In-service materials performance

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Influence of magnetic cork particles on the thermal properties of epoxy resin

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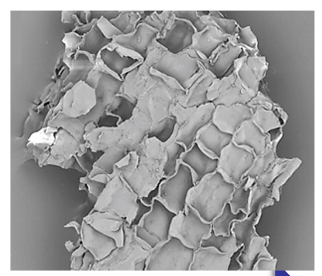
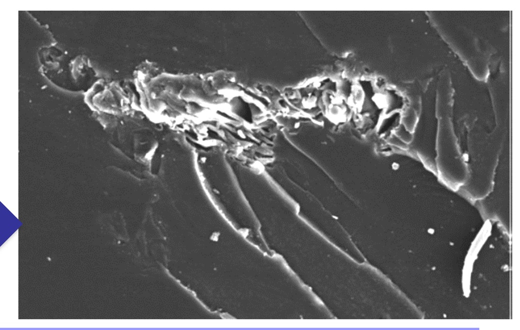
Cork:

- It is a biological material.
- It may be described as a homogeneous tissue of thin-walled cells.
- It reveals an alveolar structure, similar to a honeycomb.
- Cork has a good impact behaviour due to its cell structure disposition, giving a damping effect.



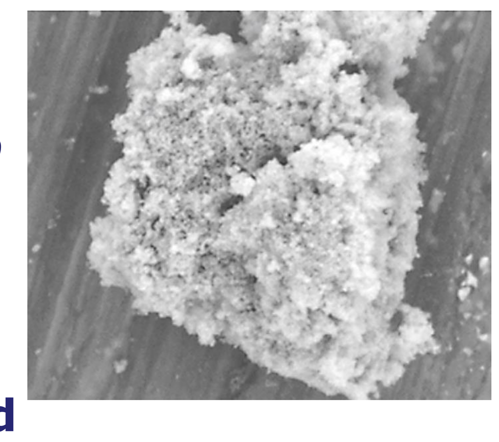
Filler for brittle resins



Composites Part B, 114 (2017) 299-310

Magnetic cork particles P201730993 and PCT/ES2018/070519

Wood Sci Technol, 54/4 (2020) 869–889



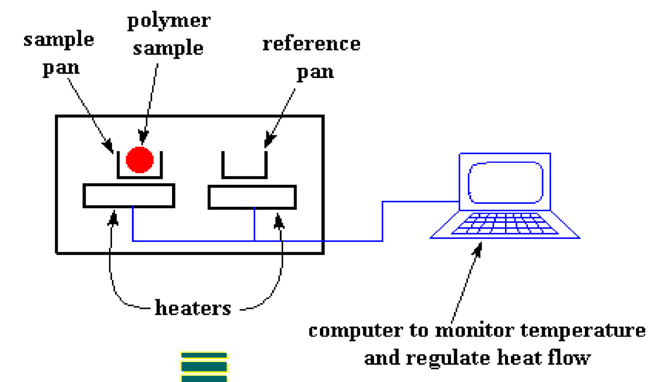
To manufacture functionally graded joints using magnetized cork microparticles (PAT354/2019).

This research aims to study the influence of magnetic cork particles on the thermal properties of epoxy resins, comparing magnetic to non-magnetic particles.

EXPERIMENTAL PROCEDURE

Araldite 1564 + Aradur → 3405 (100:36) and 5003 (100:20)

\+ Cork or Magnetic cork (1 and 5 v/v %) 38-53 µm and 75-125 µm → Sonication processes → 8 - 8.5 mg mix

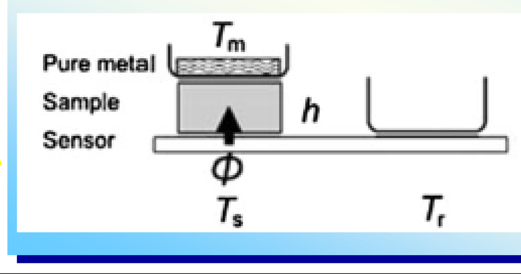


Hardener 3405 Cured for 8 h at 80 ºC

Hardener 5003 Cured for 2 h at 80 ºC

2[4] factorial design was used to check which of the variables have the greatest influence.

Thermal Conductivity from 28 to 38 ºC at 0.5 ºC/min



$$\lambda = \frac{\phi\, h}{\Delta T\, A}$$

$$\lambda = \frac{1}{\left(\frac{1}{S_G} - \frac{1}{S_S}\right)} \frac{h}{A}$$

- **Non-Isothermal method (20 ºC/min)** from 0 to 200 ºC

T_g

- **Non-Isothermal method (5, 10, 15 and 20 ºC/min)** from -20 to 250 ºC

MFK model

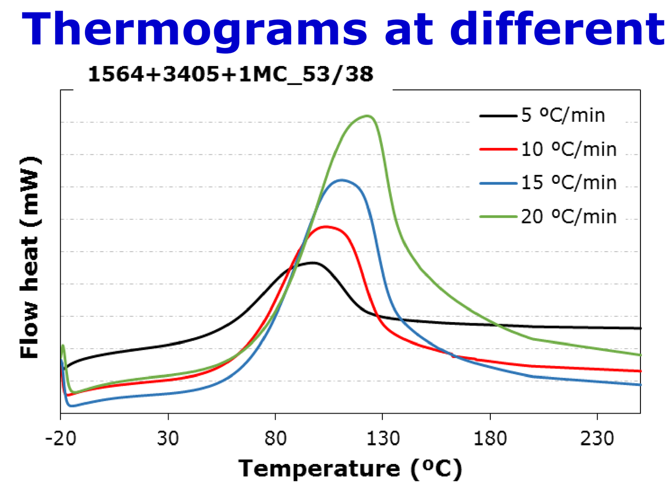
Activation energy depends on conversion degree

Kissinguer model

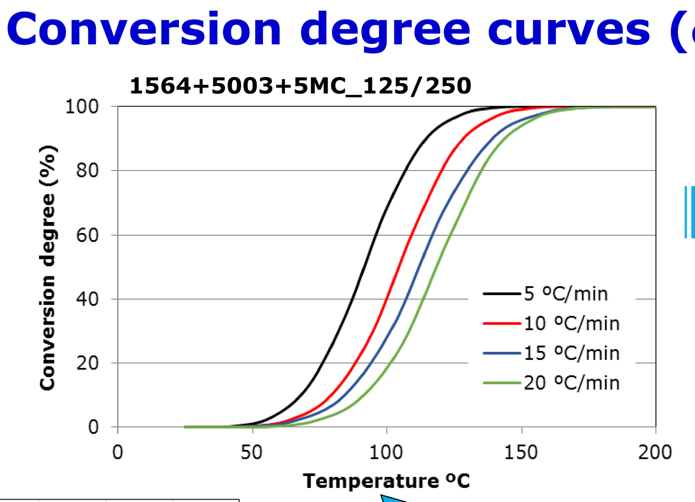
RESULTS

Kinetics - MFK

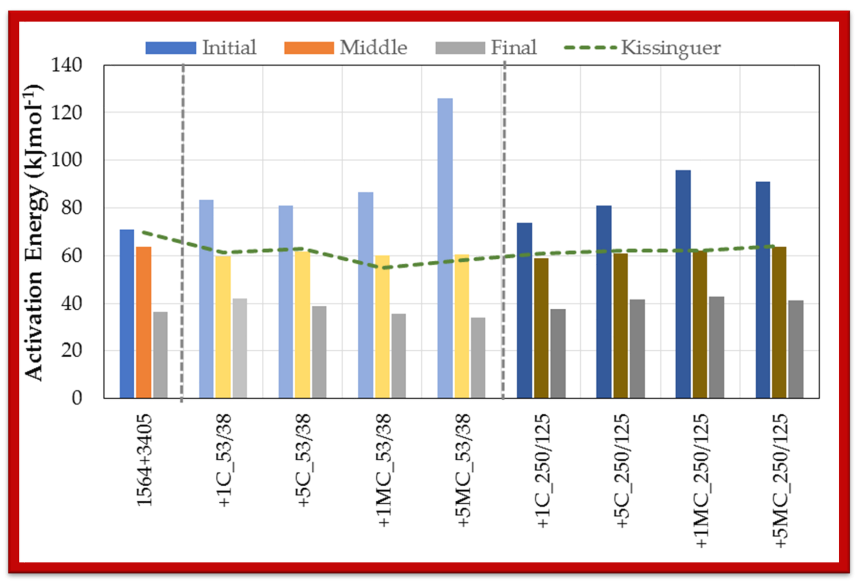
Thermograms at different rates

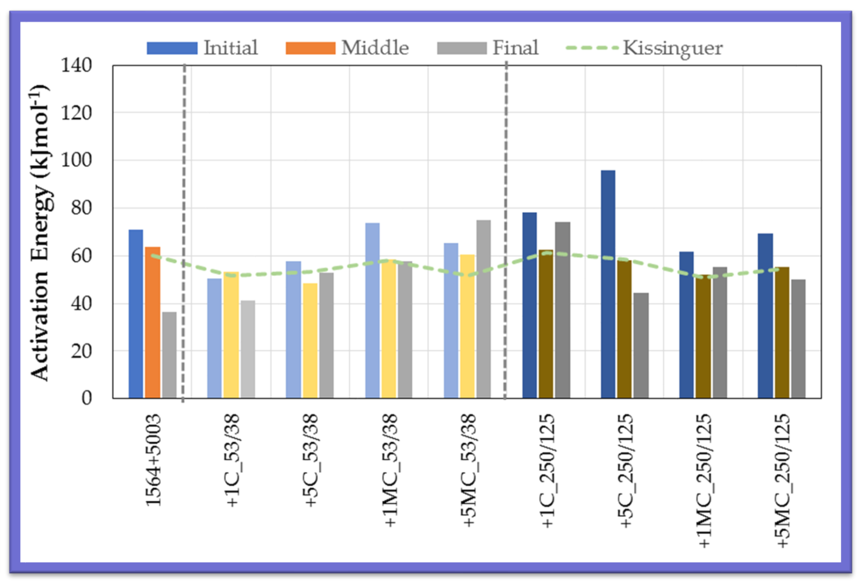


Conversion degree curves (α)

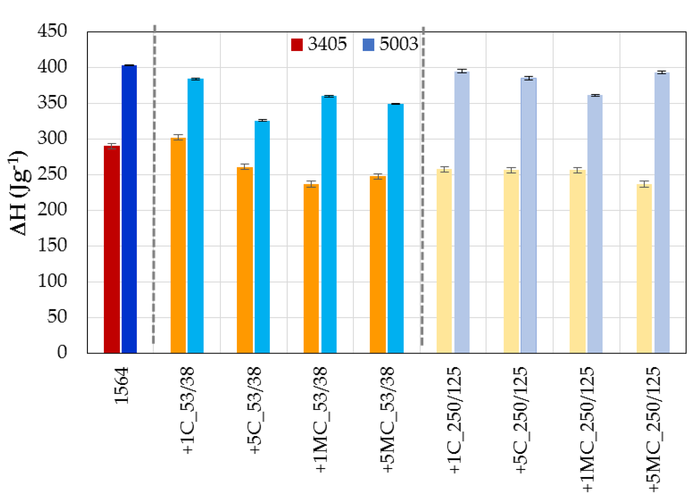


Activation energy



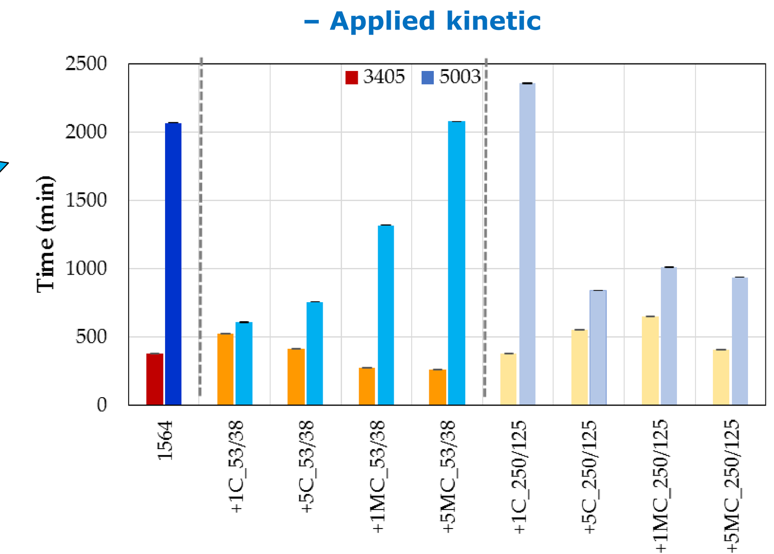


ΔH_{Total}



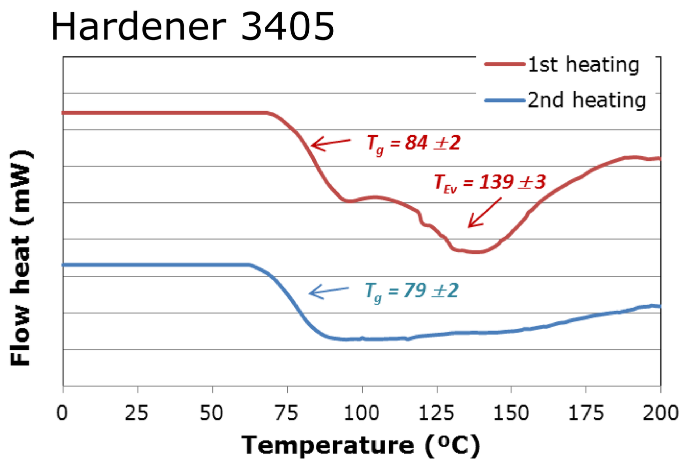
$$\alpha = \frac{\Delta H_{at\ predetermined\ time}}{\Delta H_{Total}}$$

Cured isothermal simulating - Applied kinetic



T_g

Hardener 3405



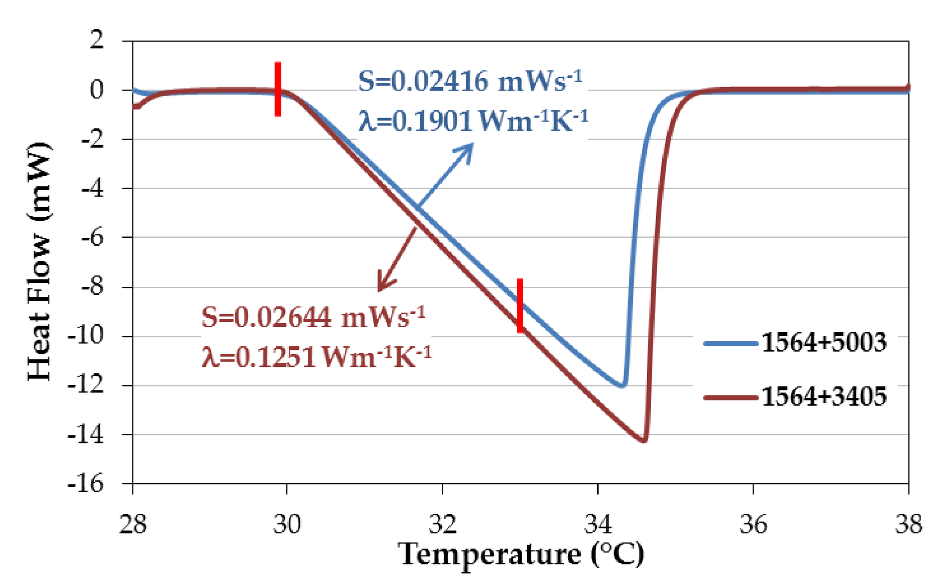
	2nd heating	
	Tg (ºC)	Step mW
1564-5003	116.64	-1.03
+1C 53/38	114.78	-1.12
+5C 53/38	112.99	-1.03
+1MC 53/38	114.00	-0.77
+5MC 53/38	115.52	-1.14
+1C 250/125	116.22	-1.07
+5C 250/125	110.31	-1.04
+1MC 250/125	111.56	-0.09
+5MC 250/125	113.03	-0.61
1564-3405	79.98	-1.06
+1C 53/38	79.53	-0.88
+5C 53/38	79.00	-0.36
+1MC 53/38	80.06	-0.22
+5MC 53/38	78.48	-0.62
+1C 250/125	76.95	-1.08
+5C 250/125	79.45	-0.94
+1MC 250/125	78.64	-1.58
+5MC 250/125	75.33	-0.14

114±2 ºC (hardener 5003)

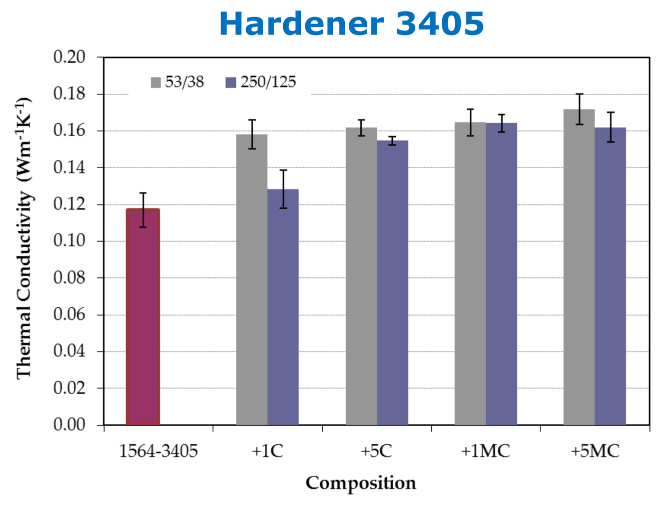
79±2 ºC (hardener 3405)

There is enthalpy of relaxation on first heating for resin with hardener 3405 and for resin and composites with hardener 5003. Evaporation only occurs when hardener 3405 is added.

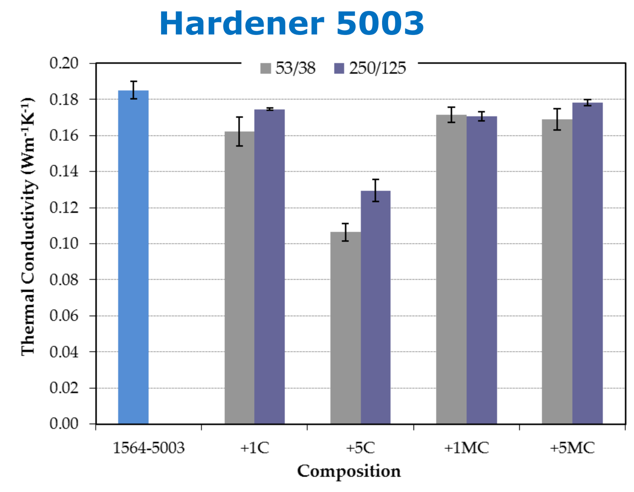
Thermal conductivity



Hardener 3405



Hardener 5003



CONCLUSIONS

- Hardeners are significantly different, both in curing conditions and in the properties obtained. Total enthalpy of curing (ΔH_T), thermal conductivity (λ) and T_g are higher when hardener 5003 was used. This is due to its chemical composition, the choice of one or the other will depend on sought mechanical properties.
- According to factorial design, the factor that most influences on the T_g and the ΔH_T is the use of hardener 5003. However, in the λ the factor with the greatest influence is the use of magnetic cork, together with the interaction between cork magnetic, higher percentage of particles and hardener 5003.
- The most influential factor on initial activation energy and middle (similar to Kissinger activation energy) is the use of hardener 3405; followed by the interaction between hardener and particle size. As long as hardener 5003 is the most influential factor for the final activation energy.