Kerem KÜÇÜK

6th EMship cohort: October 2015 – February 2017

Master Thesis

Effect of Seawater on Ageing of Polyester Composites and Study of Aged Composite Polymer

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Outline

-Introduction & Objectives

-Literature

-Ageing of Composite polyester

- Production Process and preparation
- Test Conditions
- Accelerated Ageing
- Results

-Mechanical behavior of aged composites

- Preparation & Testing
- Test Results
- Analysis of the Results

-Conclusion and future work

Introduction

Maritime Industry

End of the Service Life

After

???

Objectives

The objectives include:

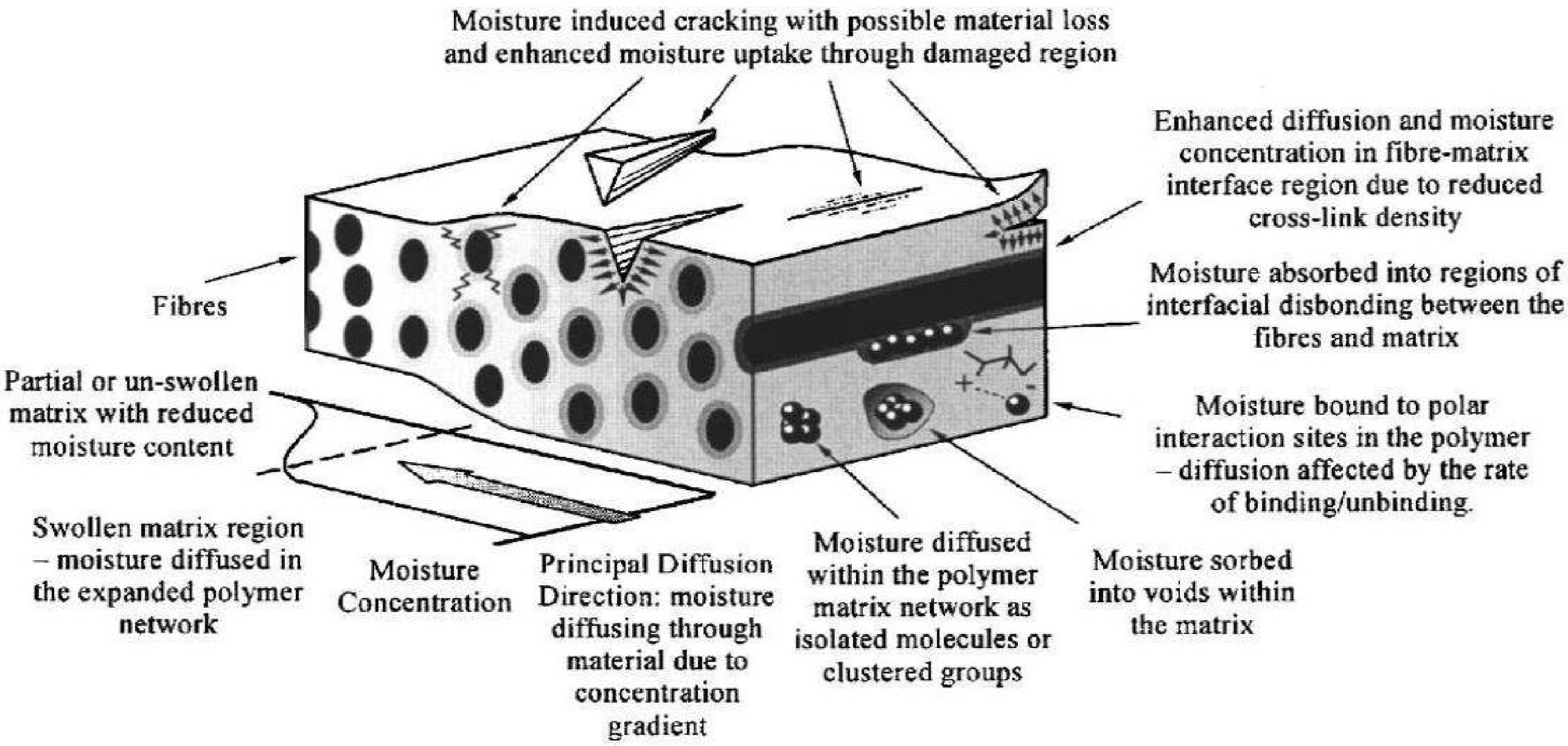
Scope of the study >>>> Glass fiber / Polyester Composite

- The quantification of the sea water ingression in glass/polyester laminates at different temperature levels ;

- The determination of the change of flexural property of the glass/polyester composite at different temperature levels.

Literature

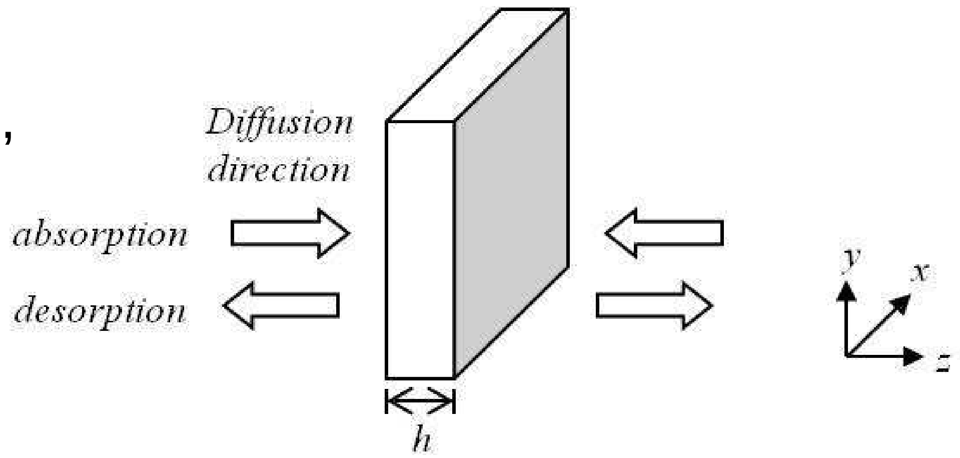
Moisture sorption locations and mechanisms in polymer



Literature

-Fickian Diffusion

- Concentration profile and gradient changes by the time,
- Driving force (gradient),



$$\frac{\partial c}{\partial t} = \frac{\partial}{\partial z}\left(D_z(T)\frac{\partial c}{\partial z} \right) = D_z(T)\frac{\partial^2 c}{\partial z^2}$$

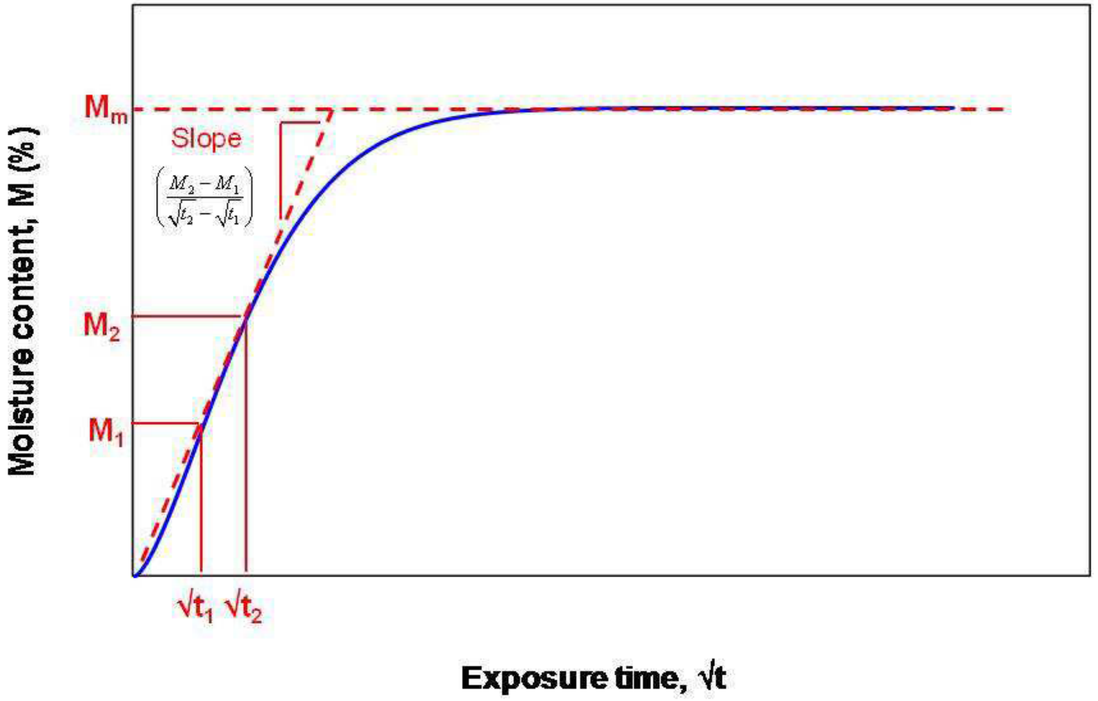
c = moisture concentration
Dz = moisture diffusivity (independent of distance, time and concentration)

Literature

-Fickian Diffusion

$$D_z = \pi\left(\frac{h}{4M_m}\right)^2\left(\frac{M_2 - M_1}{\sqrt{t_2} - \sqrt{t_1}}\right)^2$$

where:
h= thickness of the material where seawater diffuse
Mm= Maximum moisture content
M1= Moisture content at time of t1^1/2
M2= Moisture content at time of t2^1/2
t1= First measurement time of the moisture content
t2= Second measurement of the moisture time



Literature

-Langmuir Model

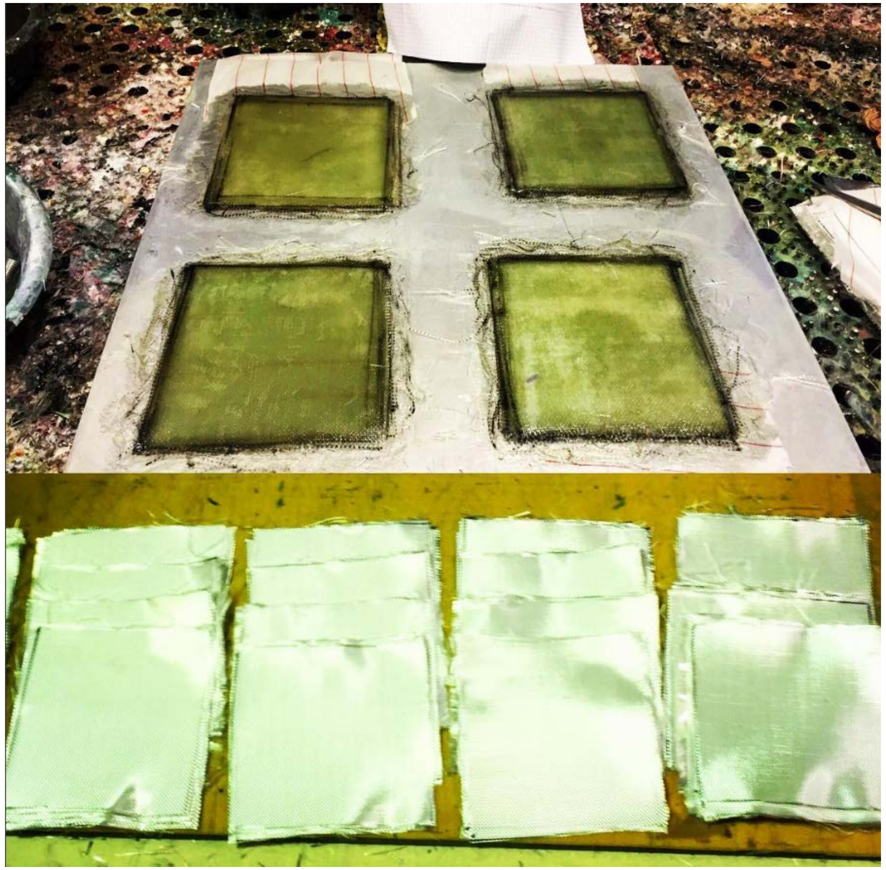
$$\frac{M_t}{M_s} = \frac{\beta}{\gamma+\beta} e^{-\gamma t}\left(1 - \frac{8}{\pi^2}\sum_{n=1}^{\infty} \frac{e^{-(2n+1)\pi^2 Dt/4h^2}}{(2n+1)^2}\right) + \frac{\beta}{\gamma+\beta}\left(e^{-\beta t} + e^{-\gamma t}\right) + \left(1 - e^{-\beta t}\right)$$

Where:
Mt= Moisture content at the time
MS= Moisture content at saturation
N= number of the bound molecules per unit volume
n=mobile molecules per unit volume

- Water molecules are not diffuse freely
- Acting on active regions of resin by hydrogen bridges
- There are mobile and bound molecules
- M∞ when γn = βN

Ageing of Polyester Composite

- Production Process and Preparation > Plates



- EN ISO 14125 Standards
- Hand Lay-up
- Fiber/Resin Weight fraction (%60 Fiber - %40 Resin)
- Cured Plates >> ~156-165 gr
- 70 Plates are produced
- Coding of Plates (PT1P101)

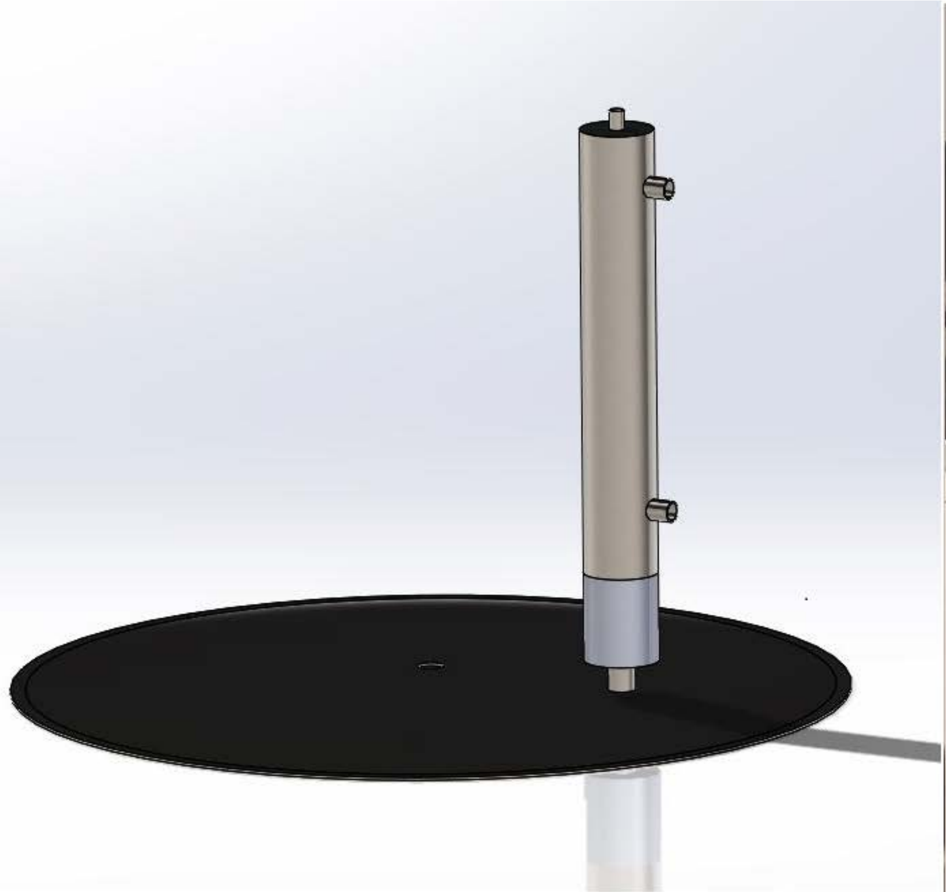
Ageing of Polyester Composite

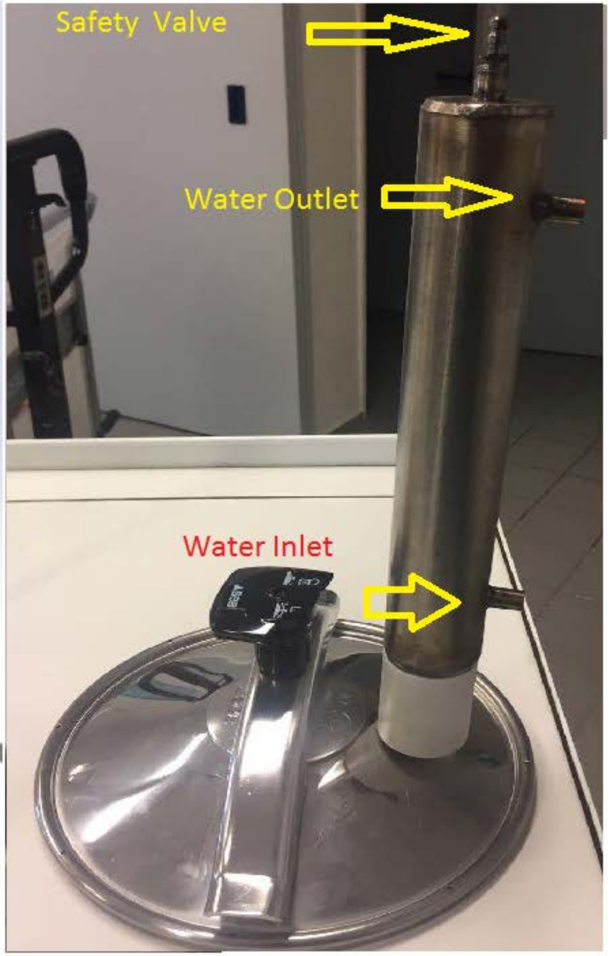
- Production Process and Preparation > Sea Water

Composition of Ions	# of mole	Composition of Salts	M salt g/mol	Quantity	For Salinity 35gr/l (gr)
Na^{+}	0,469	NaCl	58,5	27,4	25,0
Mg^{2+}	0,053	$MgCl_2$	95	5,035	4,6
SO^{4-}	0.028	Na_2SO_4	142	3,976	3,6
Ca^{2+}	0,0103	$CaCl_2$	111	1,1433	1,0
K^{+}	0,0102	KCl	74,5	0,7599	0,7
-	-	Total	-	38,4	35,0

Ageing of Polyester Composite

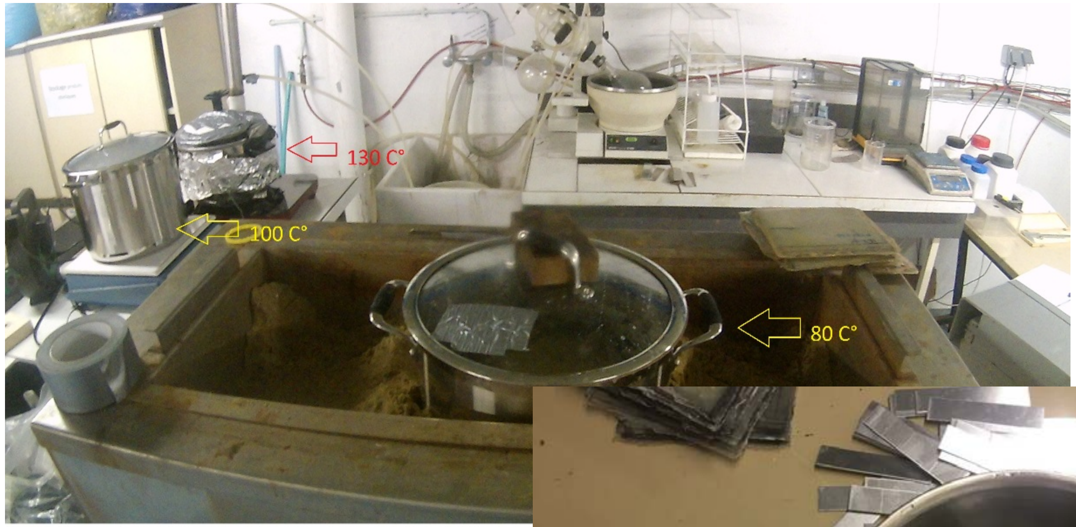
- Production Process and Preparation > Design of Cooler for Pressure Cooker





Ageing of Polyester Composite

- Test Conditions



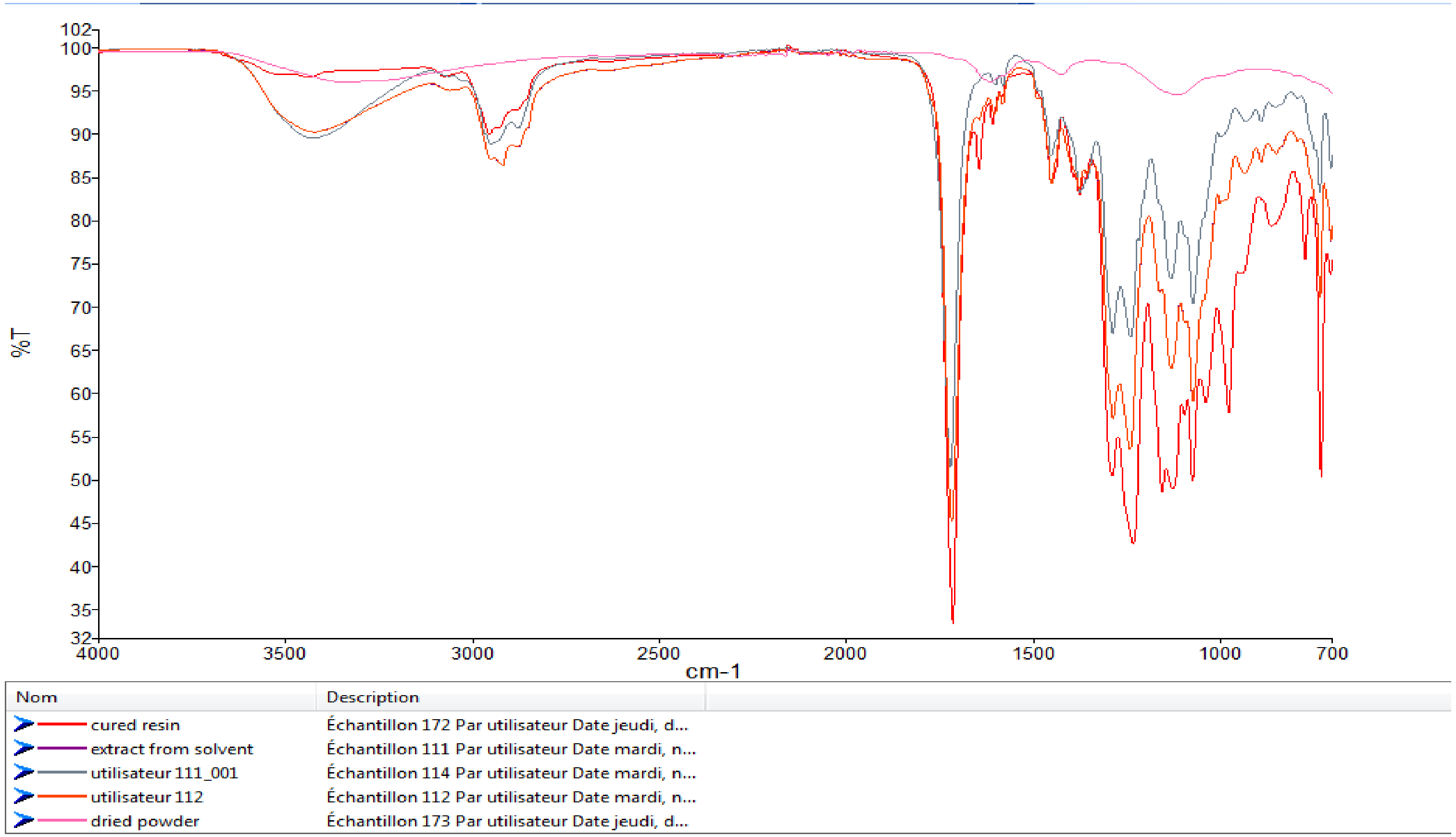
- Temperature
  (80C°, 100C°,and 130C°)

- Time Period
  (3 weeks & 6 weeks)

- Placement of Plates

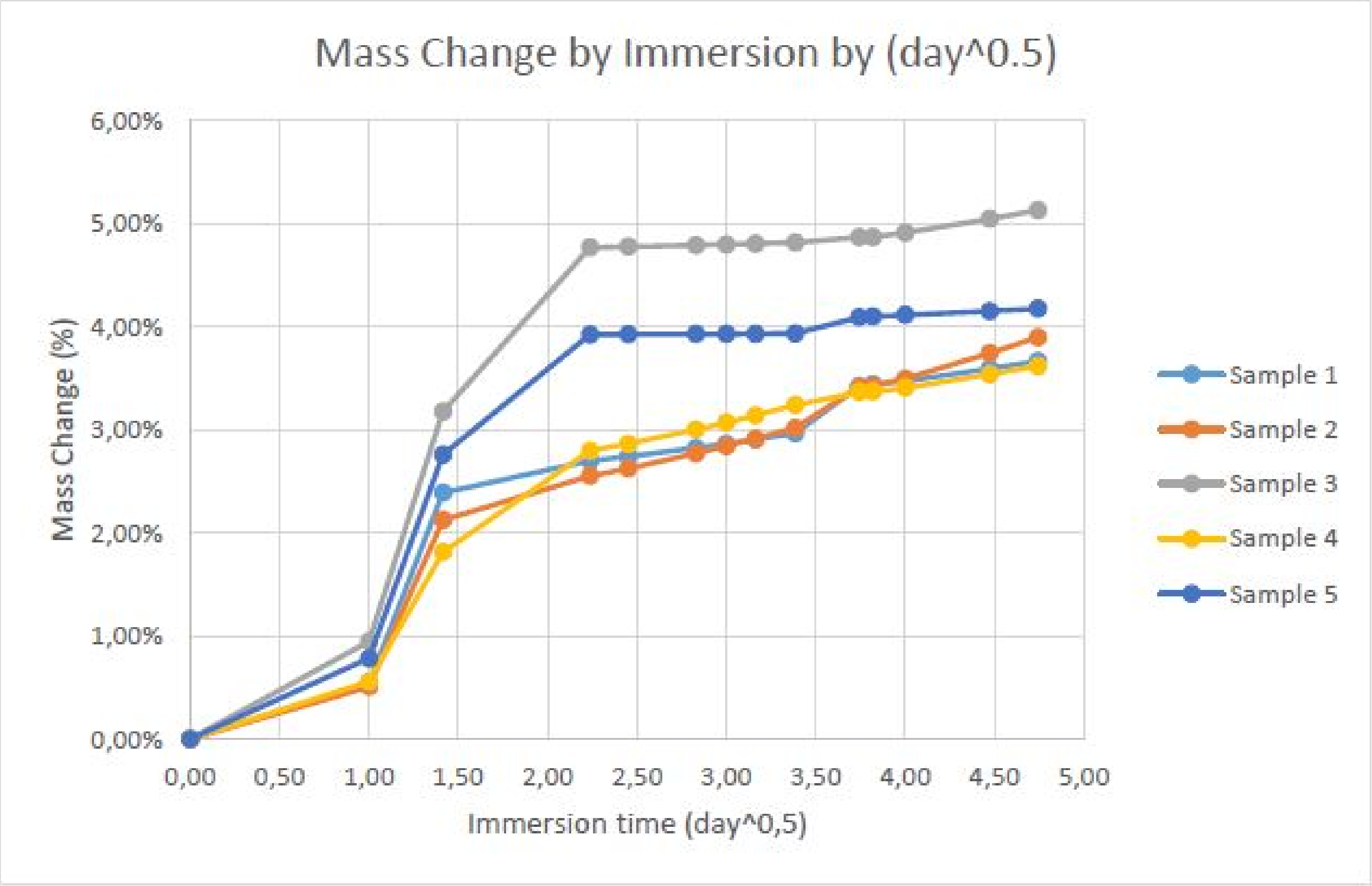
Ageing of Polyester Composite

- Notes about tests



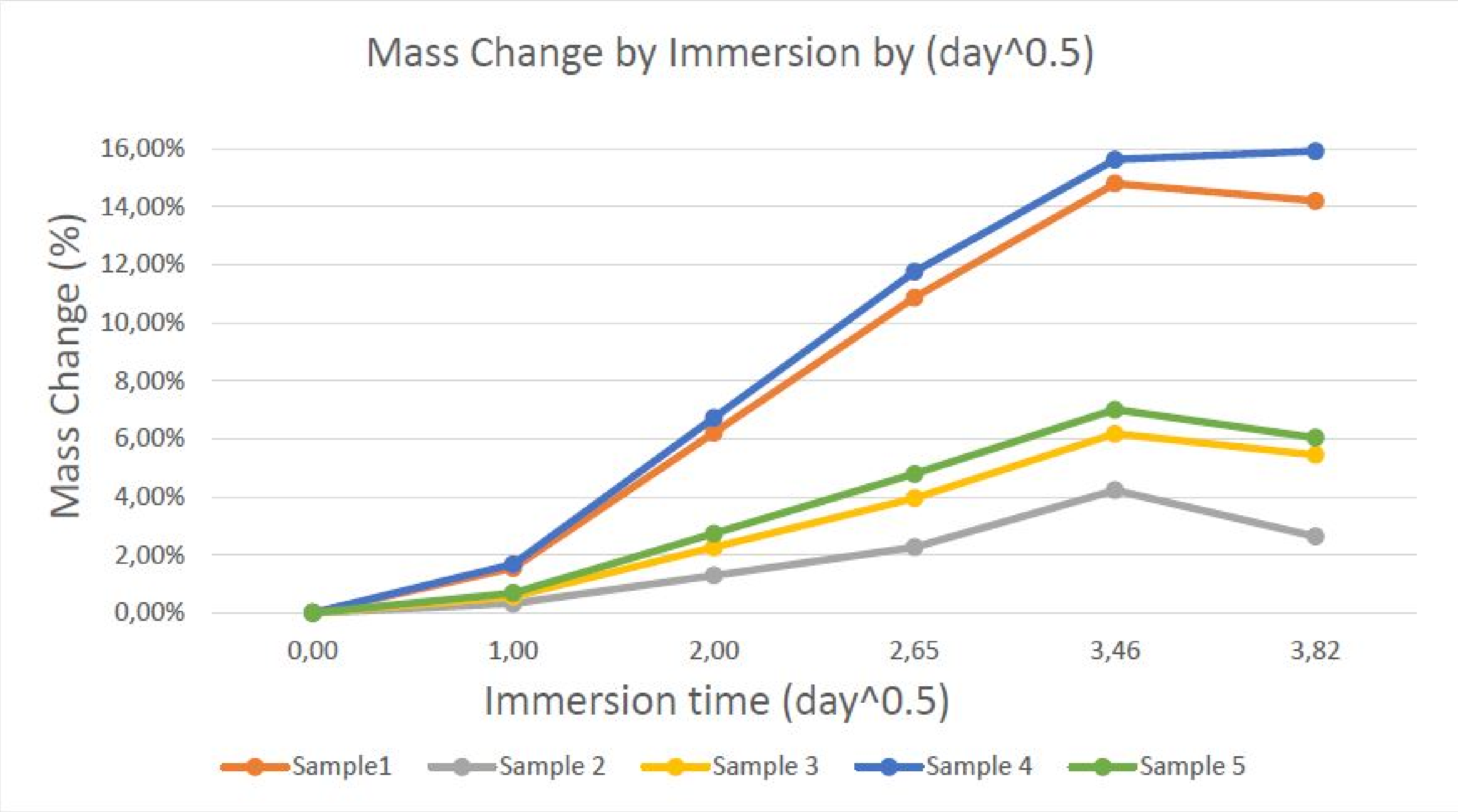
Ageing of Polyester Composite

- Results > 80C° Mass change (%) by time (day^0,5)



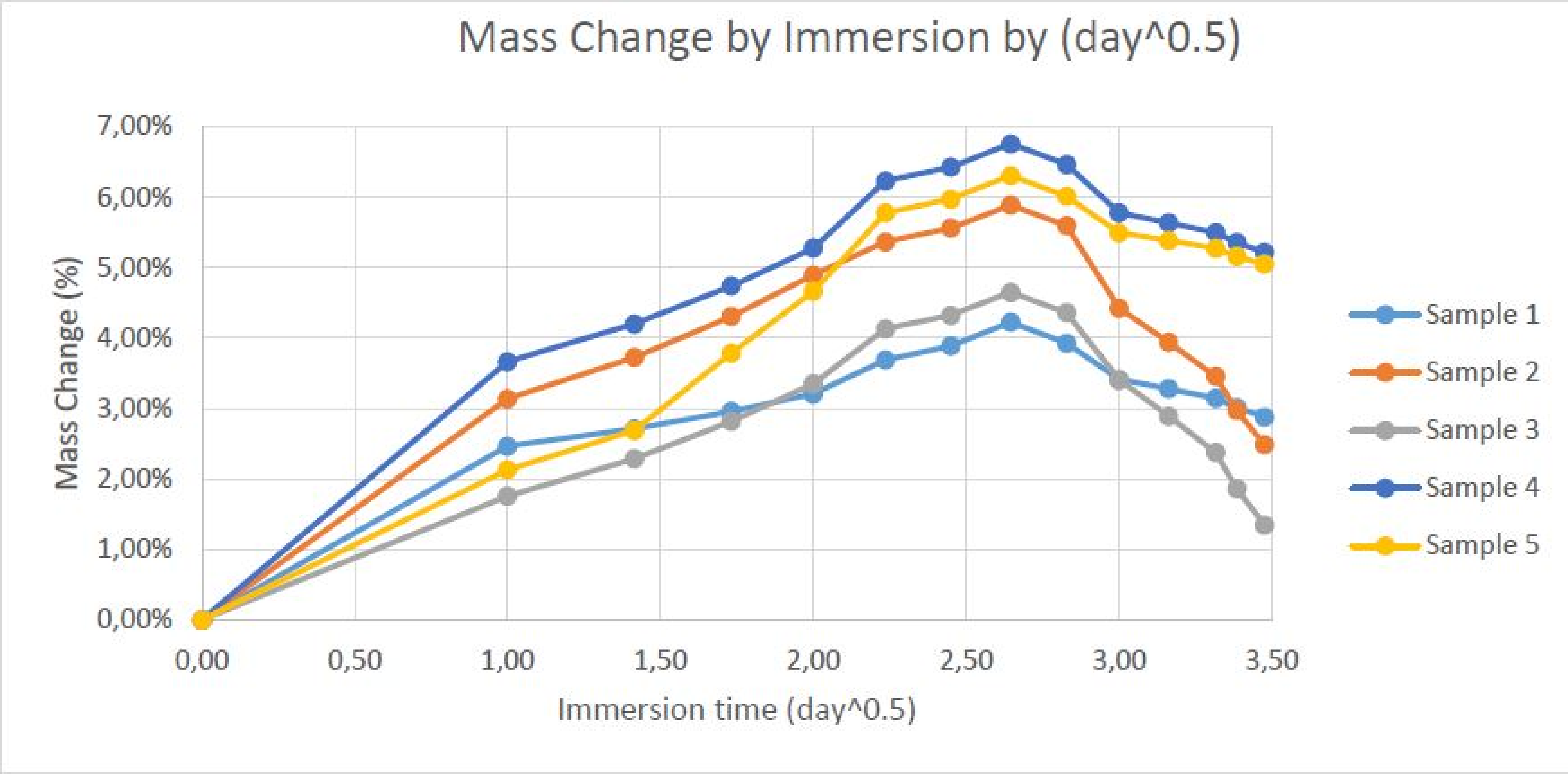
Ageing of Polyester Composite

- Results > 100C° Mass change (%) by time (day^0,5)



Ageing of Polyester Composite

- Results > 130C° Mass change (%) by time (day^0,5)



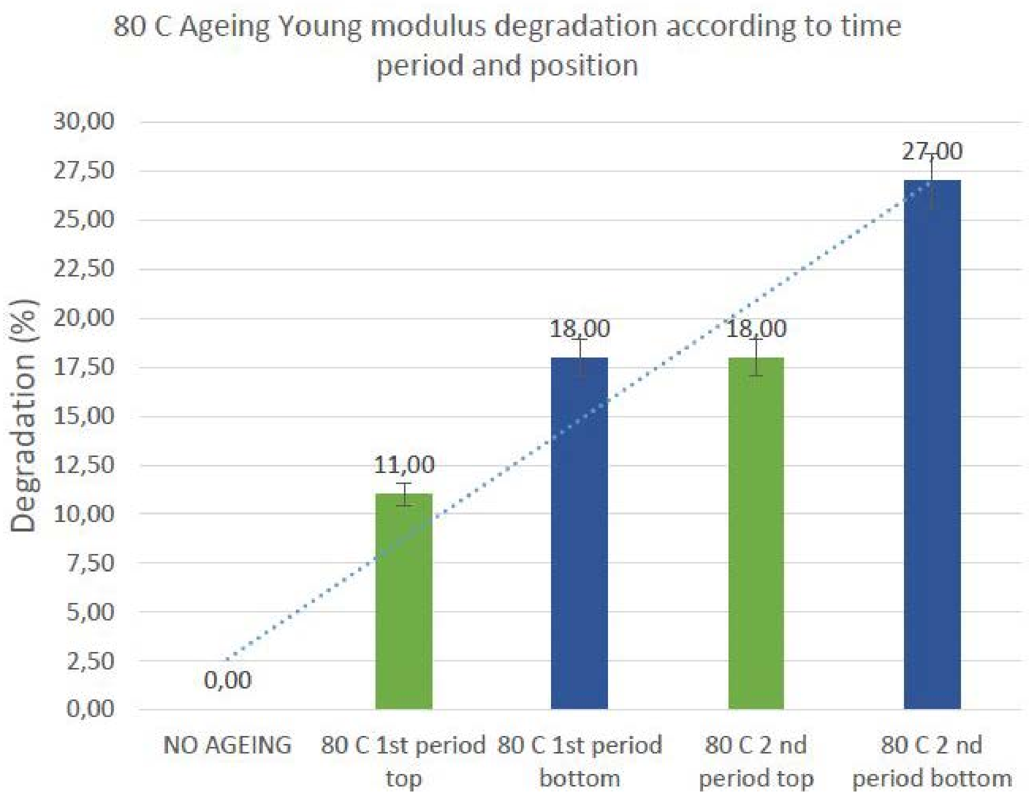
Mechanical Behavior of Aged Composites

- Preparation & Testing

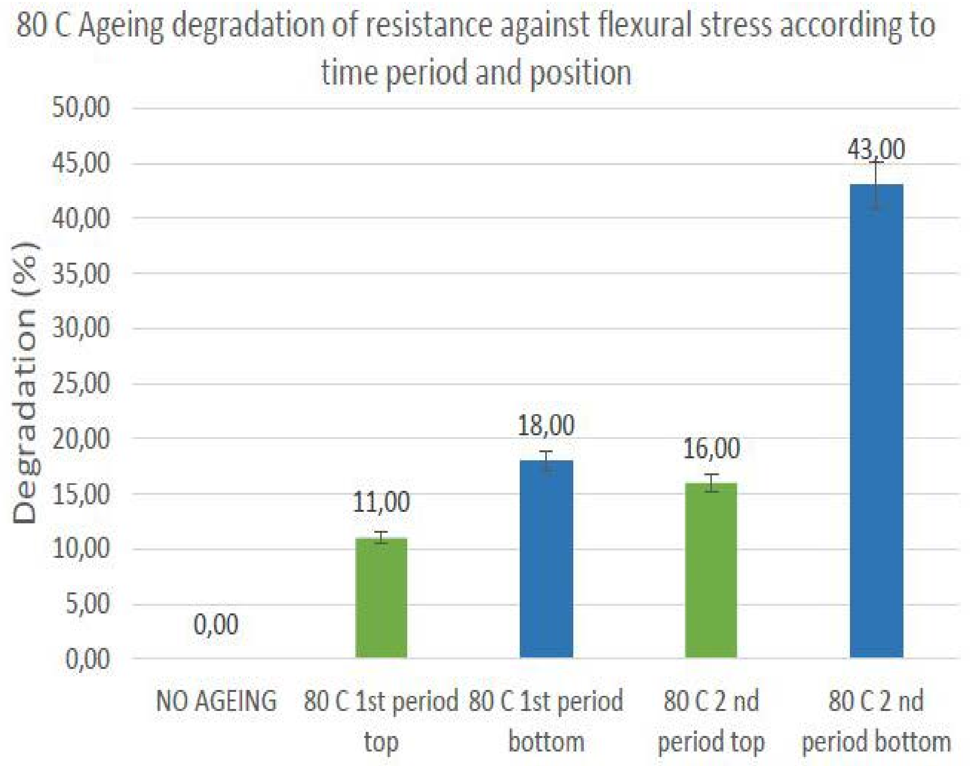
Mechanical Behavior of Aged Composites

- Results > Change of Young modulus and resistance against flexural stress at 80C°

Modulus



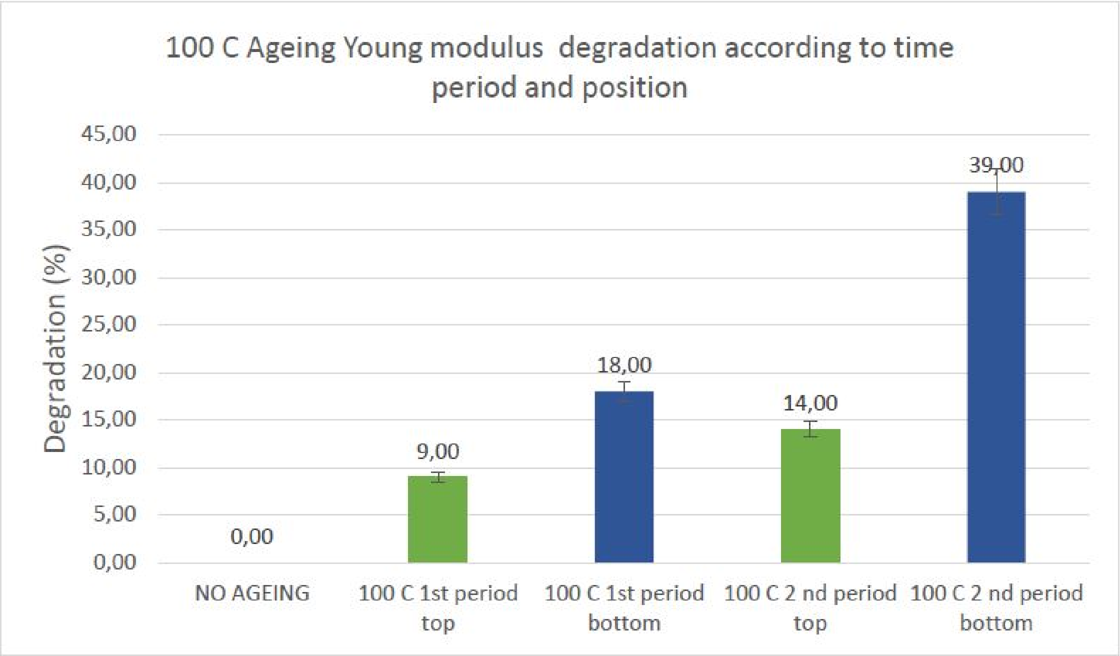
Flexural resistance



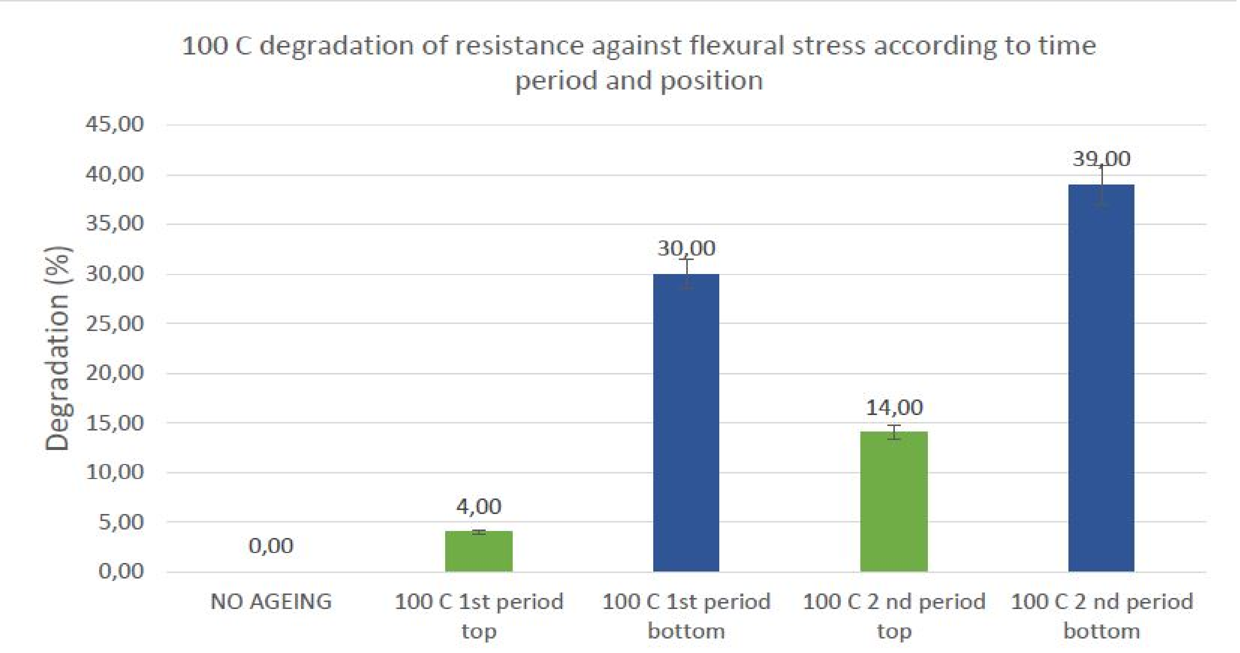
Mechanical Behavior of Aged Composites

- Results > Change of Young modulus and resistance against flexural stress at 100C°

Modulus



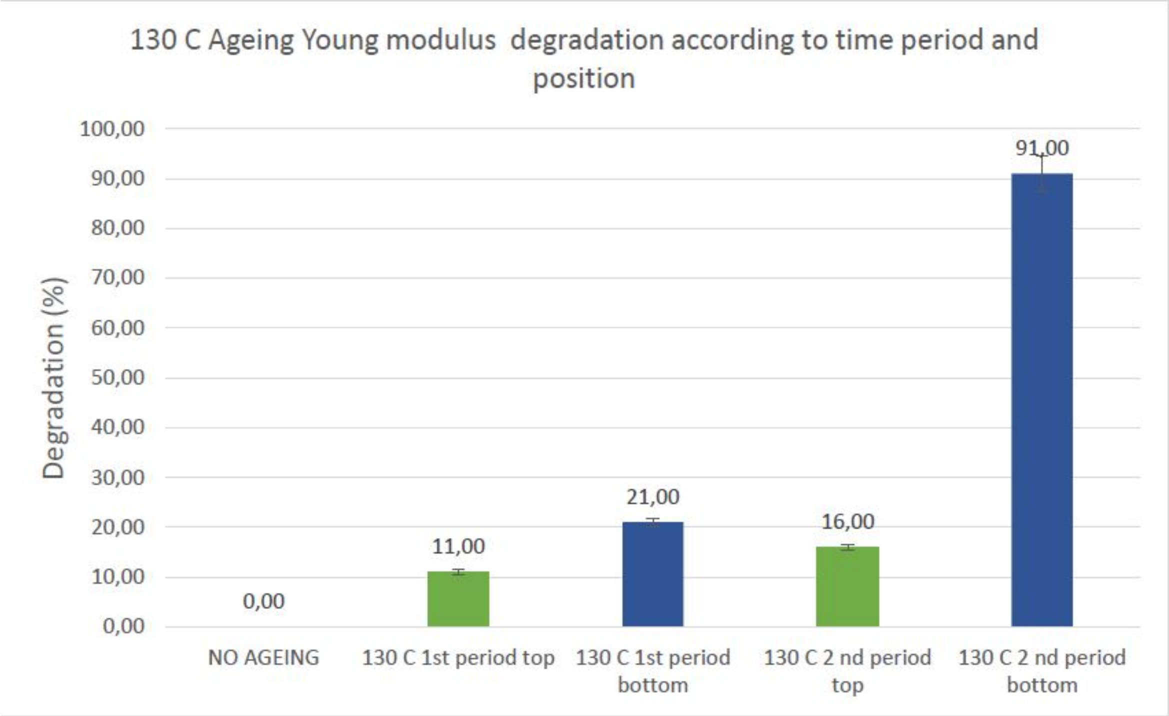
Flexural resistance



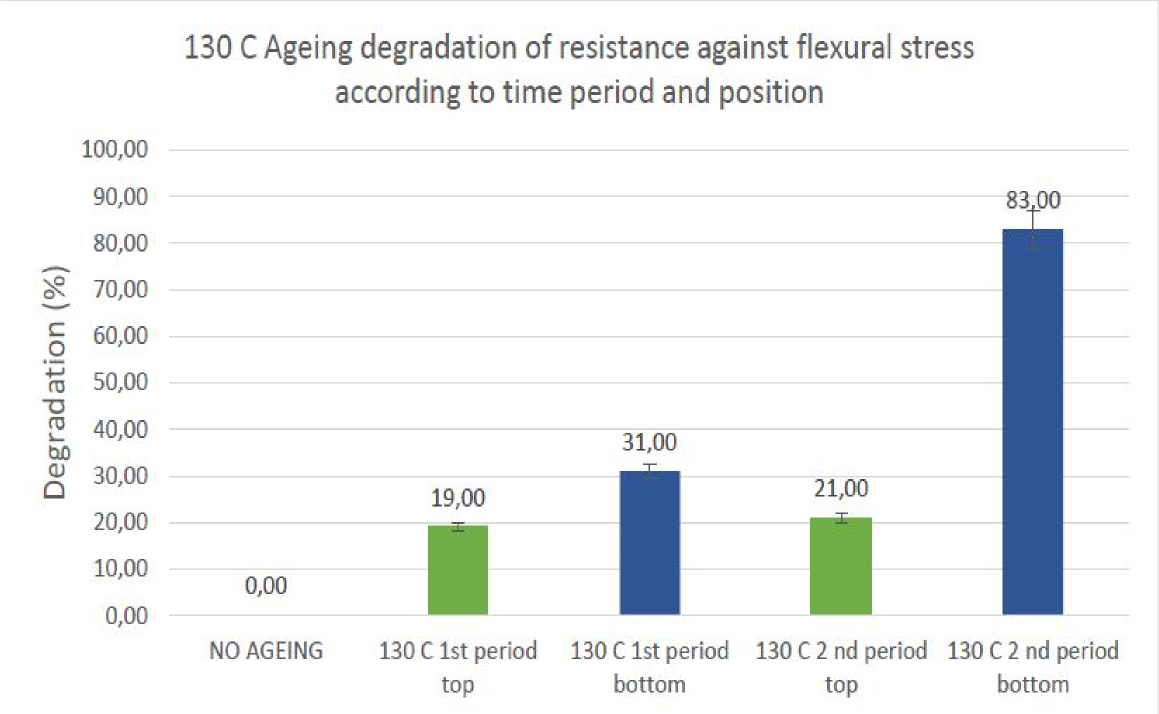
Mechanical Behavior of Aged Composites

- Results > Change of Young modulus and resistance against flexural stress at 130C°

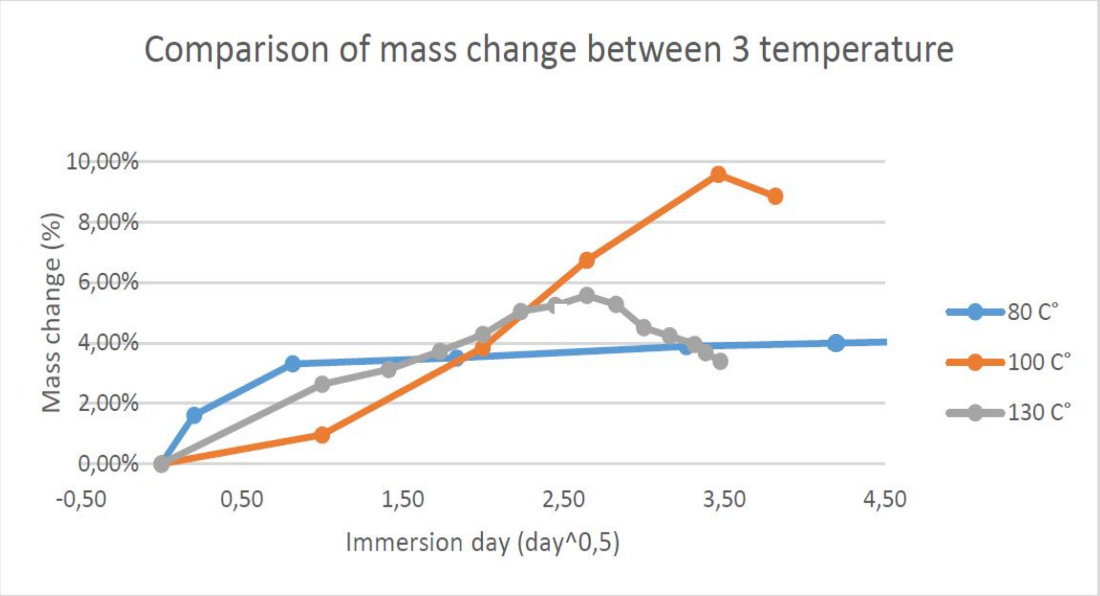
Modulus



Flexural resistance



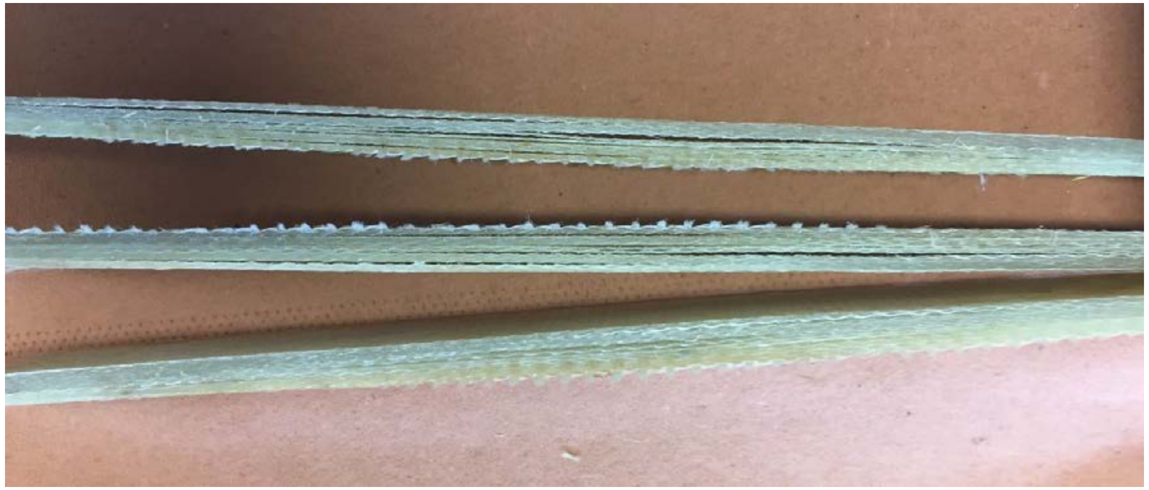
Analysis of the Results



Mass change

- Effect of the temperature

- Effect of the time



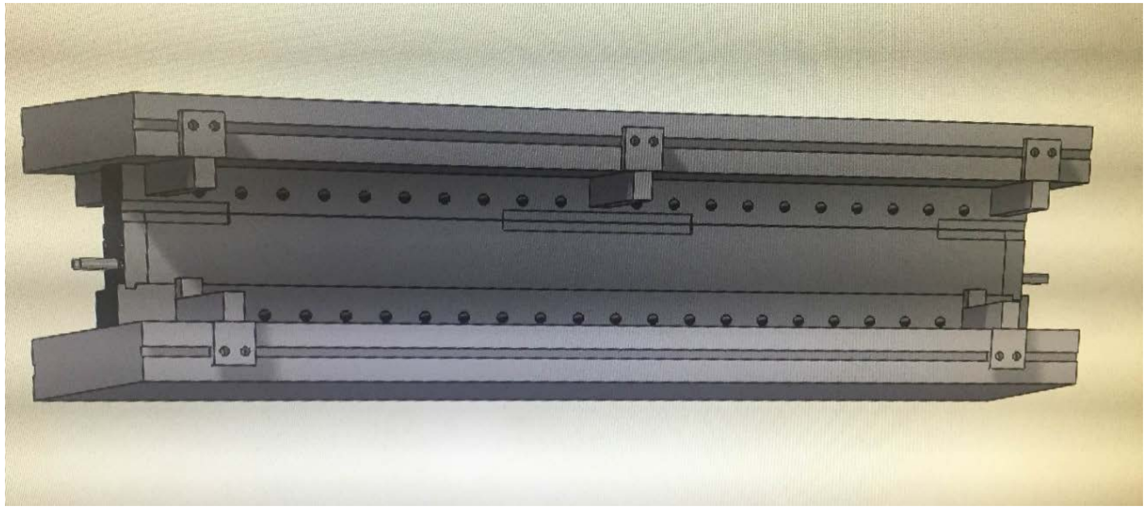
Conclusion

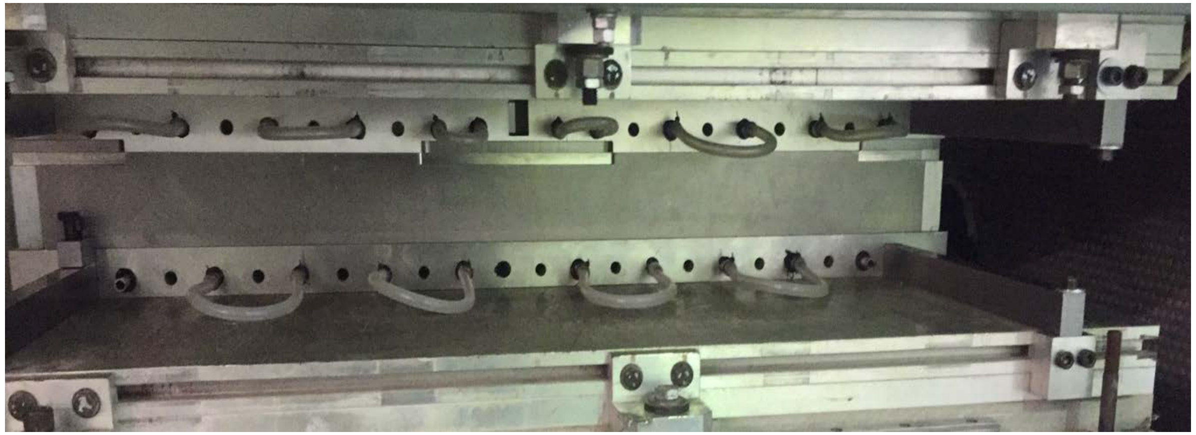
- Concerning the study shows that at the thermal effect, an increase in temperature changing the damage to the structure and causes a decrease in its mechanical properties.

- Experiment shows that the time is a factor influences differently with different temperatures about degradation of the material.

Future Work

- Thermo-mechanical recycling
- İnvestigation of convenience of the method





Thank you...

Questions ?