This project has received funding from the Clean Sky 2 Joint Undertaking (JU) under grant agreement No 887104.

Innovative test methodology for shelf life extension of carbon fibre prepregs

MANIFICA
CARBON FIBRE RECYCLING PROCESS

WP2 : *Life extension of prepregs*

Constance Amaré*, Olivier Mantaux, Arnaud Gillet, Matthieu Pedros, Eric Lacoste*

I2M BORDEAUX
université de BORDEAUX

easn
ecoDESIGN and Sustainable Productivity

Plan

1. **Outdated prepregs**: Context & current recertification

2. **MANIFICA WP2** : Comprehension & simplification

3. **Preliminary results** on a type of prepreg

4. **Conclusions & Perspectives**

1.1 Context

➔ **Prepregs** are widely used by aircraft manufacturers.

- Small variations in the fibre and resin ratios of the final material
- Simplified shaping

➔ **Unused and uncured** prepreg waste

- Expiry of shelf life
- Expiry of out life

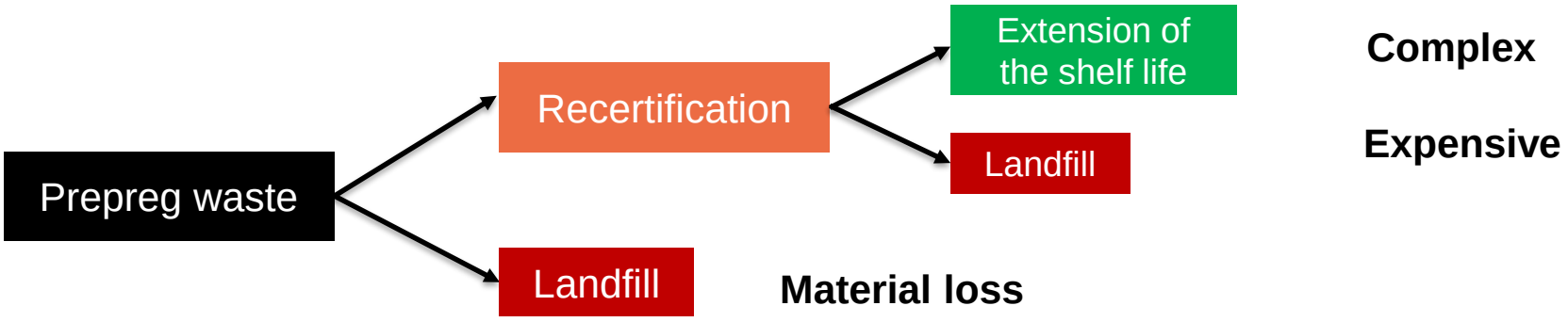
+ Covid crisis : different manufacturing organization, **stocks**

1.1 Context

➔ **Expiry cases**

- Minimum batch orders: **> than required**.
- Process time ≈ expiry date at room temperature
- **Covid crisis** : production differed

➔ **Current recertification** method



1.2 Current method

➔ Different quality points to **control a prepreg**

- Processability
- Physicochemical tests
- Mechanical properties
- Defects detection

➔ **Current recertification** : Complete certification procedure !

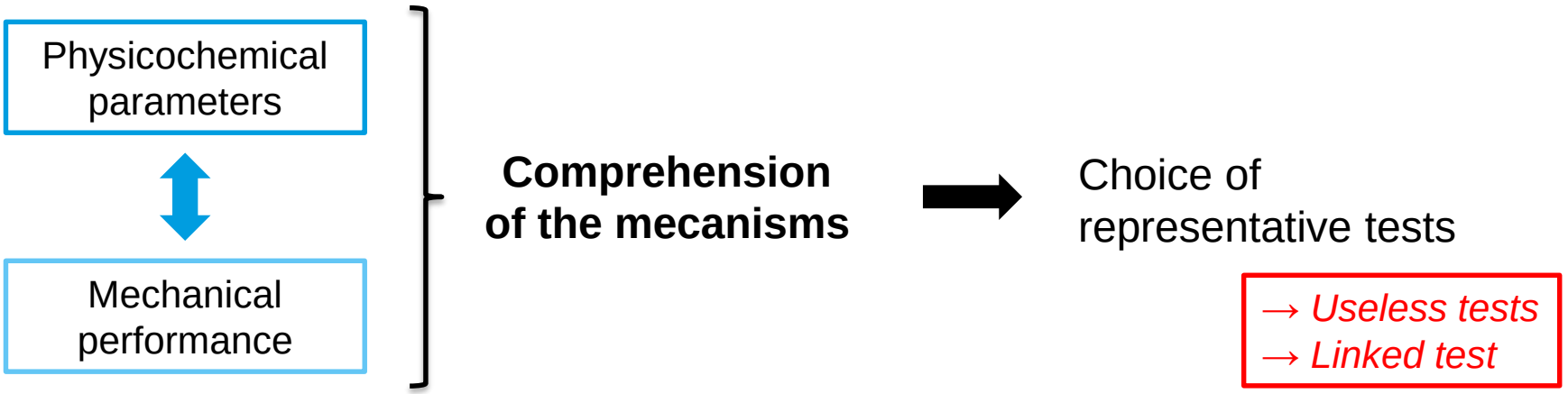
- ✓ Flow
- ✓ DSC
- ✓ DMA
- ✓ Peel
- ✓ Volatiles
- ✓ Resin/Fibre ration
- ✓ Tensile 0°
- ✓ Tensile 90°
- ✓ ILSS
- ✓ Honeycomb Tack
- ✓ Tack test
- ✓ Tensile test on AFP Wick

1.3 Introduction

MANIFICA
CARBON FIBRE RECYCLING PROCESS

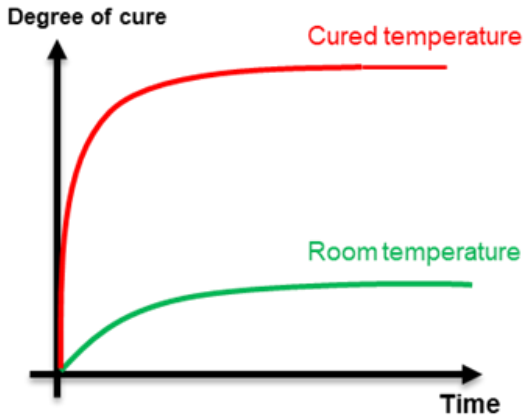
➔ **WP2** of the MANIFICA project
- › Simplified method to extend the shelf life of prepregs
- › Develop **new reuse scenarios** to avoid landfilling

➔ **MANIFICA** methodology



2.1 Polymerization advancement during storage

- A prepreg is in **an unstable state**
  - Advance of the reaction over time
  - Storage at -18° C to minimize the reaction



- Physical parameters to be controlled :

Rheological behavior	Degree of cure	Chain mobility	Resin composition and quantity
• Gel point and resin viscosity	• Enthalpy of reaction	• Glass temperature	• Consumption of functional groups

2.2 Selected tests & materials

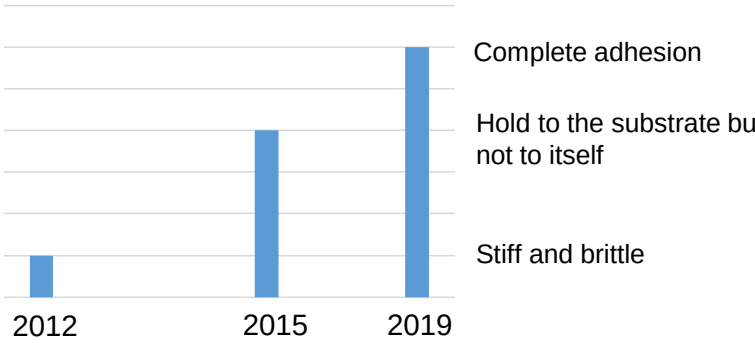
Type of tests	Parameter	Method	Standard
Processability	Tack	*"Tack test"*	NF L17-461
Physicochemical	Degree of cure	DSC	ISO 14322:2018
	Glass temperature		ISO 11357-2:2020
	Volatile content	Mass measurement of an uncured prepreg before and after its cure cycle	NF EN 2558
Mechanical	Tensile properties	Tensile test	NF EN 2561
	Compression behaviour	Pure bending	*test developed by I2M*
	Interlaminar properties	ILSS test	NF EN 2563

3.1 Preliminary results : **physico-chemical**

Tested material : UD Hexcel carbon/epoxy ; 3 expiry dates : 2020, 2015, 2012

➔ **“Tack”** test

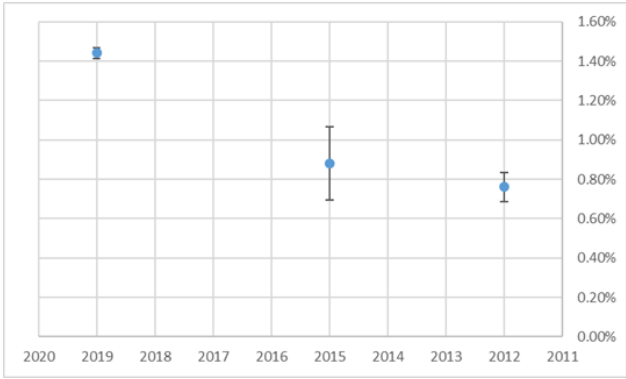
- Ability of a prepreg to adhere to a substrate.
- Determination of a “grade” of tack



Aging effect : No adherence between plies and support

➔ **Volatile content**

- Progress of the polymerization reaction
- Mass measurement of an uncured prepreg before and after its cure cycle



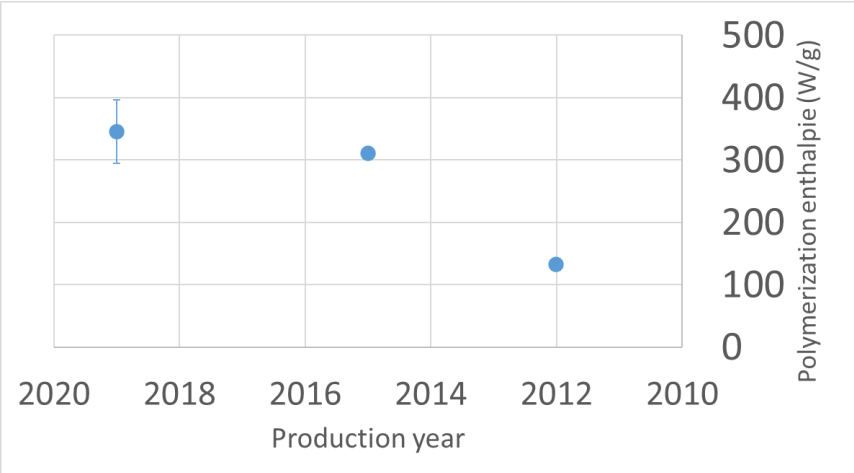
$$\%volatiles = \frac{m_{before} - m_{after}}{m_{before}} \times 100$$

Aging effect : Decrease of the volatile content

3.1 Preliminary results : **physico-chemical**

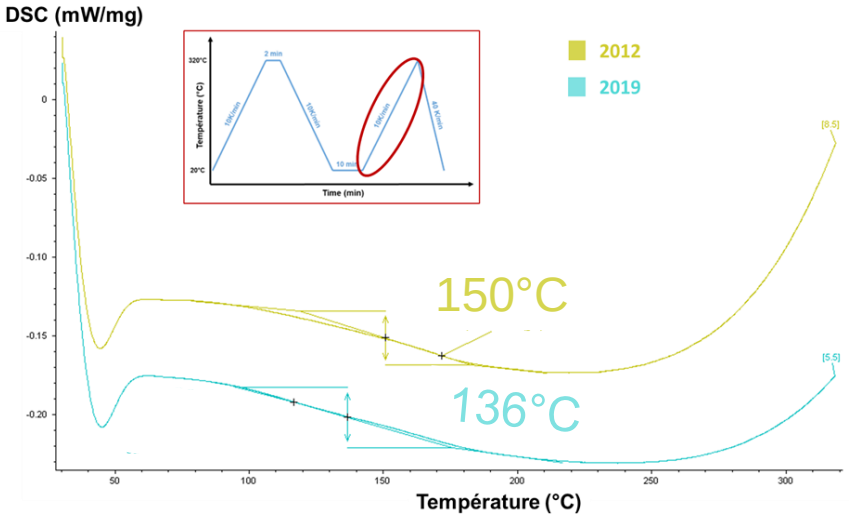
➔ **DSC** measurements

› Polymerization enthalpy



Aging effect : Decrease of the enthalpy *(> 5 years)*

› Glass temperature of the cured sample

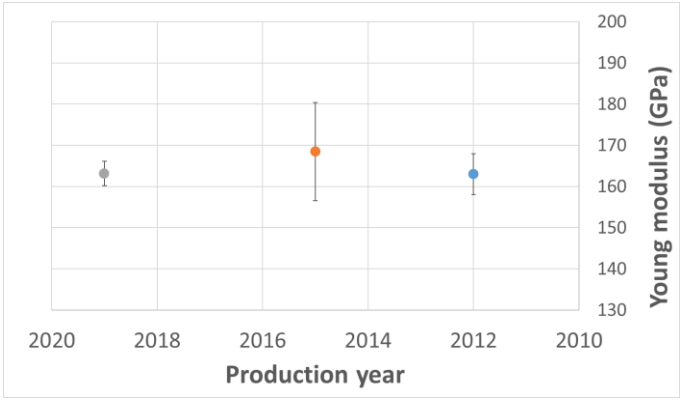


Aging effect : Increase of the glass temperature *(14°C in 7 years)*

3.2 Preliminary results : **mechanical properties**

➔ Tensile test 0°

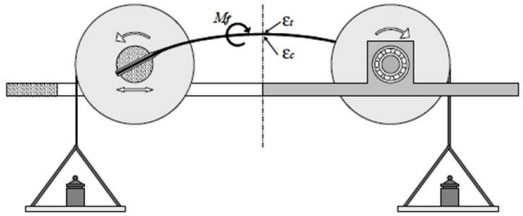
- Young modulus
- Tensile strength

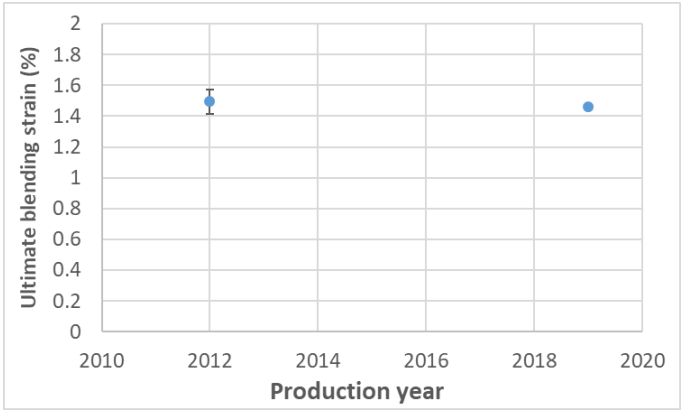


No aging effect : No modification of tensile properties at 0°

➔ Pure bending

- Compression behaviour



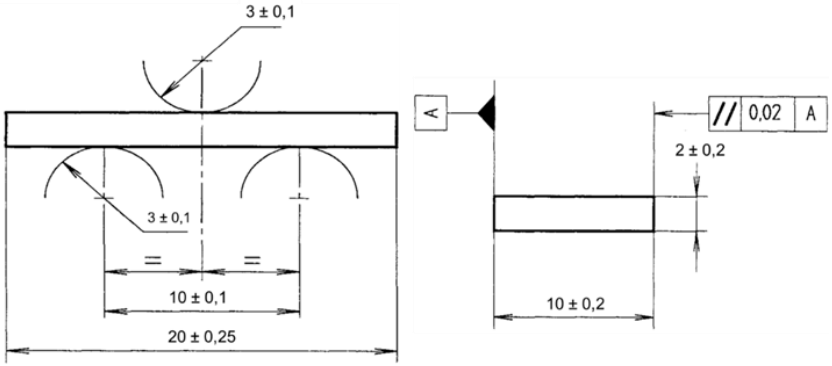


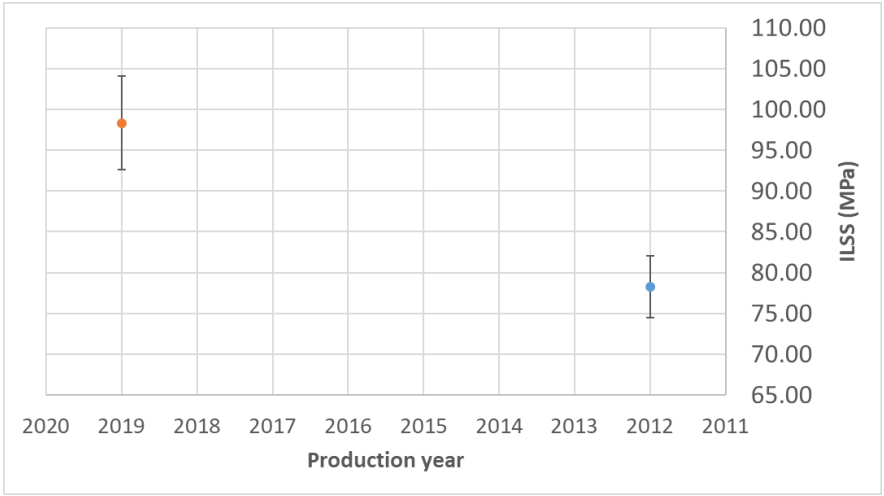
No aging effect : No modification of bending properties

3.2 Preliminary results : **mechanical properties**

➔ **ILSS** test

› Interlaminar shear strength





Aging effect : Decrease of the ILSS

3.3 Review on the first tests

➔ **Parameters not changing with long storage**

- Young modulus at 0°
- Tensile strength at 0°
- Compression behavior

➔ **Parameters changing with long storage**

- Tack (processability)
- Glass temperature
- Enthalpy of the matrix during polymerization
- Volatile content
- ILSS

4. Conclusion & Perspectives

- **Loss of processability** may be the main problem
  - Inter plies adhesion
  - More defects
- Some parameters do not evolve
  - Possible simplification of the recertification
- MANIFICA WP2 **is investigating**
  - Aeronautical prepregs at different expiry dates
  - Physicochemical, mechanical and processability tests
- Reused scenarios
  - Aeronautical applications
  - Non-aeronautical applications
  - Recycling

➡ **Less carbon waste sent to landfill**

This project has received funding from the Clean Sky 2 Joint Undertaking (JU) under grant agreement No 887104.

MANIFICA
CARBON FIBRE RECYCLING PROCESS

Thank you for your attention !