



High Temperature Permeation Testing

February 10th, 2010
2010 Webinar Series

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High-barrier Materials and High Temperature Applications



Flexible Display



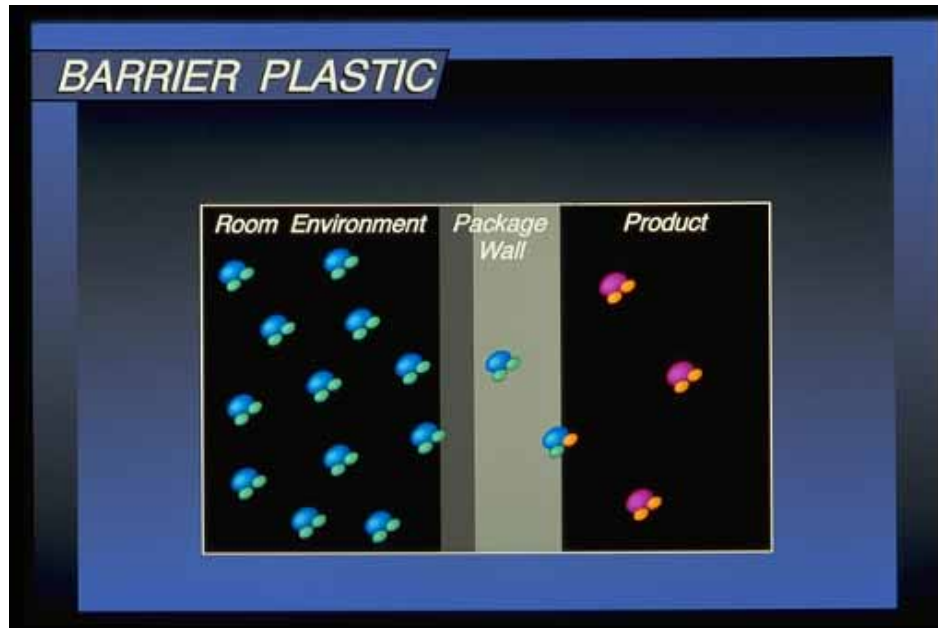
OLED Cell Phone Screen



Solar Panels



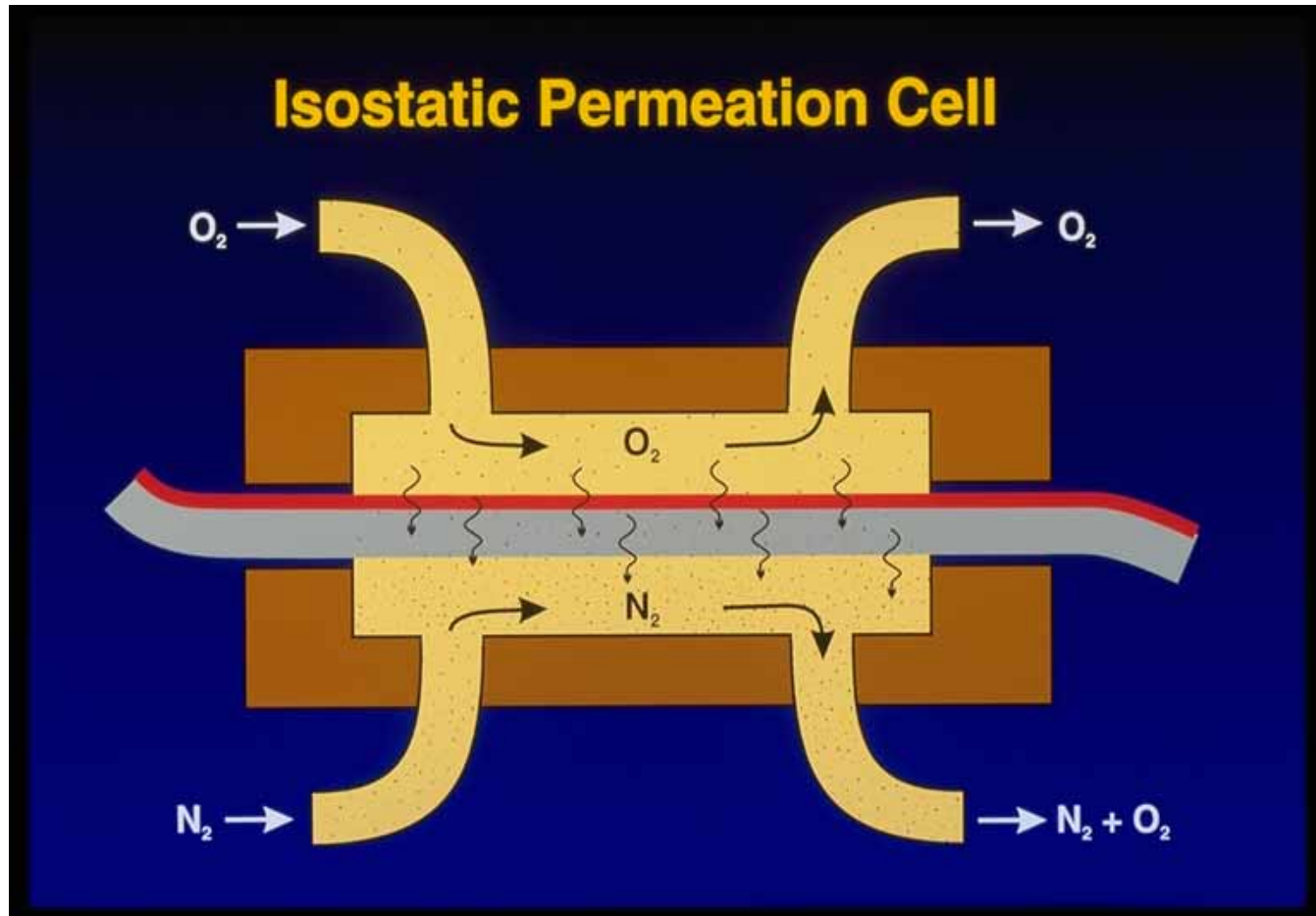
Permeation - Solution-Diffusion Mechanism



- The gas absorbs at the entering face
- Diffuses through the polymer phase
- Desorbs or outgases at the low-pressure side.

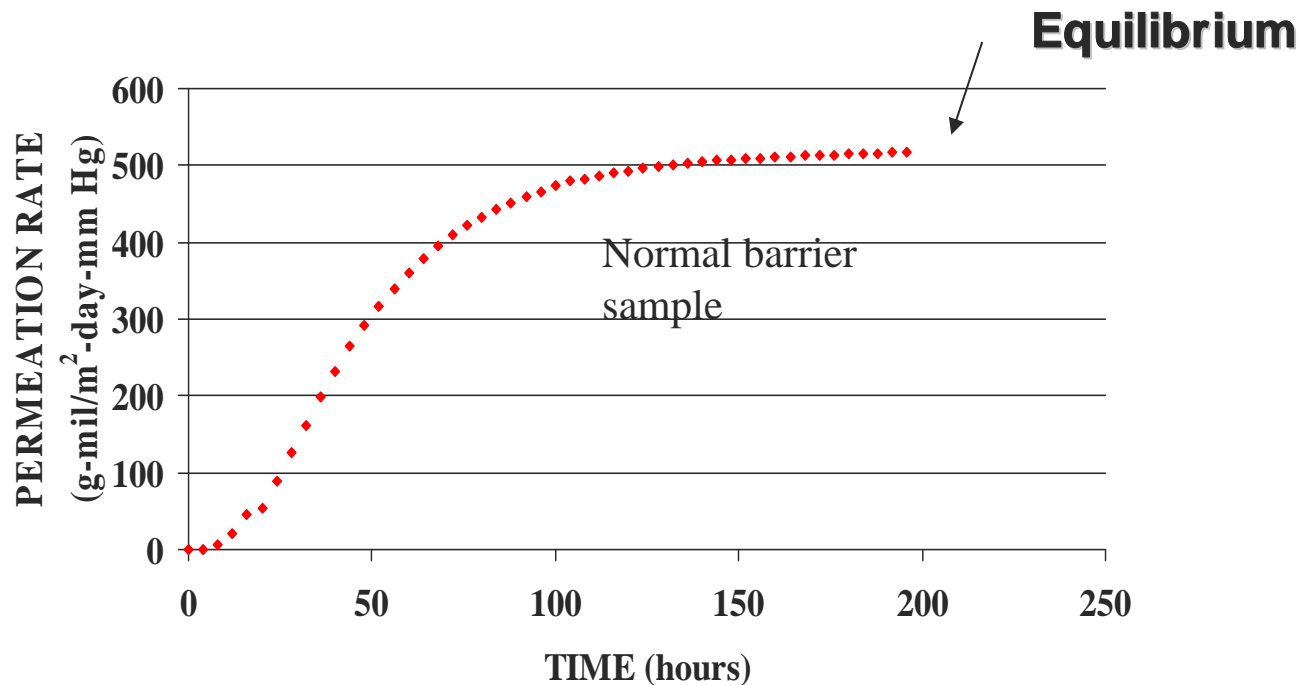


Permeation - How is it measured?





Permeation – What does it look like?



- There is no universal time to reach equilibrium.
- Each material has its own nature. Generally speaking, the better the barrier, the longer it takes.



Permeation

- Permeation is simply the flux of molecules through a material.
- Units of permeation “explain” the mechanism:

$$\frac{\text{volume of gas at STP} \rightarrow \text{cm}^3(273.15K; 1.013 \times 10^5 Pa) \times \text{material thickness} \rightarrow \text{cm}}{\text{area} \rightarrow \text{cm}^2 \times \text{time} \rightarrow s \times \text{pressure drop, driving force} \rightarrow Pa}$$



Permeation basics

Permeation rate

$$\frac{cc \times mil}{m^2 \times day \times atm}$$

Transmission rate

$$\frac{cc}{m^2 \times day}$$



Permeability

- Permeability can be defined as the product of the solubility coefficient and the diffusion coefficient

Solubility coefficient Diffusion coefficient

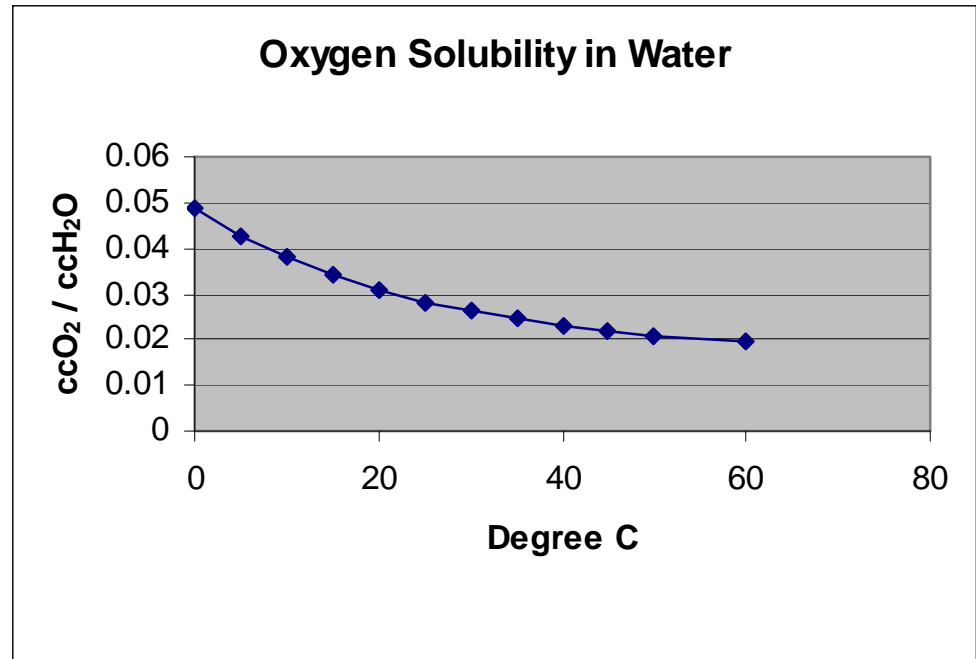
$$P = S \cdot D$$



Solubility

Solubility relates the concentration of permeant within the film to the partial pressure of the permeant.

Units of **S**: $\frac{cm^3(STP)}{cm^3 - mmHg}$

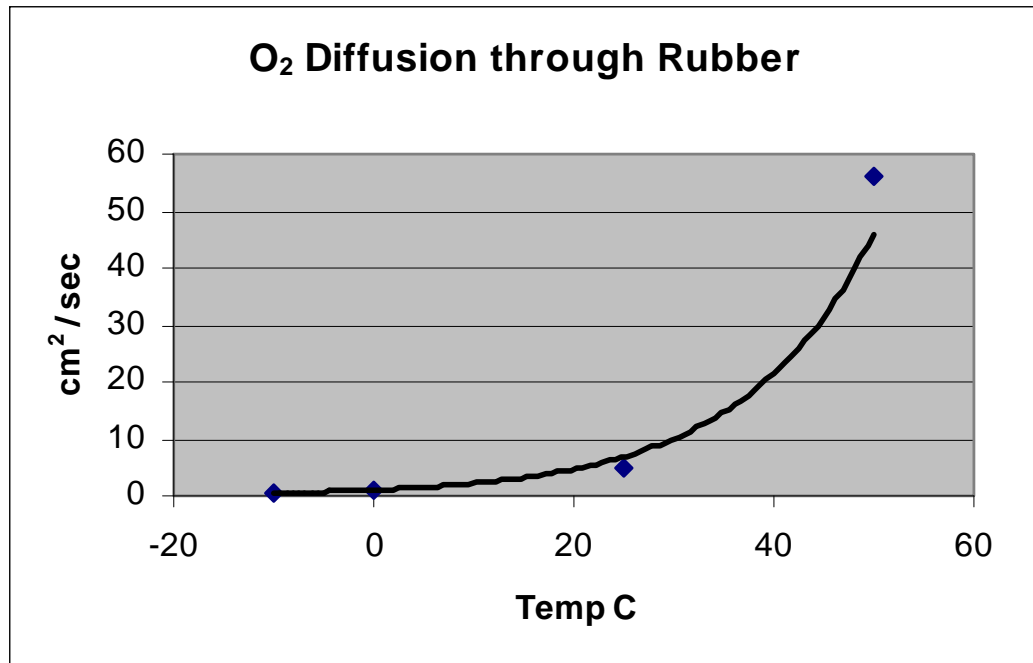




Diffusion

Diffusion is the process by which matter is transported from one part of a system to another as a result of random molecular motions.

Units of **D**: $\frac{\text{cm}^2}{\text{sec}}$





Temperature Impact on Permeation?

- As Temp Increases → Solubility decreases
- As Temp Increases → Diffusion increases

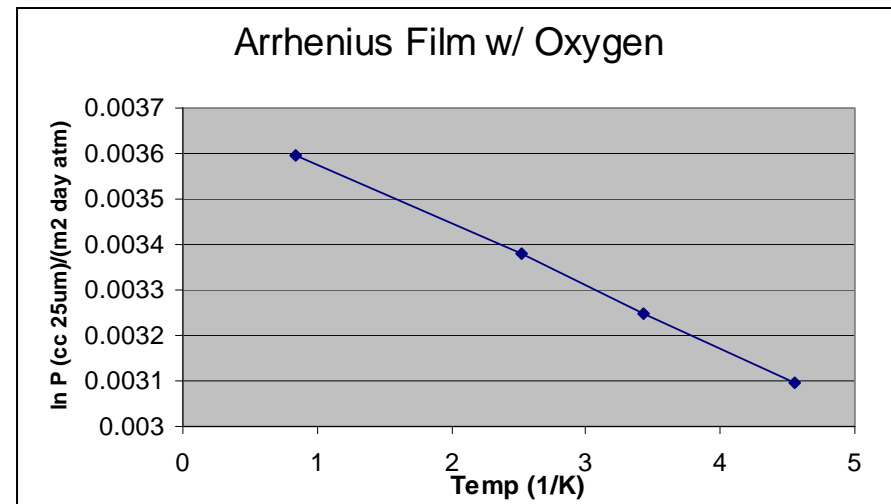
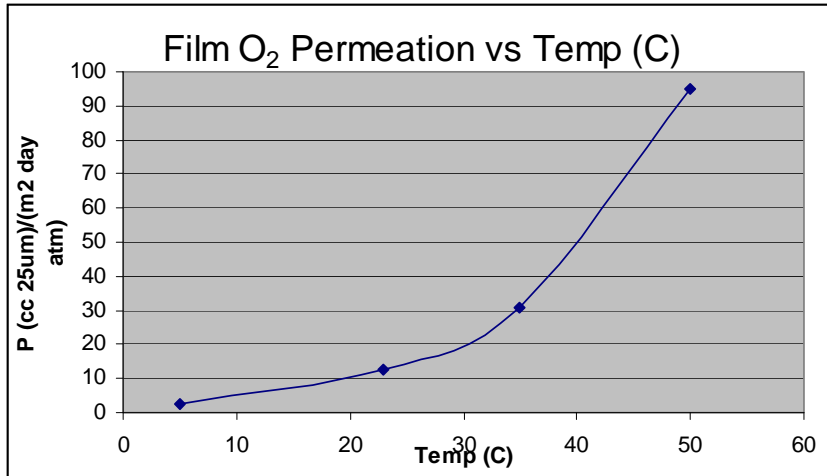
- $P = S \times D$

- D over-rides S in the above equation and....

- Generally: For every 10C increase in Temp, the Permeation Rate Doubles



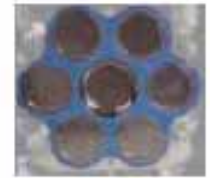
Temperature and Transmission Rate





MOCON Equipment

Temperature Range (10-40C or 5-50C)





High Temperature Set-up



- Remote permeation test cells
- High temperature Oven



High Temperature WVTR Cell





Two cells loaded in the oven





Water trap for “insurance”



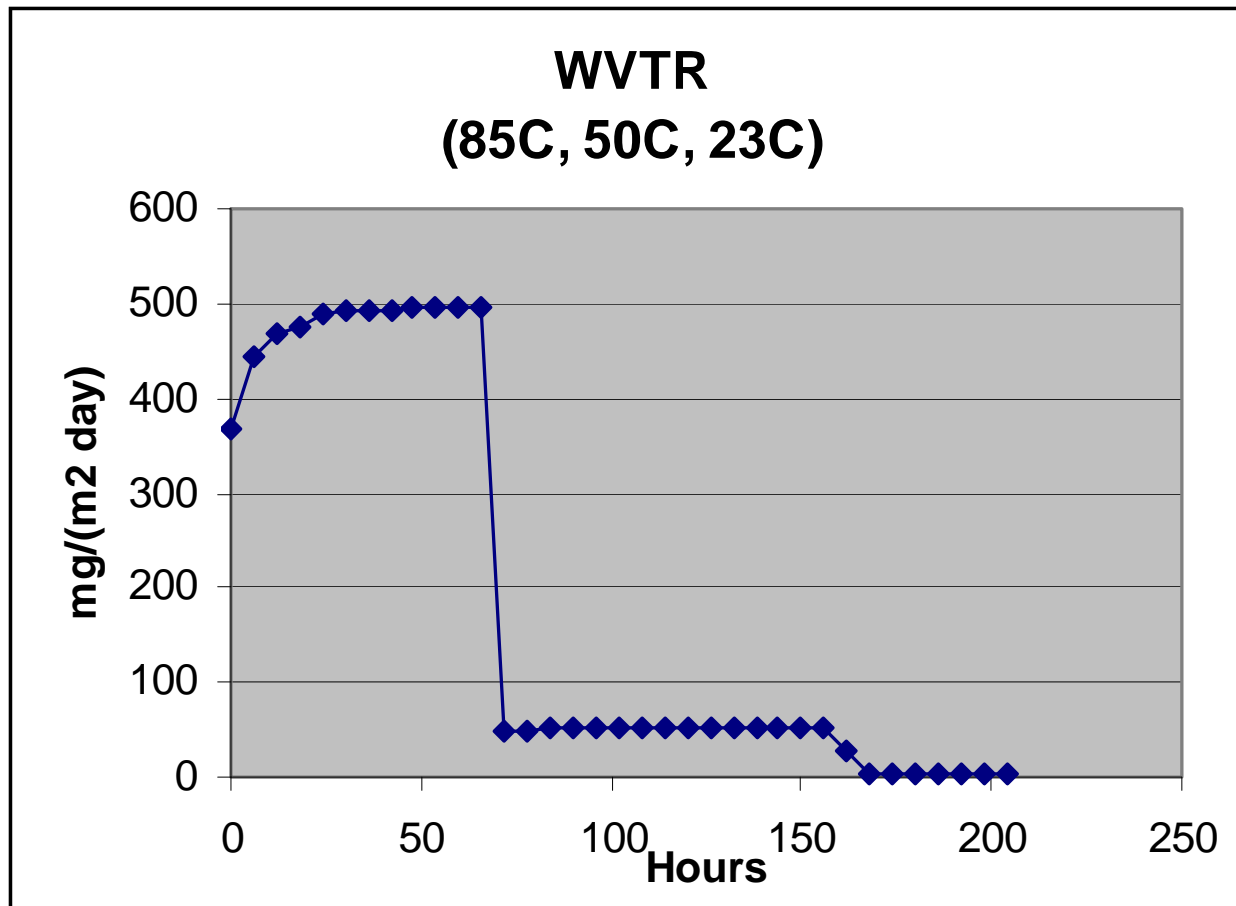


Two cells attached to instrument



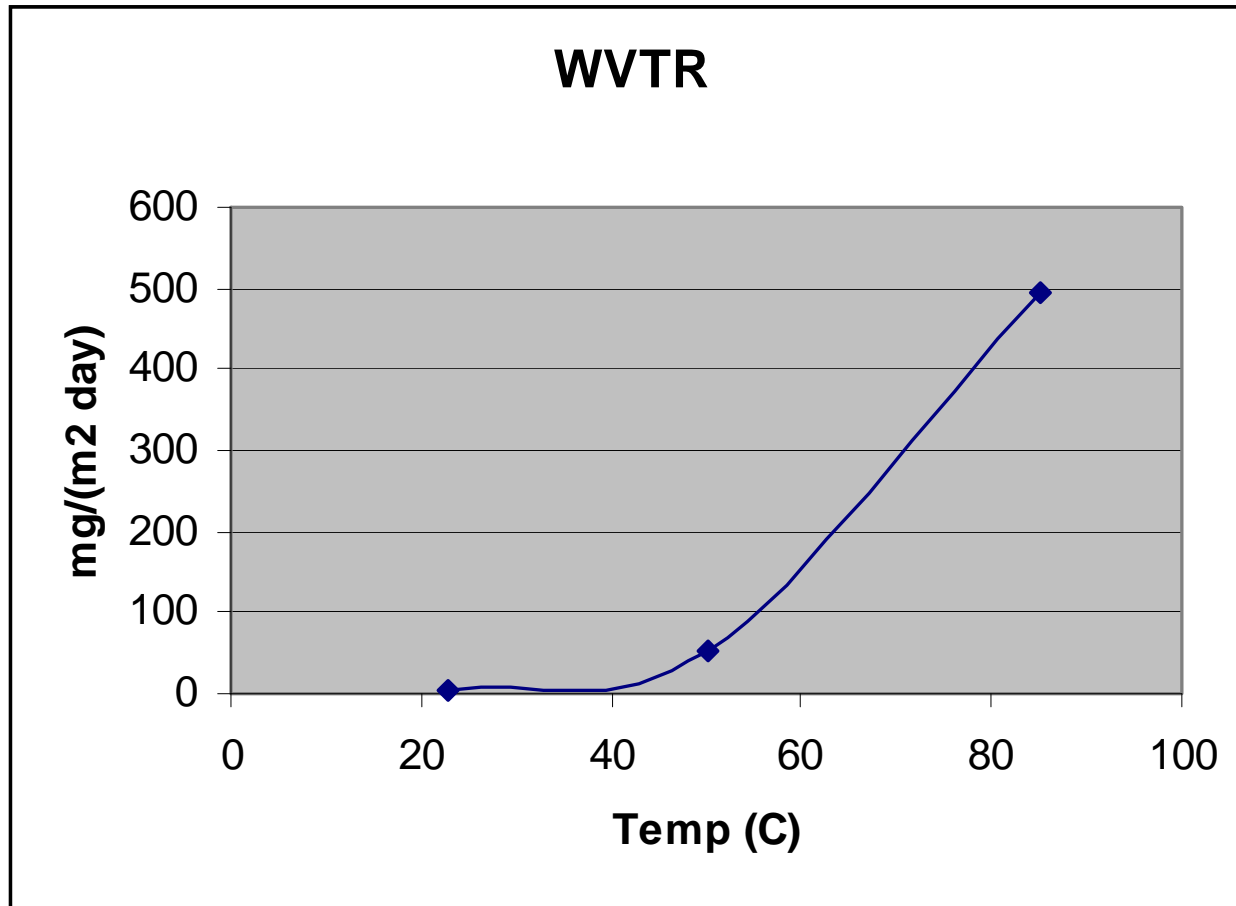


Water Vapor Film Test Aquatran Results



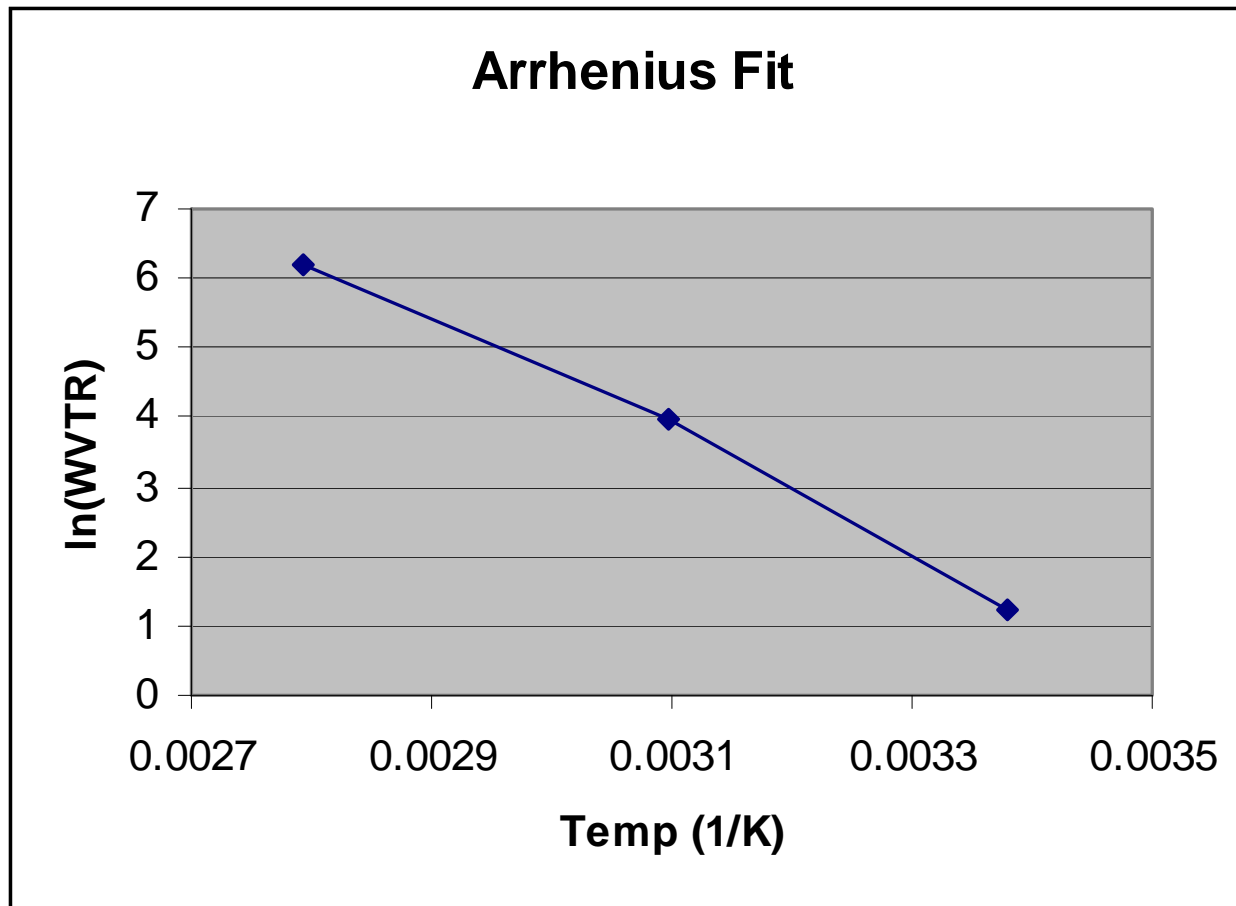


Water Vapor Film Test Aquatran Results



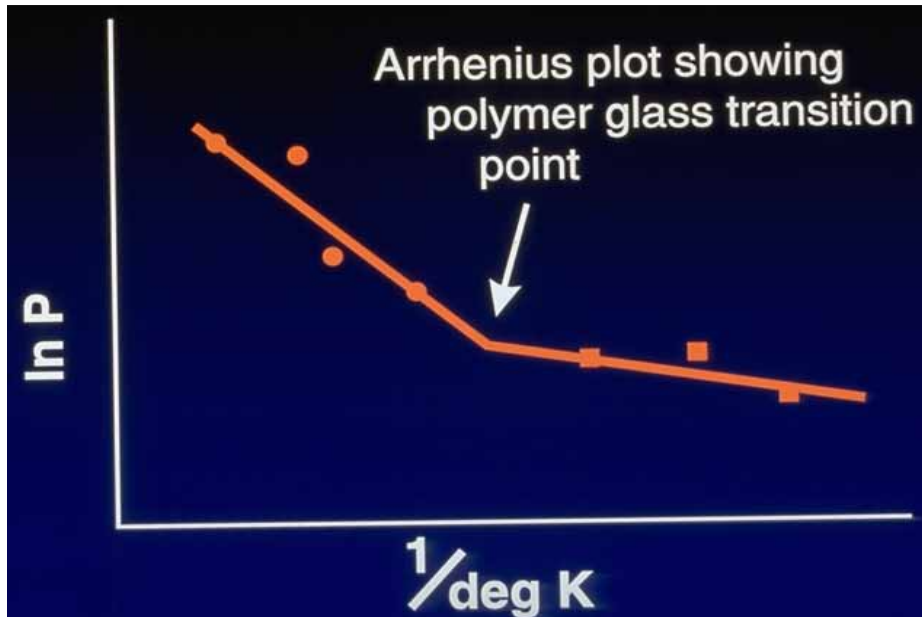


Water Vapor Film Test Aquatran Results





Beware ...

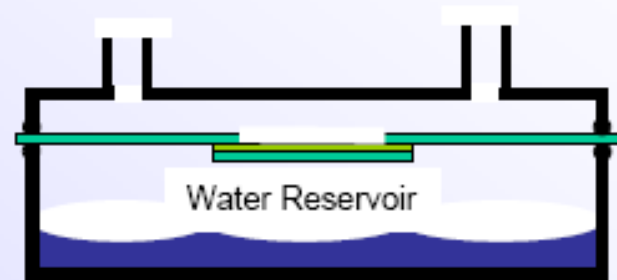
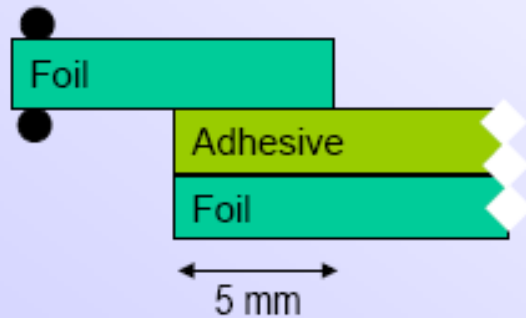


Film melting temperature

Polymer Tg (glass transition temperature)



Edge Seal Testing





Whole Package Testing





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