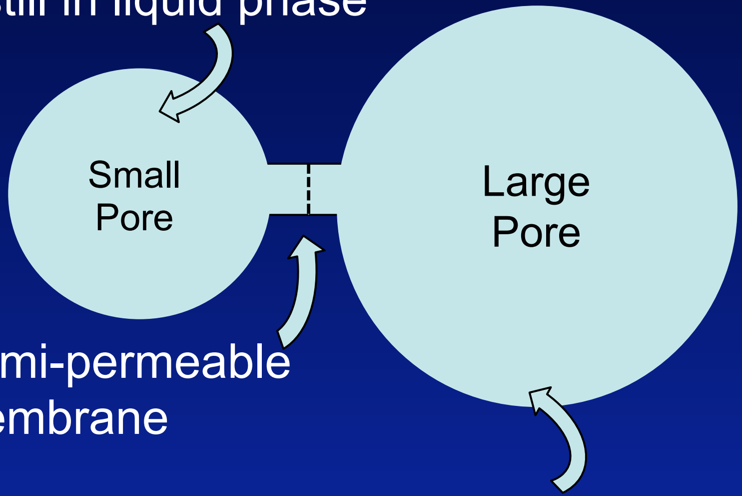
What is Osmosis?

- Osmosis is a special type of diffusion
- Osmosis is the process in which a liquid passes through a membrane whose pores permit the passage of solvent molecules but are too small for the larger solute molecules to pass through.

Background

Osmotic pressure in non-uniform, nano-porous media

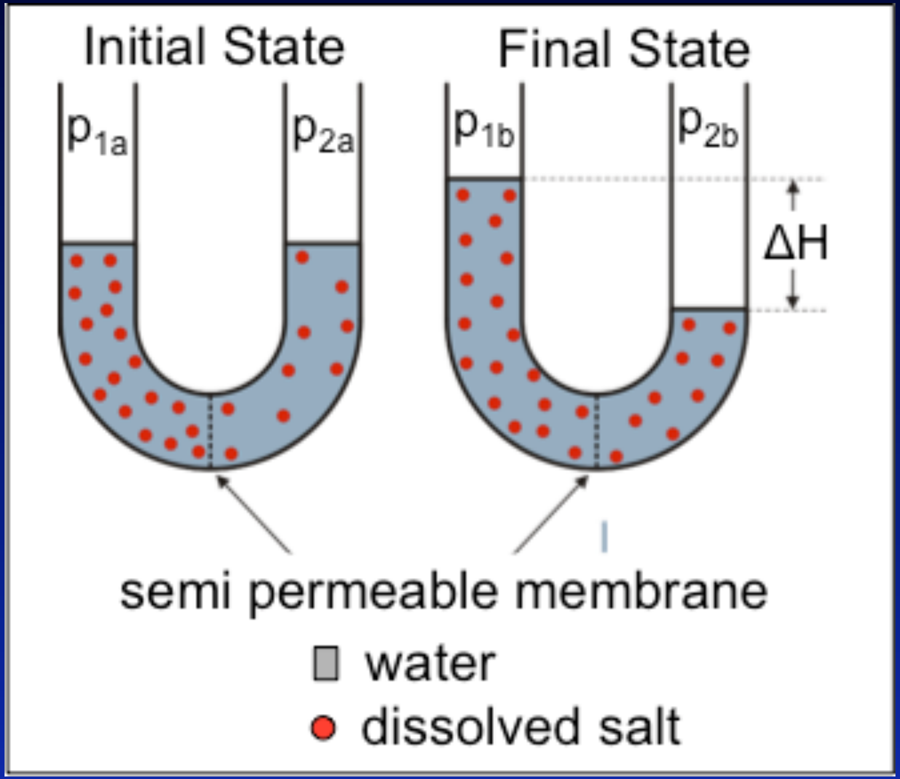
Lighter components (smaller molecules) still in liquid phase



Semi-permeable membrane

Lighter components (smaller molecules) in the gas phase

Liquid phase consists of heavier components (larger molecules)

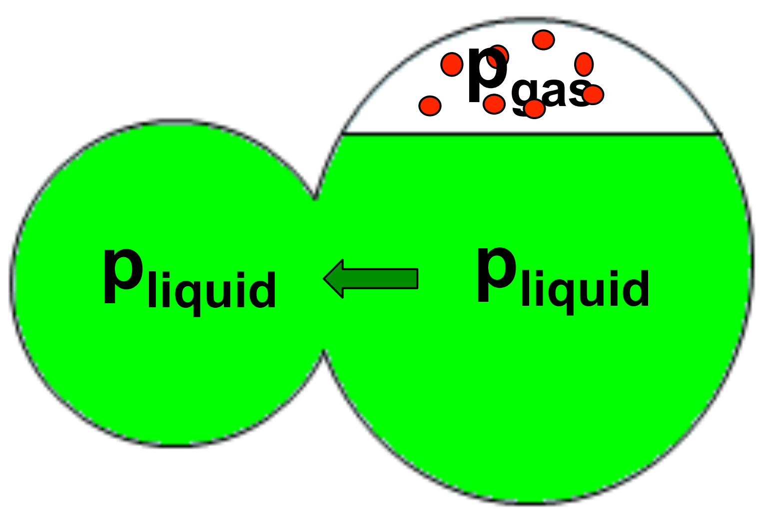


Osmotic Pressure

Diffusion and Osmosis for different cases

Self Diffusion

Large connection between two different-size pores

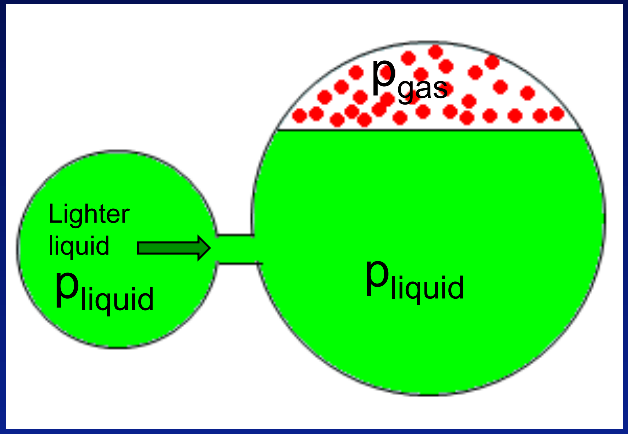


- Concentration difference between the pores
- Self diffusion to establish equilibrium
- Heavier fluid molecules will go from the large pore to the small pore

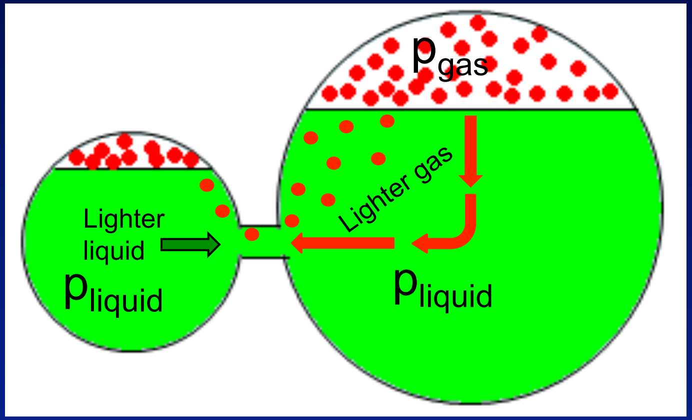
Diffusion and Osmosis for different cases

Osmosis

Narrow pore throat between two different-size pores.



After pressure decreases



- While large molecules can not pass through small pore throat, small molecules can do.
- Osmosis will be from small pore to large pore.

- While lighter fluid molecules pass through from small pore to large pore, lighter gas molecules pass through from large pore to small pore.
- Osmosis will be in both direction.

Objectives

Involve in the experimental study of Dr. Manika Prasad to observe osmosis in non-uniform and nano-porous unconventional reservoir samples

Choose (and improve) the constitutive relations appropriate to model transport by osmosis in unconventional reservoirs

Formulate a flow model including self-diffusion and osmosis

Integrate osmosis into a special numerical simulator (COZsim)