FORTAPE PROJECT: FROM LAB-SCALE IMPREGNATION LINE TO PRE-INDUSTRIAL MANUFACTURING OF GF AND CF-BASED UD TAPES FOR TRANSPORTATION INDUSTRIES

MARGOT CHAUVET - CANOE
THIBAUT SAVART – ARKEMA

AA-6THIC3-21

ARKEMA
INNOVATIVE CHEMISTRY

CANOE

A R&D CENTER

EXPERT IN CHEMISTRY & MATERIALS

IN POLYMER FORMULATION

IN MANUFACTURING PROCESS

FOR THE DEVELOPMENT OF INNOVATIVE PRODUCTS

COMPOUNDS

CARBON FIBER

THERMOPLASTIC PREPREG

ADDITIVE MANUFACTURING

ACRYLIC RESIN INFUSION

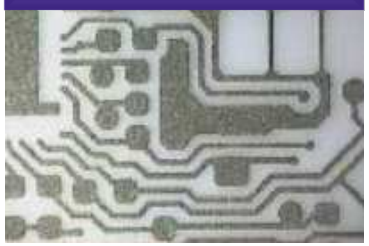
DEPARTMENTS

TP AND ELASTOMER FORMULATION AND TRANSFORMATION

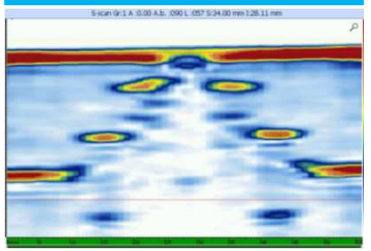
SPINNING AND CARBON

TP PREPREG AND COMPOSITES

SURFACE TREATMENT



CHARACTERIZATION AND NDT

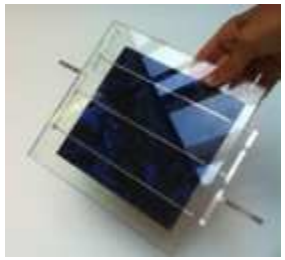


ADDITIVE MANUFACTURING AND ROBOTIZED PROCESS

CALIBRATED 3D FILAMENT MADE FROM PEKK AND GRAPHENE FOR FDM (DIAMETER 1.75 MM)

SELF LUBRICATING BEARING OBTAINED BY FDM TECHNOLOGY STARTING FROM GRAPHENE-CHARGED PEKK FILAMENT

COMPOSITE PART OBTAINED BY AUTOMATIC DEPOSITION (AFP) OF ¼'' WIDE TP PREPREG TAPE (PEEK/CF)



PV MODULE OBTAINED BY ENCAPSULATING A PHOTOCURABLE ACRYLIC-BASED RESIN USING A 6-AXIS ROBOT

THERMOPLASTIC AND ELASTOMER FORMULATION

MAJOR AXIS OF DEVELOPMENT

- COMPOUND
- SHORT FIBER REINFORCED COMPOSITE
- BIO-BASED POLYMER LIGNIN
- NATURAL CHARGE REINFORCED COMPOSITE
- ACRYLIC-BASED COMPOSITE RECYCLING BY CRACKING
- RECYCLED POLYMER
- FOAM

WORKSHOP FOR PLASTICS

MATERIALS TESTING AND NDT

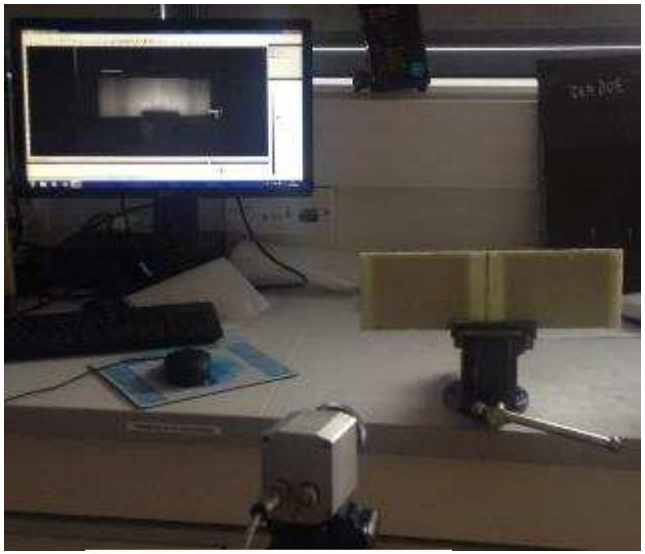
TRANSVERSE AXIS

- PHYSICOCHEMICAL TESTS
- MECHANICAL TESTS
- OPTICAL OBSERVATIONS
- RHEOLOGY
- AGEING
- INFRARED THERMOGRAPHY
- ULTRASOUNDS
- EN 4179 CERTIFICATIONS LEVEL 3 AND LEVEL 2

FACILITIES

MECHANICAL CHARACTERIZATION FROM 5N TO 250 KN

ULTRASONIC C-SCAN TANK

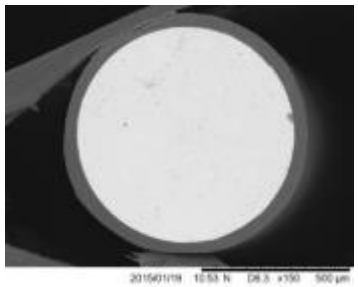


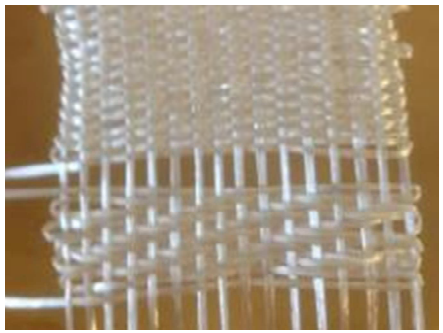
INFRARED THERMOGRAPHY (UT2 COSAC)

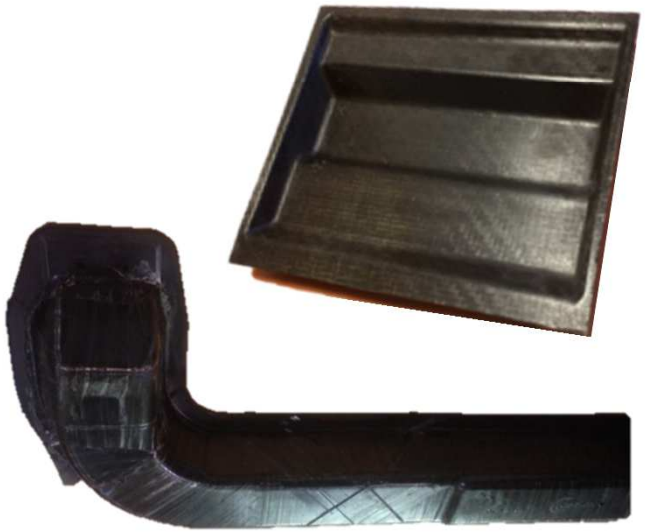
COMPOSITE AND THERMOPLASTIC PREPREG

MAJOR AXIS OF DEVELOPMENT

- FIBER CASING BY EXTRUSION
- BICOMPONENT FIBER
- THERMOPLASTIC PREPREG
- THERMOPLASTIC UD TAPE
- THERMOPLASTIC DRY PREFORM
- INFUSION, RTM, THERMOCOMPRESSION
- THERMOPLASTIC PULTRUSION
- FILAMENT WINDING







THERMOPLASTIC PREPREG

PILOT AND PRE-INDUSTRIAL LINES FOR MANUFACTURING OF THERMOPLASTIC PREPREG TAPES

PRE-INDUSTRIAL LINE CHARACTERISTICS :

- 3 IMPREGNATION TECHNOLOGIES VALIDATED ONTO PILOT LINE
- MANUFACTURING SPEED : UP TO 40 M/MIN
- SIMULTANEOUS IMPREGNATION OF (UP TO) 32 CALIBRATED TAPES → SEVERAL T/YEAR
- TAPE WIDTH : ¼'', ½'', 15MM, 23MM, 1'', 50MM … 400MM
- DRY PREFORM AND READY-TO-USE TAPE

MATERIALS

- POLYMERS : CONVENTIONAL AND SPECIFIC POLYMERS, EVEN HT°
- FUNCTIONAL ADDITIVES : PROCESSING AID, PIGMENT, FLAME RETARDANT, NANOCARBON CHARGE
- REINFORCED FIBERS : CARBON, GLASS, FLAX, HEMP, BASALT, POLYMER…

IMPREGNATION TECHNOLOGIES AT CANOE

Technologies & Materials Dev + 1st scale-up

New Technologies & Materials Dev

Pre-Industrial scale-up

IMPREGNATION TECHNOLOGIES AT CANOE

Installed in August 2017 at CANOE Facilities in Lacq (64, FR)

- 1000m² building
- Formulation/Dev/Fabrication/Characterization
- More Visibility

More Industrial and Chemical Environment

- Production/Delivery Facilities
- Possibility to visit it more as a “Firm” than a “Lab”
- 1st trials → Scale-up (2 lines in parallel)

IMPREGNATION TECHNOLOGIES AT CANOE

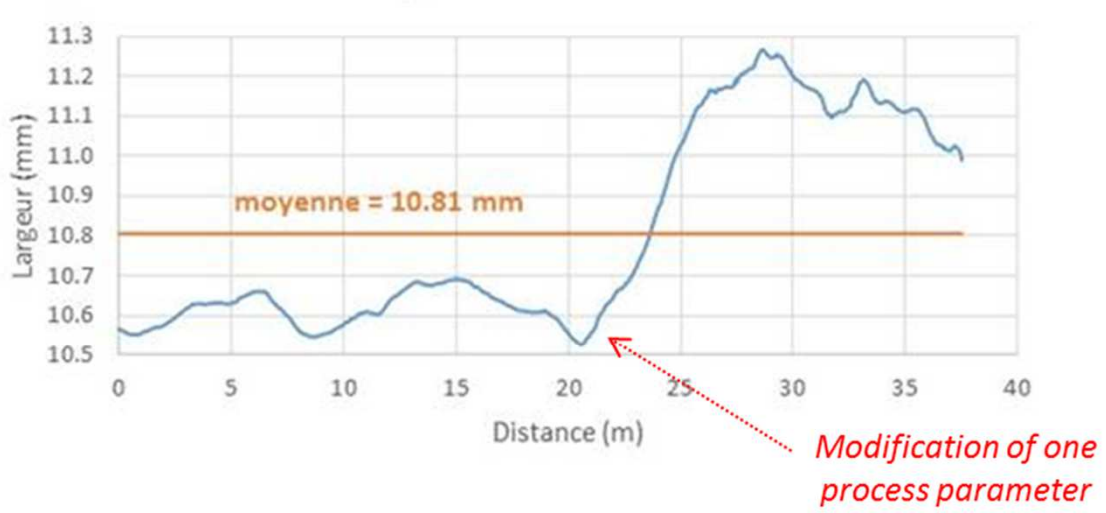
IN-LINE CONTROL

- TEMPERATURE
- IMPREGNATION QUALITY
- DIMENSIONS (WIDTH, THICKNESS)

BETTER QUALITY

BETTER PRODUCTIVITY

INDUSTRIAL-LIKE PROCESS CONTROL



FORTAPE PROJECT

- **FORTAPE : Efficient and optimized integrated system for the manufacturing of complex parts based on unidirectional fibre tapes with the minimum use of material and energy for automotive and aeronautical industries.**

H2020: 02/2015-02/2018

CTAG Centro Tecnológico de Automoción de Galicia · canoe Composites / Organic Nanostructures · ARKEMA INNOVATIVE CHEMISTRY · EADS · IRT JULES VERNE · Ford · Fraunhofer ICT – IMM

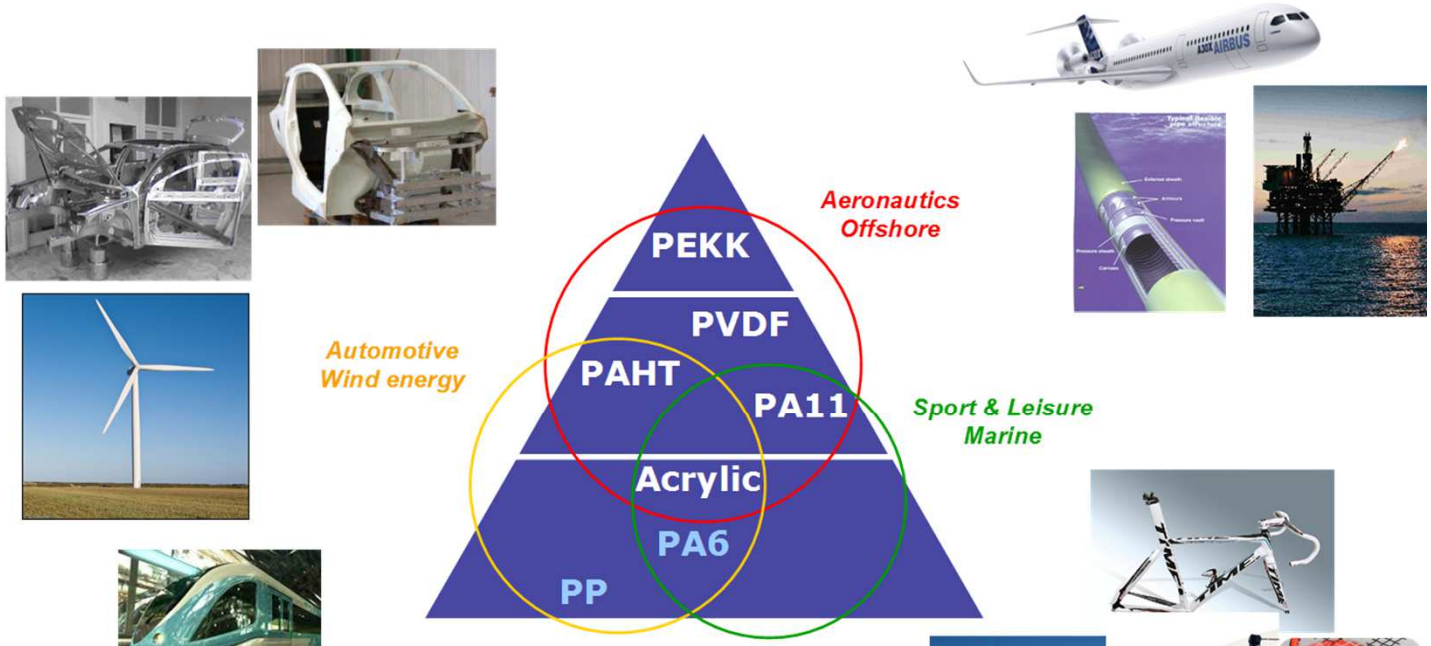
New polymer formulations
New impregnation and heating technologies
Improved quality with reduced energy

FROM POLYMERS AND FIBERS…

…..TO FINAL COMPOSITE DEMONSTRATOR

ARKEMA IN THERMOPLASTIC COMPOSITES

Offering a broad range of TP matrices suitable for most markets



KEPSTAN BY ARKEMA

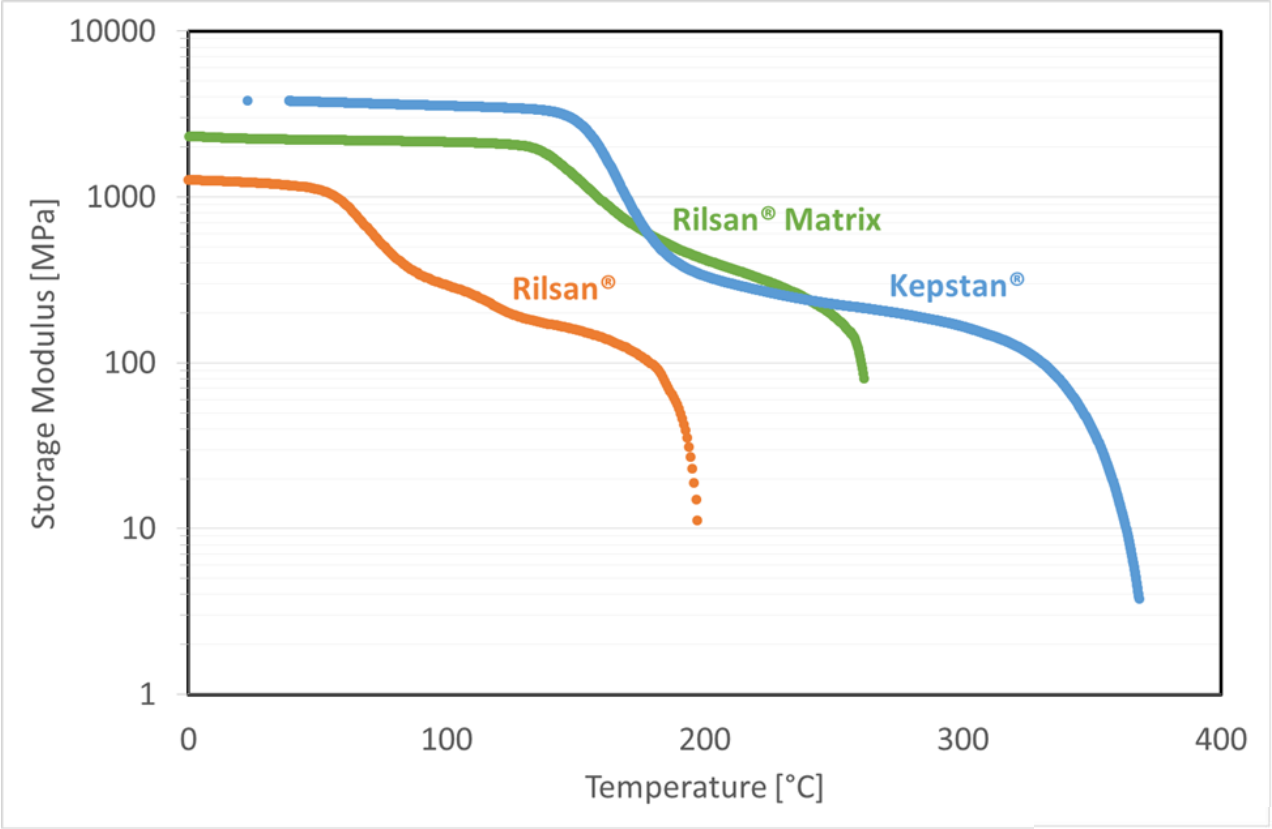
Courtesy Coriolis Composites

ELIUM BY ARKEMA

POLYSTRAND VIA ARKEMA

COMPARISON WITH OTHER ARKEMA PRODUCTS

- Resin initially designed for the automotive market.
- But high Tg and high crystallinity (fire resistance) might allow to meet aerospace technical requirements.



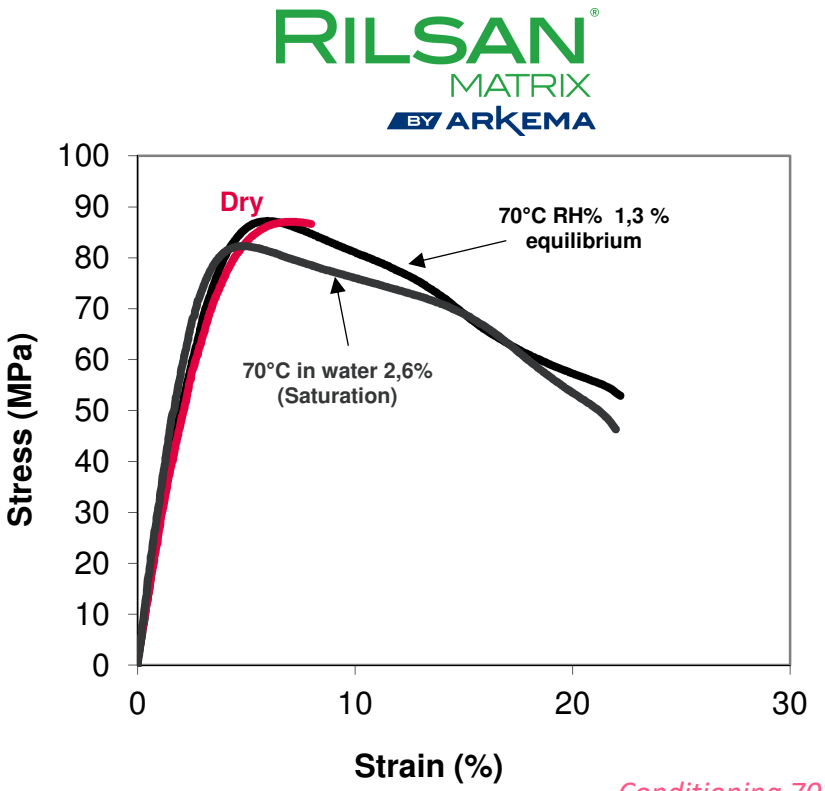
KEY PROPERTIES : 2 GRADES (AND MORE UP TO COME)

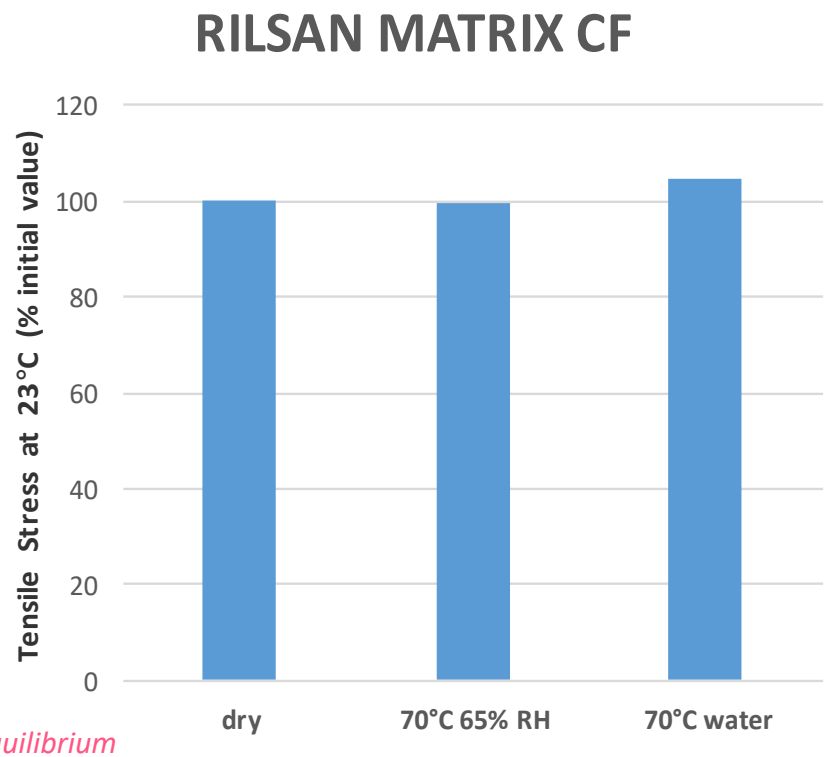
Grades	Tf	Tg (DSC)	Tα (DMA)	Tc	ΔH	T_{onset} (ATG)	RT Modulus	200°C Modulus	Water uptake
Units	℃	℃	℃	℃	*J/g*	℃	*MPa*	*MPa*	%
RILSAN® MATRIX BY ARKEMA	**275**	**140**	**158**	**240**	**60**	**450**	**2200**	**420**	**2.6**
Higher Tg	**285**	**160**	**178**	**250**	**57**	**450**	**2500**	**620**	**2.6**

KEY PROPERTIES : 2 GRADES VERY DIFFERENT FROM OTHER PPA

PPA	Tf	Tg (DSC)	Moisture uptake % (saturation in water)	Stress at yield	Strain at yield	Modulus
Units	℃	℃	%	*MPa*	%	*MPa*
RILSAN® MATRIX BY ARKEMA	**275**	**140**	**2.6**	**87**	**7**	**2200**
PA6	**220**	**50**	**8.5**	**22**	**55**	**2000**
PA66	**265**	**60**	**9.5**	**65**	**3**	**3000**
6/6T	**295**	**105**	**>6**			
66/6T	**315-325**	**90-100**	**6.5**			
6I/6T	**325**	**130**	**5**			

MOISTURE EFFECT ON RILSAN MATRIX™ (NEAT RESIN) AND RILSAN MATRIX CF COMPOSITE



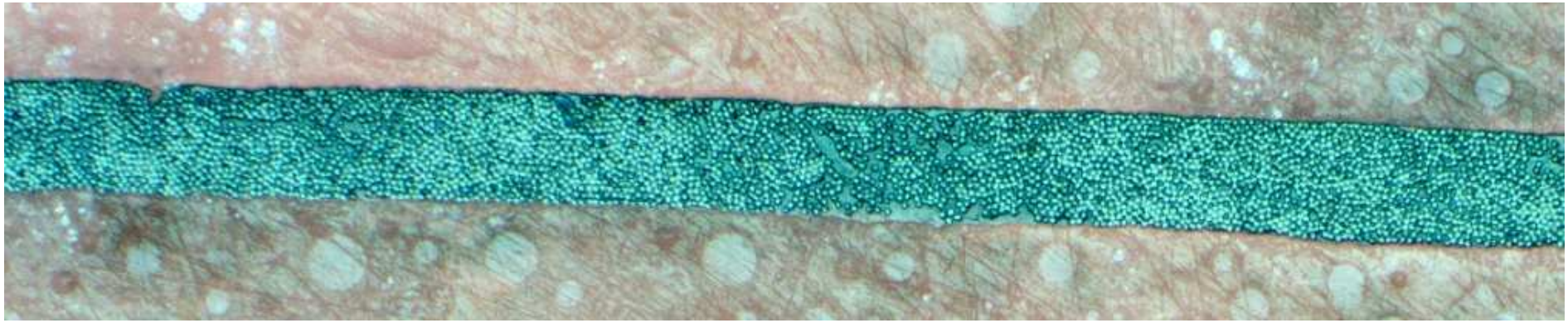


Conditioning 70°C/65% RH : equilibrium
Conditioning in pure water: saturation

- **Stability of the resin explains the stability of RILSAN MATRIX CF composite**

FORTAPE RESULTS

- **LOW POROSITY level in the tape and final composite part**

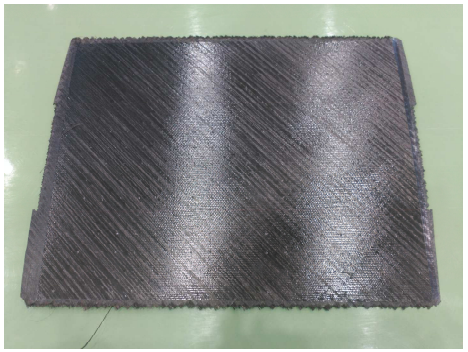


- **Development of NOVEL HEATING TECHNICS**
  - REDUCTION of energy consumption
  - IMPROVEMENT of the efficiency of heating technics thanks to the formulation of polymers
- **NO (organic) solvent = GOOD working conditions (industrial)**
- **VERY LOW level of SCRAPS → NO SLITTING, NO SPLICING, Process is quickly stable (few meters lost)**
- **GOOD IMPACT OF CALIBRATION SYSTEM on tape morphology**

FORTAPE PROTOTYPES FOR AERONAUTICS

Flat sheets for mechanical properties

- AFP processing at FIDAMC (Getafe, SPAIN)
- With in-situ consolidation
- With and without autoclave post-consolidation



Airplane Window Frame

- AFP processing
- With in-situ consolidation
- Thermostamping
  - (Pre)Heating
  - Heating of the mold
  - Stamping
  - Part release

FORTAPE PROTOTYPES FOR AUTOMOTIVE

Simulation of local reinforcement of composite part for automotive

- FORD, CTAG
- Door structure reinforced with UD tapes

→ 4 to 5 zones to be reinforced

Development of part processing

- CTAG → small press
- Fraunhofer + IRT JV → tape placement + bigger press

Door structure (Grupo Antolin → FORD)

- Done at IRT Jules Verne
- Local AFP placement of GF/PP patch
- Mold placed into a vertical press
- Overmolding using reinforced PP
  - Talc
  - Long Glass Fibers

RILSAN® MATRIX CF TAPES: PRELIMINARY DATAS CF TORAY T 700S

RILSAN® MATRIX BY ARKEMA

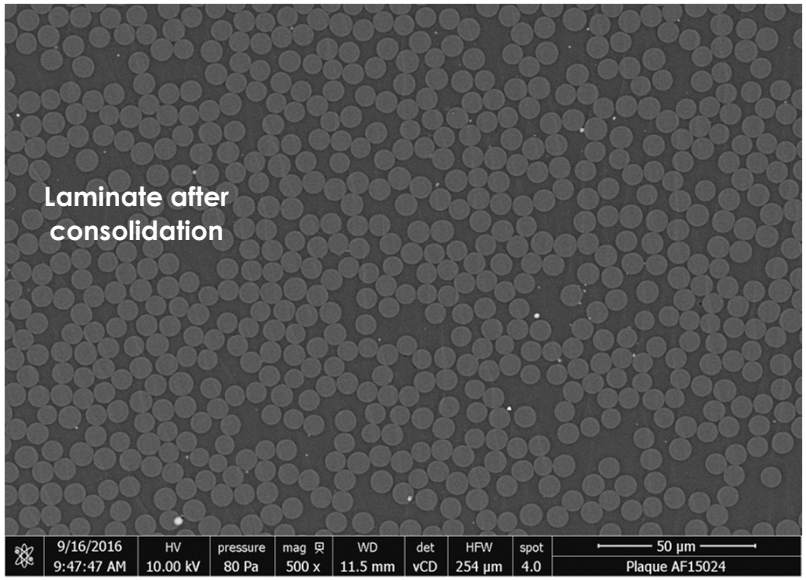
RILSAN MATRIX CF

100% UD

50% fiber volume ratio

thickness 130~250 µm

width ~ ¼" & ½"& 1"



LAMINATE PROPERTIES	Fiber angle	RILSAN MATRIX
Fibre content vol%		50
Tensile modulus 0° (GPa)	0°	120
Tensile stress 0° (MPa)	0°	2075
Max elongation 0° (%)	0°	1.7
Shear modulus +/-45° (GPa)	+/-45°	2883
In plan shear stress +/-45° (MPa)	+/-45°	78
Max shear strain +/-45° (%)	+/-45°	31
Transverse modulus 90° (GPa)	90°	6,9
Transverse stress 90° (MPa)	90°	39
Max elongation 90° (%)	90°	0,6
Flexural modulus (GPa)	0°	102
Max flexural strength (MPa)	0°	1542
Elongation (%)	0°	1.6
Flexural modulus (GPa)	90°	6,6
Flexural strength (MPa)	90°	83
Max elongation (%)	90°	1,4

QSP MOLDING FROM CORIOLIS PREFORM

- HT PA Rilsan Matrix synthesis for tapes manufacturing and injection molding at ARKEMA
- Tape manufacturing at ½'' at CANOE facilities
- AFP processing at Coriolis facilities
- QSP processing at CETIM facilities (heating, thermostamping, overmolding)

Overmolded
with Rilsan Matrix

ANY QUESTIONS ?

MARGOT CHAUVET - CANOE
THIBAUT SAVART – ARKEMA

AA-6THIC3-21

ARKEMA
INNOVATIVE CHEMISTRY