Permeation Basics

MOCON International Web Seminar Series

Presenter: Michelle Stevens

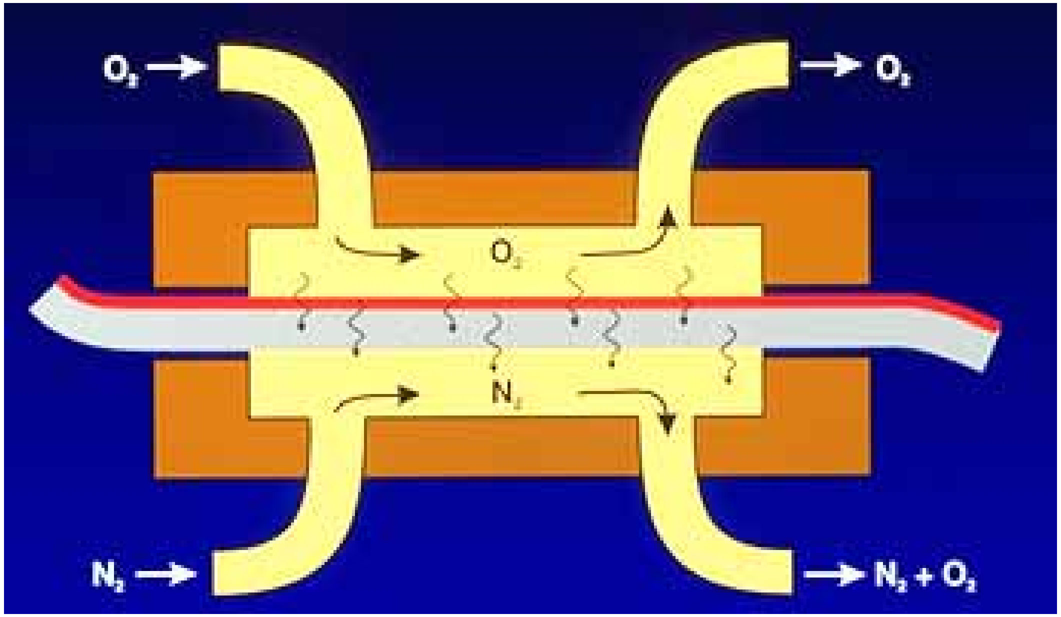
The perfect package…

- Contains and encloses the product
- Provides an inert, perfect barrier between the product and the environment
- DOES NOT EXIST!

mocon

Permeation

The movement of gases or vapors across a packaging material



mocon

Driving force

- CHEMICAL POTENTIAL
  - Fundamental driving force that prompts a molecule to diffuse within a polymer
  - Analogous to the electrical potential of a battery
  - Substances will naturally tend to move from a higher chemical potential to a lower one
  - FOR MOST PACKAGING APPLICATIONS, THE ACTIVITY CAN BE REDUCED TO CONCENTRATION OR PARTIAL PRESSURE

Solubility

- Process by which a gas compound is molecularly mixed with a solid is called a solution.
- SOLUBILITY provides a relationship between the concentration in the solid and the concentration (or partial pressure) in the gas.
- Henry's Law constant is also called the solubility constant, S, and is a function of temperature.

Diffusion

- Introduces the rate aspect of mass transfer.
- Process by which matter is transported from one part of a system to another as a result of random molecular motions.
- Fick's First Law

$$F = -D\frac{\partial C}{\partial x}$$

Permeability

$$P = DS = \frac{q\ell}{At\Delta p}$$

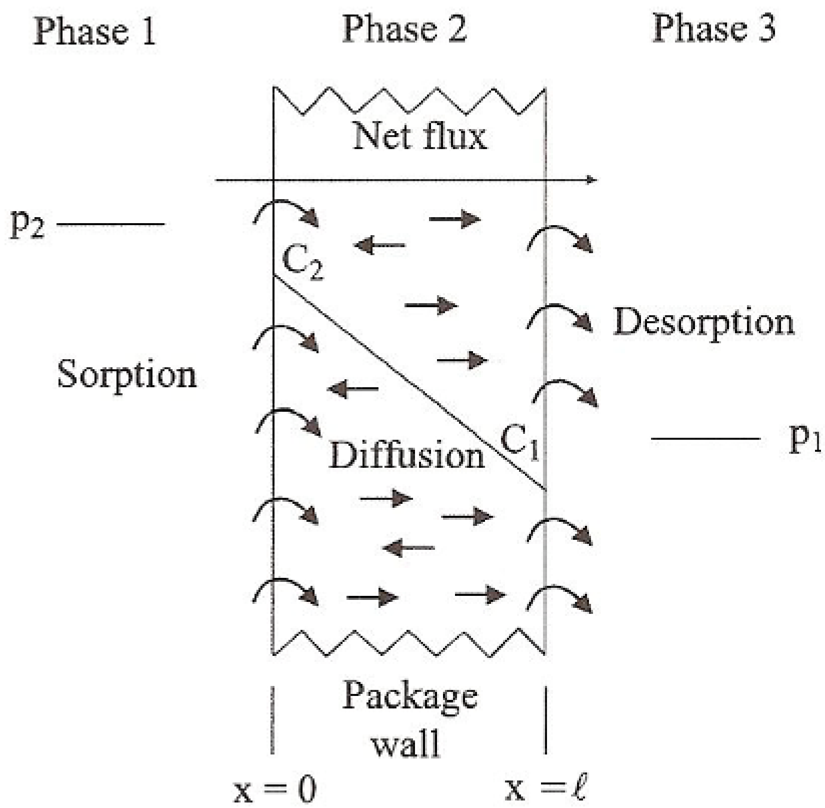
Where P is the permeability coefficient, D is the diffusion coefficient, S is the solubility coefficient, q is the quantity of permeant transferred by a unit of area, A, in a time t, *l* is the thickness of material and Dp is the partial pressure difference.

Permeation mechanism

1. Permeant dissolves at the polymer interface
2. The permeant diffuses within the polymer from the side of high concentration toward the low concentration side
3. The permeant diffuses out from the opposite polymer interface.

Permeation

The movement of gases or vapors across a packaging material



Polyethylene example

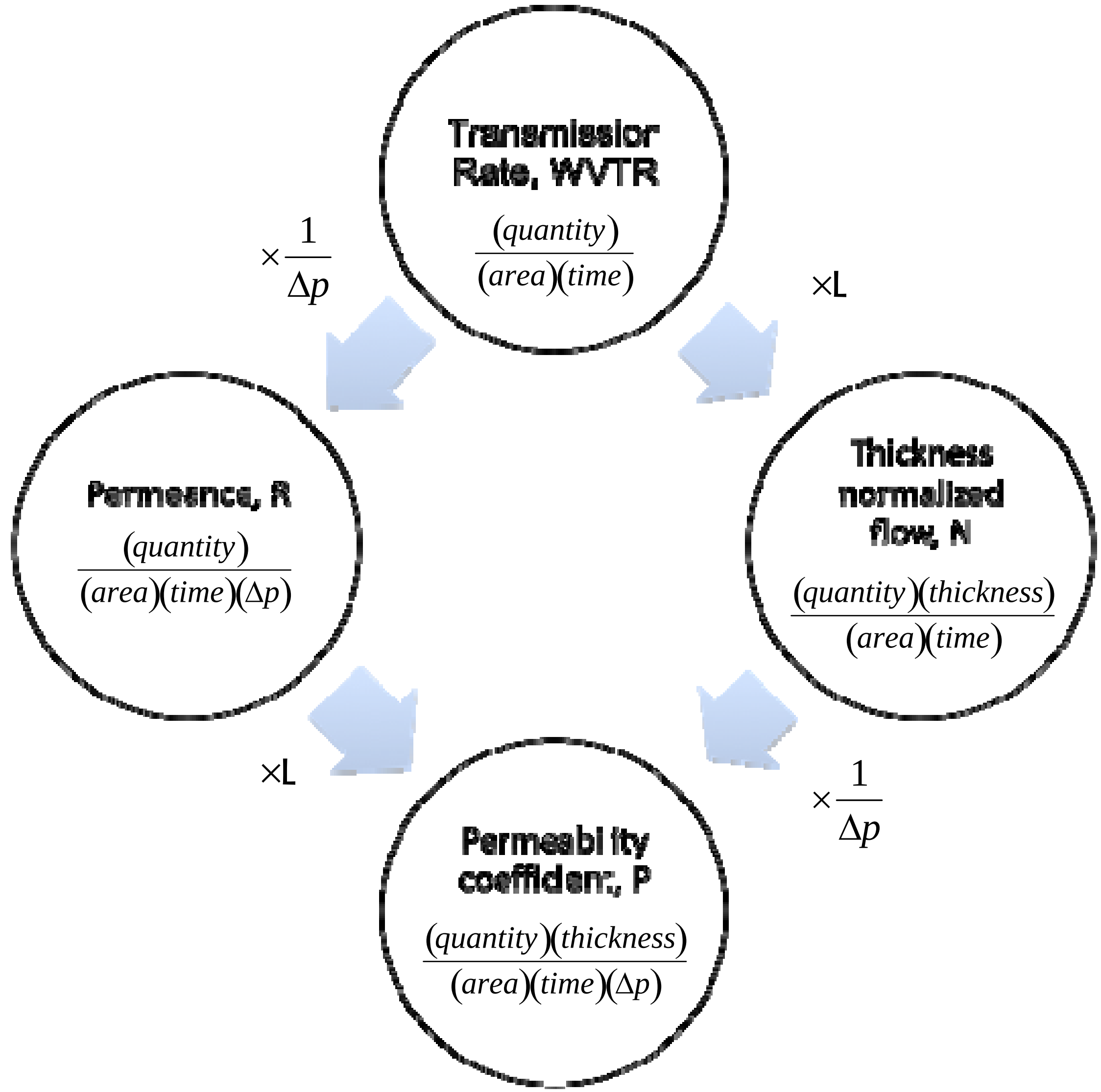
- A material that is a good barrier has a low value of the combined S and D values for a particular penetrant.
- Polyethylene is an excellent barrier to water because water has low S and D values in PE.
- However, PE is not an excellent barrier to O_2 because O_2 has higher S than water.

mocon

Variables Affecting Permeability

- Chemical structure of the polymer
- Chemical structure of the permeant
- Temperature
- Humidity
- Physical structure of the polymer
- Permeant concentration

Commonly used terms



Units

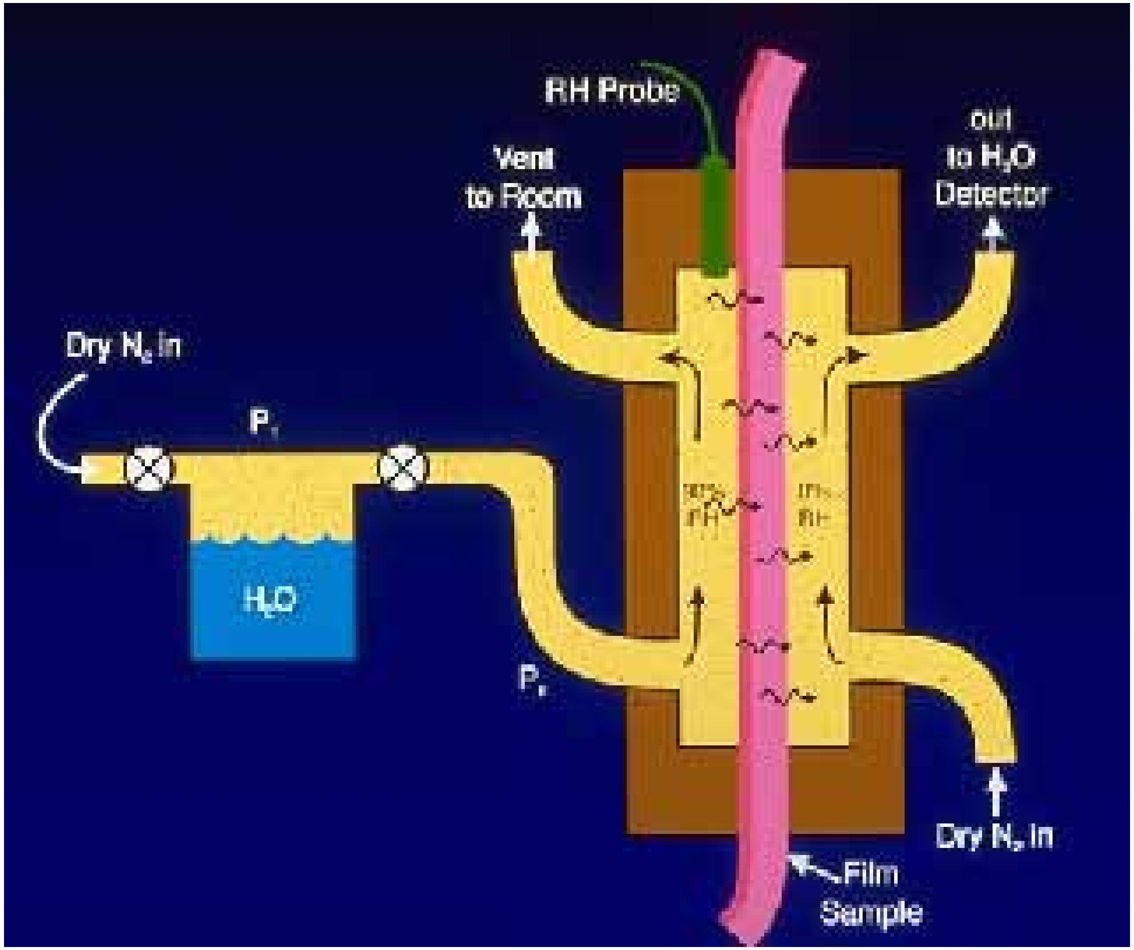
Variable	Common Units	SI units
q, quanitity	g, cm^3 (STP), mol	kg
l, thickness	cm, mil	m
t, time	hour, day	sec
A, area	cm^2, in^2, 100 in^2	m^2
p, partial pressure	atm, psi, cm Hg, mm Hg	Pa

The permeability coefficient, P, is expressed in a combination of the above units:

$$\frac{cm^3\,(STP)\,mil}{m^2\,day\,atm} \qquad \frac{kg\,m}{m^2\,sec\,Pa}$$

mocon

Measuring Transmission Rate



Example

- Calculate the minimum thickness of PET of a product that has an end of shelf life when it has reacted with 0.005% oxygen. The package is a 500 ml container with 400cm^2 area. Storage conditions are 25C and 60%RH and the desired shelf life is 6 months.

mocon

Example, continued

$$L = \frac{PtA\Delta p}{q}$$

Measured P at 25C is 22 cm^3 mm/(m^2 day kPa)
t = 6 months = 180 days
A = 400 cm^2 = 0.04 m^2
Dp = 0.21 atm = 21.27 kPa

$$q = 500ml \times \frac{0.005}{100} \times \frac{mol}{32g} \times 22{,}412\frac{cm^3}{mol} = 17.5cm^3(STP)$$

$$L = \frac{\frac{22cm^3(STP)\mu m}{(m^2)(day)(kPa)} \times 180days \times 0.04m^2 \times 21.27kPa}{17.5cm^3(STP)} = 193\mu m = 7.6mil$$

mocon

Hemetek
– Largest Permeation Lab in India

- Recently expanded laboratory testing capabilities to offer a new array of permeation, package, products and material services.
- Offering O2, WVTR and CO2 permeation testing as well as leak testing, headspace analysis and package strength testing.

mocon

HEMETEK
TECHNO INSTRUMENTS PVT. LTD.

Hemetek
– Largest Permeation Lab in India

Hemetek
– Largest Permeation Lab in India

Contact Information

HEMETEK TECHNO INSTRUMENTS PVT. LTD.
503 & 5, Acme Industrial Park, W.E. Highway,
Near Aarey Flyover, Goregaon (E), Mumbai. 400 063.
Maharashtra. INDIA.

Phone: +91-022-2686 3865, 2686 0692, 02240211059
Fax: +91-022-2686 0692.
E-mail:service@hemetek.com or viraj@hemetek.com

mocon

Thank you!!

Questions, please

For a copy of today's seminar
or to ask further questions, email:
webinars@mocon.com

Next Month's Seminar

Title: *ASTM F2097 Choosing Test Methods for Medical Packaging*

Date: *Wednesday, May 12, 2010*

Time: *10:00 AM - 11:00 AM CDT*