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Liqui-Cel® Membrane Contactors

TechBrief

Henry's Law Technical Brief

Why do gases tend to dissolve into water? This technical brief reviews the fundamental gas laws that explain why gases dissolve into water and provides a sample calculation for illustration.

Gas Laws

Dalton's Law states that the total pressure of a gas mixture is equal to the sum of the partial pressures of the individual gases in the gas mixture.

$P_{total}=P_1+P_2+P_3+\ldots$ ***eq. 1***.

The partial pressure component of each gas can be rewritten as:

$P_{total}=P_{total}\,y_1+P_{total}\,y_2+P_{total}\,y_2$

$P\ \ y_3+\ldots$ ***eq. 2***.

Where y_n= mole fraction of the component (moles of gas component in the mixture/mole of gas mixture).

These relationships tell us that the pressure that a gas will exert in a fixed volume is dependent on the total pressure of the gas mixture and the individual concentration of the gas in the mixture. This is an important relationship that is used to create the driving force to remove or dissolve gases into water.

Henry's Law states that the solubility of a gas in water is directly proportional to the partial pressure of that gas. This relationship is generally valid at low dissolved gas concentrations.

$$P_1= H^*x$$ ***eq. 3***.

Where:

P_1= partial pressure of the gas

H= Henry coefficient for that gas *(this value can be found in engineering tables)*

x= concentration of dissolved gas.

What Does it Mean

This law tells us that the amount of gas that will dissolve in water is proportional to its partial pressure. By decreasing the partial pressure of a gas in contact with water, we can reduce the amount of gas that will dissolve into the water.

It is evident from Dalton's Law that the partial pressure of a gas can be lowered by lowering the total pressure of the gas mixture, the concentration of gas in that mixture or a combination of the two.

The total gas pressure can be reduced by drawing a vacuum on the gas side of the membrane. The concentration of the gas can be further reduced by replacing the gas in contact with the water with a different gas.

Example:

Using these two relationships we can calculate how much oxygen will dissolve into water exposed to air. Air is made up of approximately 21% oxygen and 79% nitrogen, from Dalton's Law, we can calculate the partial pressure of oxygen in the atmosphere. From equation 1, the partial pressure of oxygen is equal to the total pressure of the gas mixture times the mole fraction of oxygen in air.

Partial pressure of oxygen in air at 1.0 atm =1.0 atm * 0.21 = 0.21 atm.

Now that we know the partial pressure of oxygen in air at one atmosphere we can use Henry's Law to calculate how much oxygen will dissolve into water exposed to air. From engineering tables we find that at 25°C, H = $2.465{*}10^4$ atm /grams of oxygen /gram of water. From *equation 3*, we can calculate the amount of oxygen that will dissolve into water.

$$x = P_1/H$$

x = 0.21 atm/ 2.465*104 atm/gram of oxygen/ gram of water

= 8.519*10-6 grams of oxygen per gram of water

= 8.52 parts oxygen per million parts water.

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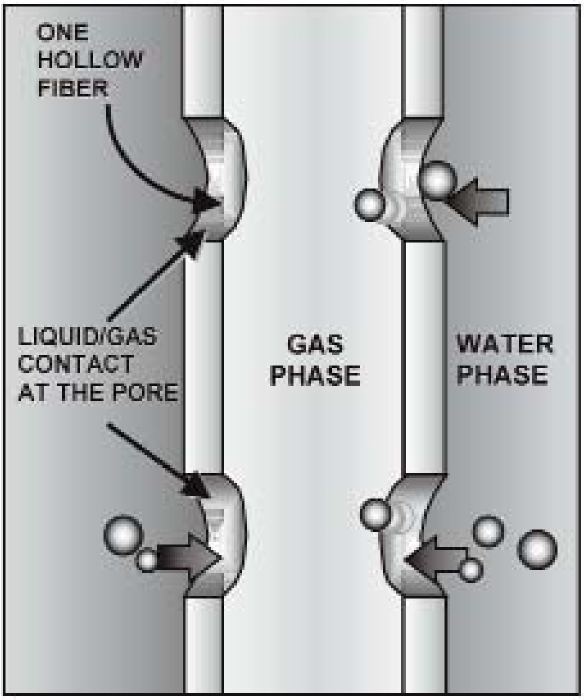
This example calculates how much oxygen will dissolve into water exposed to air at 1.0 atmosphere. By lowering the partial pressure of oxygen in contact with the water, we can create a driving force to remove the dissolved oxygen from the water. This can be achieved by creating a vacuum in the air exposed to the water, lowering the concentration of oxygen in contact with the water or a combination of the two.

These two operating conditions govern the operation of membrane contactors, vacuum degasifiers and force draft decarbonators.

The Liqui-Cel® Membrane Contactor is a unique membrane device that can be used to alter the partial pressure of gases in contact with a liquid for the purpose of dissolved gas removal. It's compact size, ease of use and versatility offer many benefits over conventional degasification equipment.

Stripping of Dissolved Gases from and Aqueous Stream



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