N86-29362

WATER PERMEATION AND DIELECTRIC BREAKDOWN

WILKES COLLEGE

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WATER PERMEABILITY in PVB TEDLAR PVB / TEDLAR AS A FUNCTION OF TEMPERATURE AND HUMIDITY

THEORY

ASSUMPTIONS:

(1) FICK'S LAW

$$J = P\, dp/dx$$

(2) IDEAL GAS BEHAVIOR

(3) IMMISCIBILITY

(4) SPONGE STRUCTURED

(5) DIFFUSION THROUGH WATER FILLED VOID SPACE

(6) CLAUSIUS-CLAPEYRON

PVB AND TEDLAR

TEMPERATURE DEPENDENCE

$$P = \frac{P_0 \exp(-Q_W / RT)}{T}$$

Q_W IS ACTIVATION ENERGY FOR WATER SELF DIFFUSION

$$J = \frac{J_0 \exp(-[Q_W + \Delta H_V] / RT)}{T^{6.57}}$$

ΔH_V IS ENTHALPY OF WATER EVPPORATION

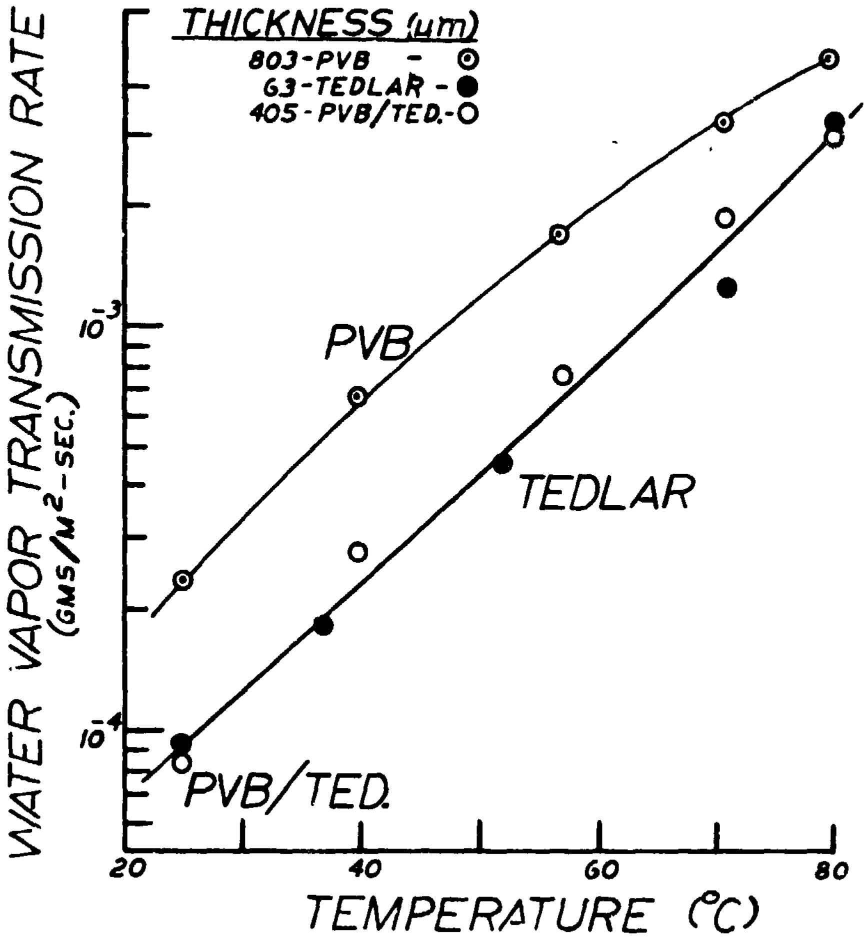
HUMIDITY DEPENDENCE

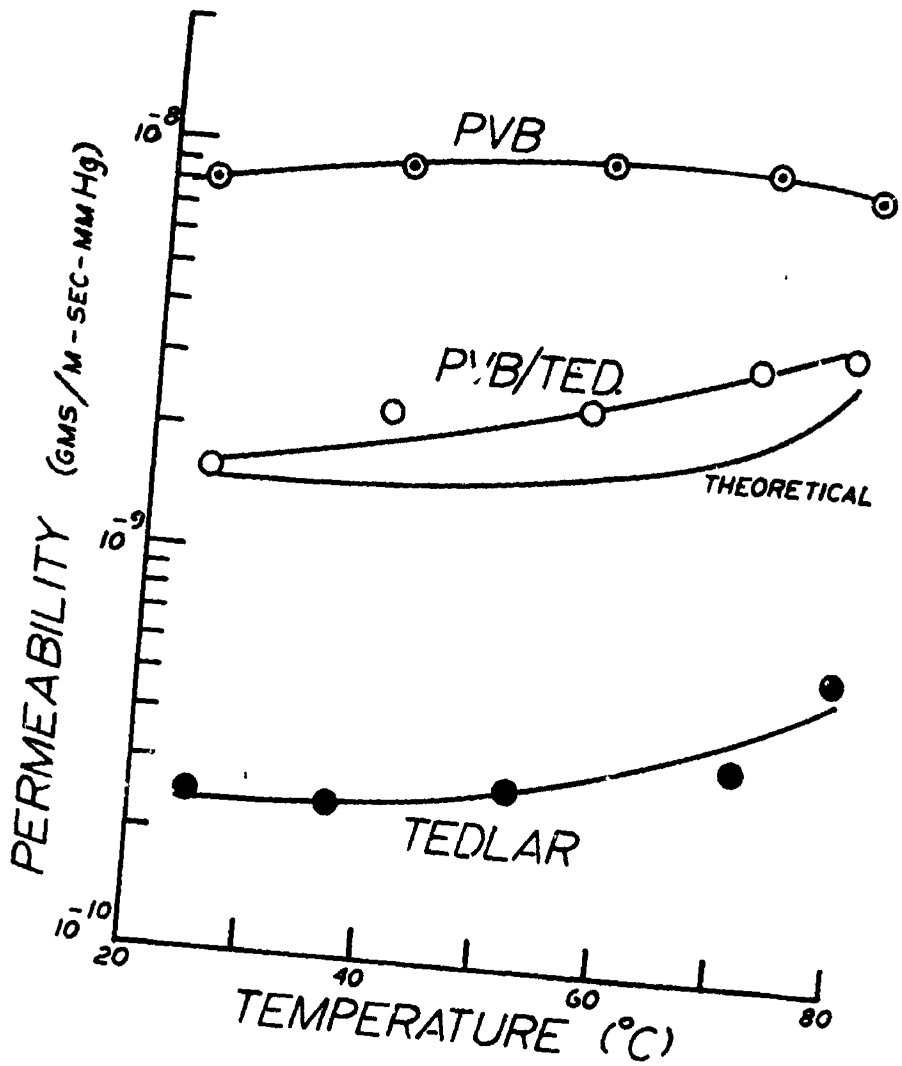
$$J = K\,[R.H.]$$

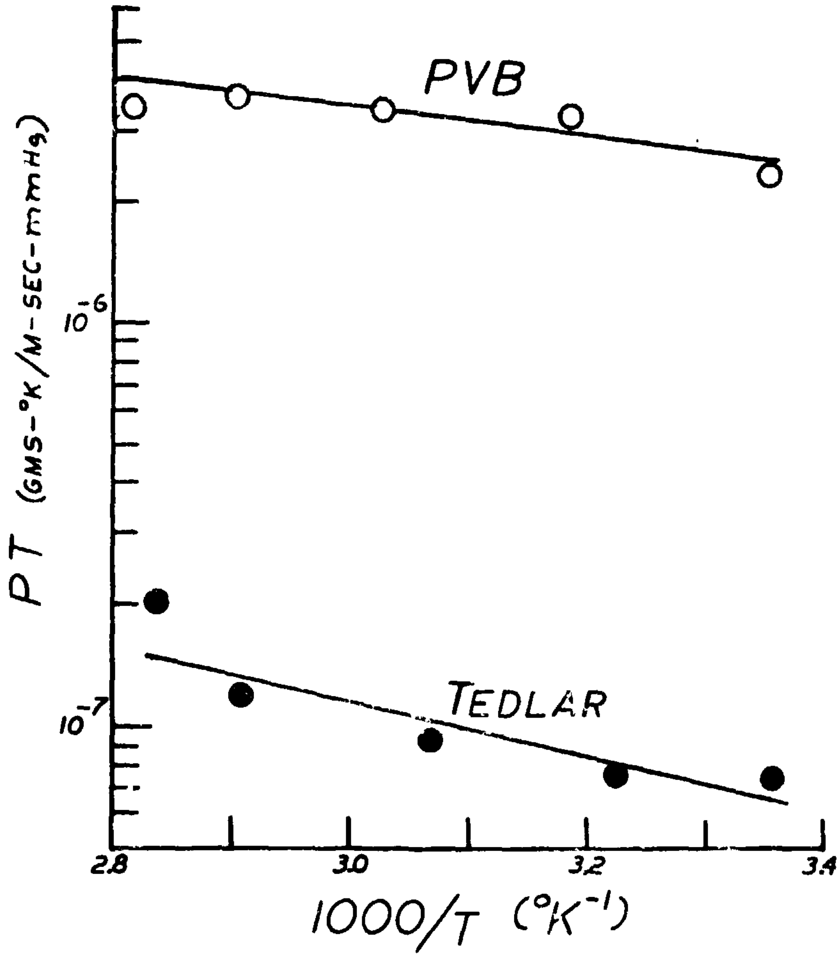
PVB/TEDLAR COMPOSITE

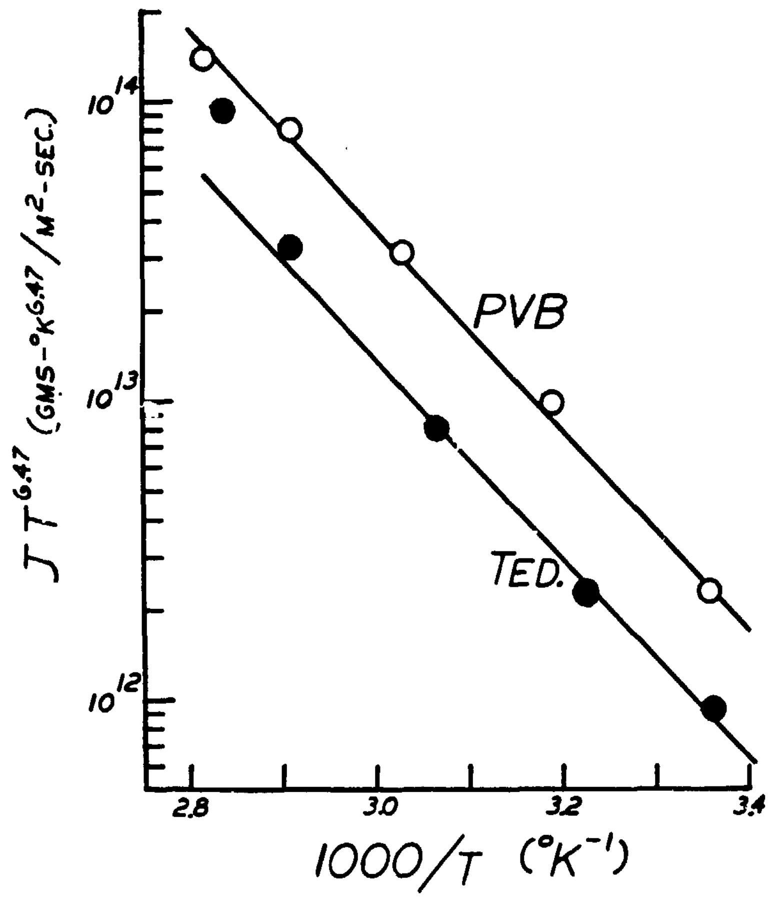
$$\frac{1}{P_{PVB/T}} = \left[\frac{t_{PVB}}{P_{PVB}} + \frac{t_T}{P_T}\right]\left[\frac{1}{t_{PVB}+t_T}\right]$$

$$J_{PVB/T}\begin{cases} = J_{PVB}\ (\text{if } J_{PVB} < J_T) \\ \text{or} \\ = J_T\ (\text{if } J_T < J_{PVB}) \end{cases}$$

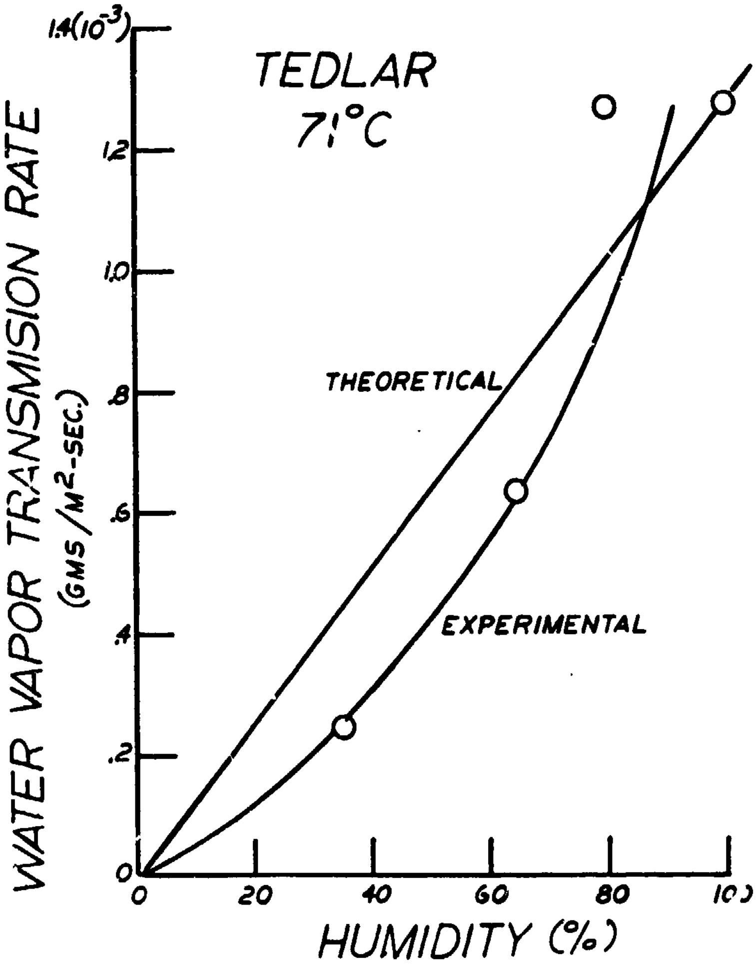

THICKNESS (um)
803-PVB -
63-TEDLAR -
405-PVB/TED.-
PVB
TEDLAR
PVB/TED.
WATER VAPOR TRANSMISSION RATE (GMS/M²-SEC.)
10⁻³
10⁻⁴
20
40
60
80
TEMPERATURE (°C)


PVB
PVB/TED
THEORETICAL
TEDLAR
PERMEABILITY (GMS/M-SEC-MM Hg)
10^{-8}
10^{-9}
10^{-10}
20
40
60
80
TEMPERATURE (°C)


PVB
TEDLAR
10^{-6}
10^{-7}
PT (GMS-°K/M-SEC-mmHg)
2.8
3.0
3.2
3.4
1000/T (°K⁻¹)



10^{14}
10^{13}
10^{12}
$J\,T^{6.47}$ (GMS-°K$^{6.47}$/M^2-SEC.)
PVB
TED.
2.8
3.0
3.2
3.4
1000/T (°K^{-1})


TEDLAR
71°C
THEORETICAL
EXPERIMENTAL
WATER VAPOR TRANSMISION RATE
(GMS/M²-SEC.)
1.4(10⁻³)
1.2
1.0
.8
.6
.4
.2
0
0
20
40
60
80
100
HUMIDITY (%)

RESULTS & CONCLUSIONS

(1) $$\frac{P_{PUB}}{P_T} \equiv 100$$

(2) $$\frac{J_{PUB}}{J_T} \equiv 3 \begin{pmatrix} t_{PUB} \equiv 803\mu m \\ t_T = 63\mu m \end{pmatrix}$$

(3) THEORY=EXPT for J(T) & P(T)

EXPT

$$Q_M + \Delta H_V = 15 \text{ Kcal/mole}$$

LITERATURE:

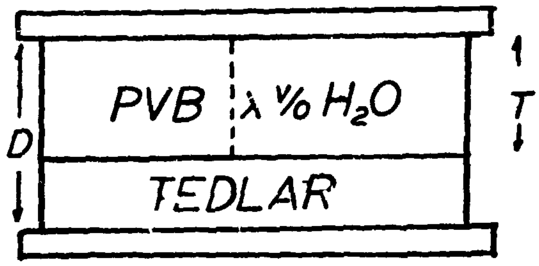
$Q_M = 4.6$ Kcal / mole

$\Delta H_V = 9.8$ Kcal / mole

$Q_M + \Delta H_V = 14.4$ Kcal / mole

(4) NEED THERMODYNAMIC INFORM

- RESISTANCE
- CAPACITANCE
- BREAKDOWN VOLTAGE



DIELECTRIC CONSTANT:

$$K = \left[\frac{K_T\left[[X][K_W - K_P] + K_P\right]}{TK_T + [D-T]\left[[X][K_W - K_P] + K_P\right]}\right]\left[\frac{1}{D}\right]$$

RESISTIVITY:

$$\rho = \rho_T\left[\frac{D-T}{D}\right] + \left[\frac{T}{D}\right]\left[\frac{\rho_W \rho_P}{\rho_W + [\rho_P - \rho_W][X]}\right]$$

DIELECTRIC BREAKDOWN

AT

25°C

IN

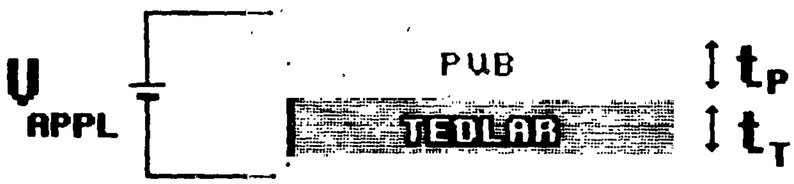
PVB
TEDLAR
PVB/TEDLAR
} 0% R.H.

AND

PVB
TEDLAR
PVB/TEDLAR
} 100% R.H.

THEORY

GAUSSES' LAW:



VOLTAGE DIVISION

$$V_P = \left[\frac{t_P/K_P}{t_P/K_P + t_T/K_T}\right] V_{APPL}$$

$$V_T = \left[\frac{t_T/K_T}{t_P/K_P + t_T/K_T}\right] V_{APPL}$$

BREAKDOWN VOLTAGE (0% R.H.)

LARGER OF:

$$V_{BR} = E_{BR_T} K_T \left[\frac{t_P}{k_P} + \frac{t_T}{k_T} \right]$$

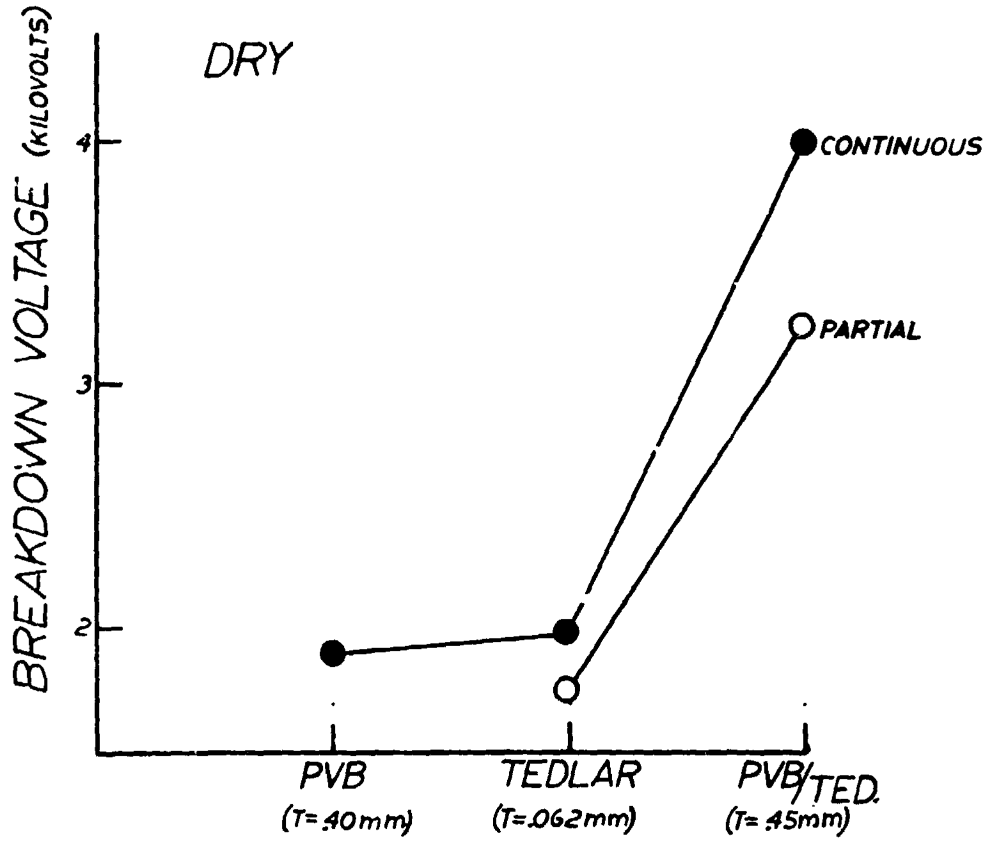
OR

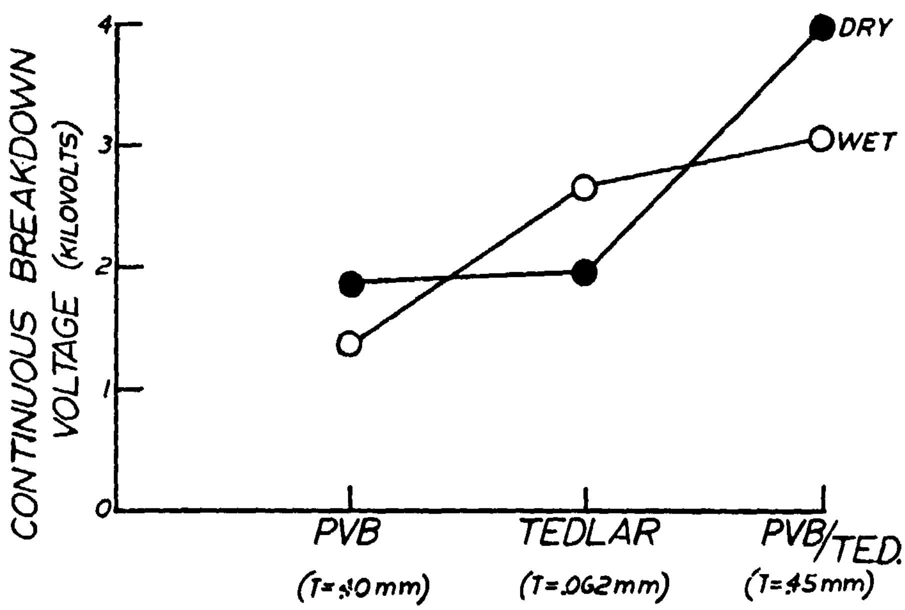
$$V_{BR} = E_{BR_P} K_P \left[\frac{t_P}{k_P} + \frac{t_T}{k_T} \right]$$

WHERE

$$E_{BR_P} = V_{BR_P} / t_P$$

$$E_{BR_T} = V_{BR_T} / t_T$$


DRY
BREAKDOWN VOLTAGE (KILOVOLTS)
4
3
2
CONTINUOUS
PARTIAL
PVB
(T=.40mm)
TEDLAR
(T=.062mm)
PVB/TED.
(T=.45mm)


CONTINUOUS BREAKDOWN VOLTAGE (KILOVOLTS)
4
3
2
1
0
DRY
WET
PVB
(T=.40mm)
TEDLAR
(T=.062mm)
PVB/TED.
(T=.45mm)

ELECTRIC FIELDS AT BREAKDOWN

	E_{BR} (KV/CM.)
PVB	25
TEDLAR	280
AIR	30

PVB/TEDLAR BREAKDOWN VOLTAGE

	V_{BR} (KV)	K_{PVB}
EXPT.	3.2	–
THEORY	10.1	4.2
	6.1	6.1
	5.3	10.0

CONCLUSIONS

BREAKDOWN VOLTAGES

THEORY ≠ EXPT. (PVB/T)

DRY > WET (PVB & PVB/T)

WET > DRY (TEDLAR)

PARTIAL ≃ .8 CONTINUOUS

DESTRUCTIVE (TEDLAR)

NON-DESTRUCTIVE (PVB & PVB/T)

CRITICAL ELECTRIC FIELD

TEDLAR > PVB ≃ AIR