41

Materials for Food Packaging - Transmission rate, permeance and permeability
Prof. Luigi De Nardo
AY 2021/2022
(Ver 30/09/2021)

Name and Surname: **Moneta Edy Giovanna** **Personal identifier:** **10566963**

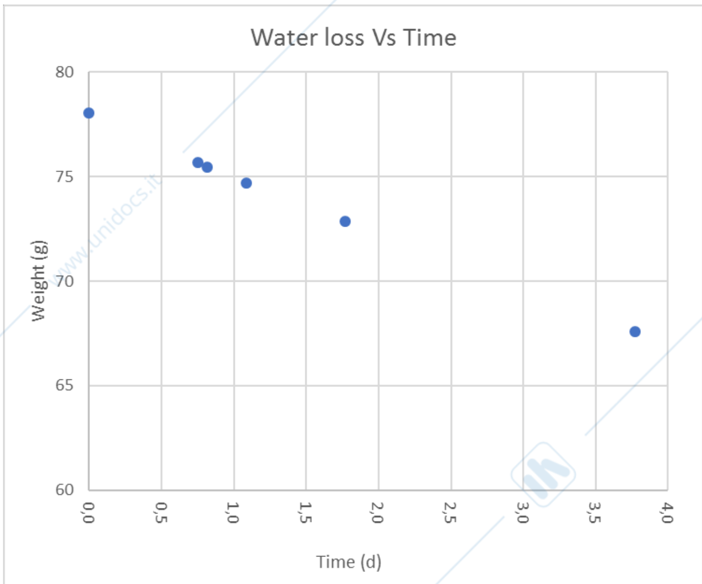
Homework n. 2 – Part 1. Determination of permeability

Goal	Determination of permeability properties toward O2 and water (vapour) of a given film starting from experimental data
Material properties:	PLA Film
	Film Thickness: 45 µm

Experimental condition and results (For Data please refer to file "annex 1.xlsx"):

WVTR was evaluated with a TQC permeability cups (VF2200).
Permeable surface area: 0.001 m²
RH inside the cup: 100 %

Environmental conditions:
Temperature: 37 °C
RH: 0 %
Pressure: 1000 hPa



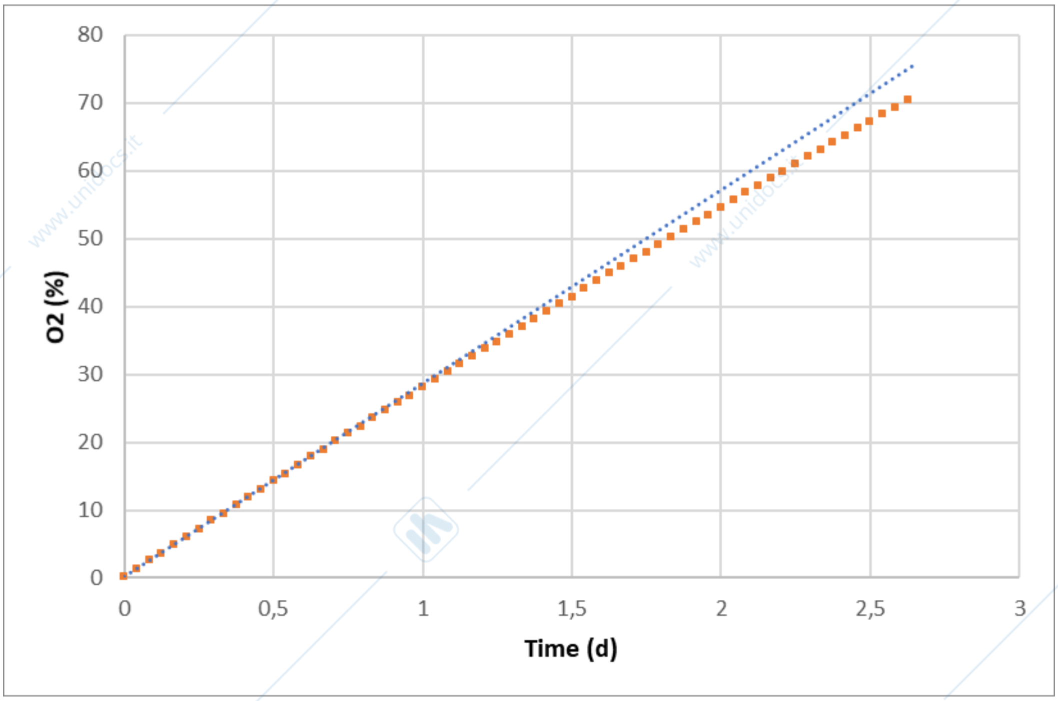
OTR was evaluated with a Fibox 4 and an oxygen permeation cell equipped with a PSt6 sensor.
Permeable surface area: 0.068 m²
Total pressure in both cells: 1007.76 hPa

O_2 % in the bottom cell: 100 %

Cell Volume: 110 cm^3

Temperature: ≈20 °C

RH: 0 %



N.B. please carefully evaluate the trend of the data recorded.

Results:

Transmission rate, OTR (cm^3 m^{-2} d^{-1}):	$OTR = \left(\frac{\Delta P^1_{O_2}}{\Delta t}\right) * \frac{V}{A}$	=40.383[cm^3 m^{-2} d^{-1}]
Transmission rate, WVTR (g m^{-2} d^{-1}):	$WVTR = \left(\frac{\Delta m}{\Delta t}\right) * A$	=2663,5332 [g m^{-2} d^{-1}]
Permeance, P O_2 (cm^3 m^{-2} d^{-1} bar^{-1}):	$P_{O_2} = \frac{OTR}{\Delta P}$	=40,070 [cm^3 m^{-2} d^{-1} bar^{-1}]
Permeance, P H_2O (g m^{-2} d^{-1} bar^{-1}):	$P_{H_2O} = \frac{WVTR}{\Delta P_W}$	=42960.241 [g m^{-2} d^{-1} bar^{-1}]
Permeability, P' O_{2_std} (cm^3 µm m^{-2} d^{-1} bar^{-1}):	$P'_{O_2} = P_{O2} * l$	=1803.1632[cm^3 µm m^{-2} d^{-1} bar^{-1}]
Permeability, P' H_2O (g µm m^{-2} d^{-1} bar^{-1}):	$P'_{H_2O} = P_{H_20} * l$	=1933209.6 [g µm m^{-2} d^{-1} bar^{-1}]

Assumptions and comments:	• To calculate the permeability in the water we assumed that the pressure for saturated water was 0.0628 Bar, since we are at 37°C • To avoid mistakes due to the initializing process we didn't consider the firsts value in both cases • The OTRstd was evaluated considering Tstd=273K and Pstd=1bar , considering O2 an ideal gas • T for the oxygen is consider constant at an average T=20.5°C • From the result we notice that the PLA film is more resistant to O2 permeation than water

Homework n. 2 – Part 2. Shelf life evaluation

Goal	Exploiting the properties measured in the Part 1 evaluate the shelf life of a generic product, packed in a parrallelepipeodial shaped box under MAP conditions.

Packaging details:

Material:	PLA	
Thickness:	100	µm
Dimensions (w l h):	10; 5; 3	Cm
Free volume:	100	cm³
O2 @ t=0	0	%
RH @ t=0	0	%
Iof (O_2)	5	%
	50	%
Iof (H_2O)		
Storing conditions:		
Gas composition (air):	79.1 % N_2; 20.9 % O_2	
RH:	35	%
Pressure:	1	Atm
Temperature	25	°C

Assumptions:

taking in account the linear model (20,9% of air is oxygen)

$$t_{SL} = \frac{1}{k} * ln\left(\frac{P_{O_2}}{P_{O_2} - P_{O_2}^{max}}\right) = 73.37769[d]$$

$$k = \frac{P'_{O_2} * A * P}{l * V_{freevolume}} = 0.003726\left[\frac{1}{d}\right]$$

$$k = \frac{P'_{O_2} * A * P}{l * V_{freevolume}} = 0.003726 \left[\frac{1}{d}\right]$$

Using the value of permeability taken from the first exercise* :

$$P'_{O_2} = 1935.584 \left[\frac{m^3 * m * \mu m}{s * bar}\right]$$

V=w*l*h=150 cm^3

A=2*[(w*l)+(w*h)+(l*h)]=190cm^2

And that the WVTR is equal to =2663,5332 [g m^{-2} d^{-1}]

Since the outer humidity is about 35%, the humidity inside our package once it reaches 35 % will go in equilibrium with the one outside and remain constant, this means that the humidity will not reach our Iof, this can be verified by calculating

$$k = \frac{P'_{H_2O} * A * P}{l * V_{freevolume}} = 5074.73 \left[\frac{1}{d}\right]$$

Then we use this value to calculate PwH2O(tsl)

$$Pw_{h20}(t_{sl}) = RH * P * \left(1 - e^{-kt_{sl}}\right) = 0.354638\ [bar]$$

Which in percentile is equal to 35 %

Results:	
t_{SL} (d), shelf life:	73.37 [dayd]s
Internal gas composition at shelf life	
O_2 (%):	5%
H_2O (%):	35 %

Comments:

- For the calculation is possible to refer to the excel file Moneta_annex
- Some conversion in different unity of measure as been made in order obtain the unit of measure desired at the end
- (*)the use of the volume of P'o2 taken from the previous point is possible thanks to the fact that P' is independent from the geometry of the system and from the pressure of O2