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C-PREG ®400 4.0

C-PREG® 400 is a heat and flame resistant prepreg, test FAR 25.853 exceeded. It is the ideal choice for high temperature applications.

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Description

C-PREG®400 4.0 is a high temperature, heat resistant prepreg developed for a wide variety of applications.
The special composition allows cure cycles between 165 °C and 300 °C. The cured composite has working temperature in oxidative environment up to 400 °C.
C-PREG®400 4.0 is easy to use and is processed in the same way as other common prepregs and can be shaped using traditional compression molding or vacuum bagging techniques.
C-PREG®400 4.0 effectively fills the void between existing prepreg systems and ceramic matrix composites, and can be used to produce thermal barriers, exhaust systems, engine parts and other components for high performance braking systems.

Key features

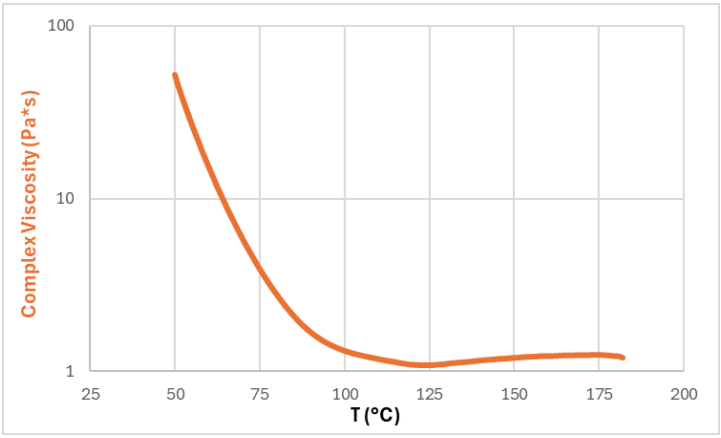
- Maximum service temperature up to 400 °C
- Suitable for autoclave, Out-of-Autoclave (OoA) cure processes
- Flexible cure characteristics between 165 °C and 300 °C
- High tack
- Easy to use prepreg
- Rated UL94-V0
- Compliance FAR 25.853 Appendix F
- Compliance MIL-STD-2031, 1991 Edition

Matrix properties

Measurement	Value
Cured resin density, g/cm^3	1,25 ± 0,01
Tack	4

*Tack: 1=low; 2=low-medium; 3=medium; 4=medium-high; 5=high

Rheological properties



Viscosity profile at 2°C/min

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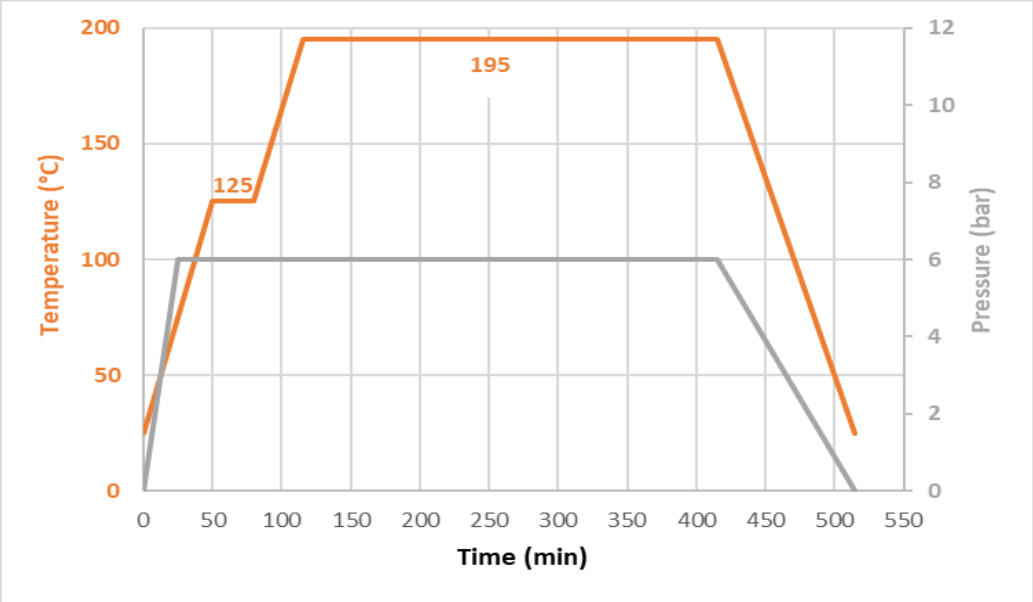
Curing process

Standard autoclave cure schedule

1. Apply full vacuum (1 bar)
2. Apply 6 bar autoclave pressure
3. Heat at 2 °C/min to 125 °C
4. Hold at 125 °C for 30 min
5. Heat at 2 °C/min to 195 °C
6. Hold at 195 °C for 300 minutes
7. Cool at 2 °C/min until room temperature



Alternative autoclave cure schedule

1. Apply full vacuum (1 bar)
2. Apply 6 bar autoclave pressure
3. Heat at 2 °C/min to 125 °C
4. Hold at 125 °C for 30 min
5. Heat at 2 °C/min to 180 °C
6. Hold at 180 °C for 300 minutes
7. Cool at 2 °C/min

Autoclave cure schedule for laminate thicknesses > 2,5 mm

1. Apply full vacuum (1 bar)
2. Heat at 2 °C/min to 135 °C
3. Hold at 135 °C for 120 min
4. Apply 6 bar autoclave pressure
5. Heat at 1 °C/min to 195 °C
6. Hold at 195 °C for 300 minutes
7. Cool at 2 °C/min

OoA cure schedule

C-Preg® 400 prepregs can be oven cured (OoA, no pressure – vacuum only).

1. Heat at 2 °C/min to 195 °C
2. Hold at 195 °C for 300 minutes
3. Cool at 2 °C/min until room temperature

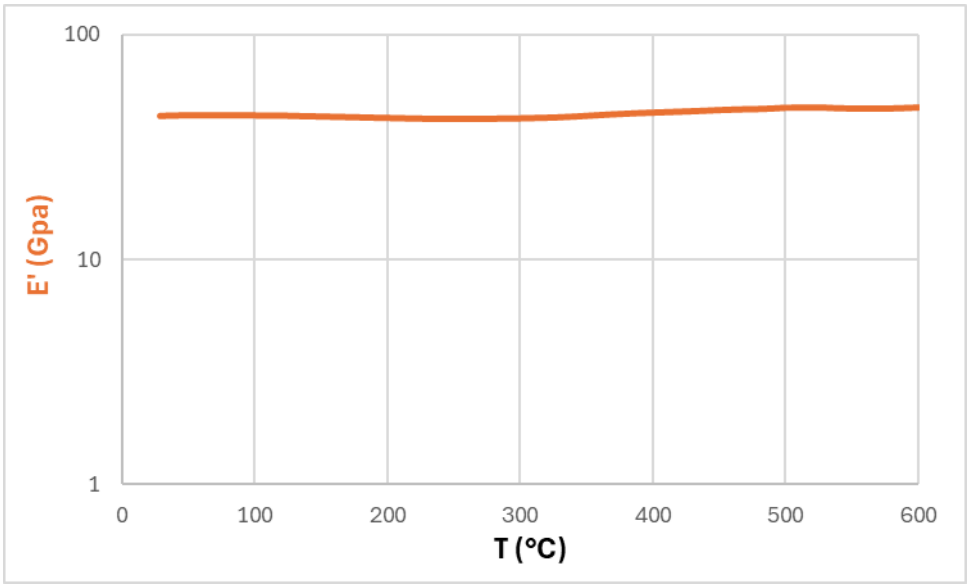
Vacuum all along the cure cycle.

Post cure is mandatory to achieve maximum thermal resistance.

Post cure schedules

Standard Post Cure Schedule		**Alternative Post Cure Schedule**
1. Heat at 2 - 3 °C/min to 170 °C 2. Heat at 0.3 - 0.4 °C/min to 245 °C 3. Hold at 245 °C for 10 hours 4. Cool at 5 °C/min to room temperature	OR	1. Heat at 2 - 3 °C/min to 170 °C 2. Heat at 0.3 - 0.4 °C/min to 300 °C 3. Hold at 300 °C for 3 hours 4. Cool at 5 °C/min to room temperature

DMA Trace (ASTM D7028)



C-PREG® 400 4.0 - CF200T(HS)- 43% cured and post cured according to standard cure and post cure schedules

Alternative cure schedule – improved aesthetic surface

It is possible to process C-Preg®400 at lower temperature, down to 165 °C, which obviously results in a partially incomplete curing. Components processed at 165 °C are self-standing (easy to be removed from the mold) but require additional attention during handling before the post curing treatment.
When curing @ 165 °C components should be post cured right away following the cure.

Autoclave cure schedule

1. Apply full vacuum (1 bar)
2. Heat at 2 °C/min to 125 °C
3. Hold at 125 °C for 30 min
4. Apply 6 bar autoclave pressure
5. Heat at 2 °C/min to 165 °C
6. Hold at 165 °C for 300 min
7. Cool at 2 °C/min

Post cure schedule

1. Heat at 2 - 3 °C/min to 170 °C
2. Heat at 0.3 - 0.4 °C/min to 205 °C
3. Hold at 205 °C for 10 hours
4. Cool at 5 °C/min to room temperature

ATTENTION: curing and post curing, according to standard process, must be done to reach thermal resistance of 400 °C.

Mechanical and physical properties - C-PREG® 400 4.0 - CF200THS-43%

Test were performed on 2 mm thick laminates cured at 195 °C and post cured according to standard post cure cycle.

Physical Properties	Unit	CF200T2HS
Fiber weave mass	g/m^2	200
Nominal cured ply thickness	mm	(0.20 ± 0.01)
Nominal Laminate Density	g/cm^3	(1.50 ± 0.03)
Nominal Fiber Volume Fraction	%	(48.4 ± 0.5)

Mechanical Property	Method	HS Twill 2/2
Test Temperature, °C		25 °C
Tensile Modulus, 0° GPa	ASTM D3039	50.5
Tensile Strength 0°, MPa	ASTM D3039	670
Flexural Modulus, 0° GPa	ASTM D790	40.2
Flexural Strength 0°, MPa	ASTM D790	283
ILSS 0°, MPa	ASTM D2344	15
Poisson coefficient (v)	ASTM D3039	0.024

Thermal Conductivity and Specific Heat							
Method	Temp [°C]	Specific Heat [J/(g·K)]		Thermal Diffusivity [mm^2/s]		Thermal Conductivity [W/(m·K)]	
		Media	STD	Media	STD	Media	STD
ASTM E-1461 DIN EN 821	50	1.20	0.00	0.26	0.00	0.45	0.01
	200	1.57	0.02	0.20	0.01	0.44	0.02
	300	1.54	0.01	0.18	0.00	0.38	0.01

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Fire resistance

Material tested: C-PREG®400 panel 1,5 mm thick with CF200T2HS
Autoclave cured and oven post cured according to the standard cure and post cure schedules

UL94 (2018 - 05): V0

Test criteria	V-0 requirement	C-Preg®400
Burning time of each individual test specimen (s) (after first and second flame applications)	≤ 10	0 - 1
Burning and afterglow times after second flame application (s)	≤ 30	0 - 1
Dripping of burning specimens	no	no
Combustion up to holding clamp	no	no

FAR 25.853 Appendix F Part 1(a)(1) (ii) to CS-25 .853 - 12 sec Vertical burning test

Properties	Test value	Acceptance criteria	Notes
Burn length (mm)	0	<203	
After flame time (s)	0	<15	
Drip flame time (s)	0	<5	No drips

FAR 25.853 Appendix F-Part IV: Heat Release Rate Test

Properties	Test value	Acceptance criteria
Maximum heat release rate (kW/m^2)	14.2	<65
Heat release over the first 2 min ($kW\ min/m^2$)	2.8	<65

FAR 25.853 Appendix F-Part V: Optical smoke density

Properties	Test value	Acceptance criteria
Maximum optical density	0.9	<200

AITM 3-0005[Issue 2] – ABD0031[Issue G]– Toxicity

Test method	Property (unit)	Result	Acceptable limits
AITM 3-0005 – ABD0031	CO (ppm) [2]	32.5	N/A
	SO_2 (ppm) [2]	0.5	150
	NO/NO_2 (ppm) [2]	3	100
	HF (ppm) [3]	0	150
	HCN (ppm) [4]	2	150

MIL-STD-2031, 1991 Edition

Material tested: C-PREG® 400 panel 3,5 mm thick with CF200T2HS
Cured in autoclave and post cured in oven following the standard cure and post cure schedules.

Fire test / characteristic	Test method	Requirement	Result obtained	Evaluation	Test Report
Flame Spread (index)	ASTM E 162	Max. 20	5	PASS	2011.0AS0070/21
Ignitability (s)	ASTM E 1354	At 100 kW/m^2	At 100 kW/m^2	At 100 kW/m^2	2011.0AS0070/21
		Min. 60	152	PASS	
		At 75 kW/m^2	At 75 kW/m^2	At 75 kW/m^2	
		Min. 90	203	PASS	
		At 50 kW/m^2	At 50 kW/m^2	At 50 kW/m^2	
		Min. 150	254.0	PASS	
		At 25 kW/m^2	At 25 kW/m^2	At 25 kW/m^2	
		Min. 300	N/A	PASS	
Heat release (kW/m^2)	ASTM E 1354	At 100 kW/m^2	At 100 kW/m^2	At 100 kW/m^2	
		Peak: Max 150	47.5	PASS	
		Average 300 s: Max 120	11.6	PASS	
		At 75 kW/m^2	At 75 kW/m^2	At 75 kW/m^2	
		Peak: Max 100	49.6	PASS	
		Average 300 s: Max 100	8.6	PASS	
		At 50 kW/m^2	At 50 kW/m^2	At 50 kW/m^2	
		Peak: Max 65	17.0	PASS	
		Average 300 s: Max 50	8.9	PASS	
		At 25 kW/m^2	At 25 kW/m^2	At 25 kW/m^2	
		Peak: Max 50	0	PASS	
		Average 300 s: Max 50	0	PASS	
Smoke obscuration Ds max occurrence	ASTM E 662	Max. 200 s	0.44 at 200 s 48.8 at 1200 s	/	2011.1AS0040/21

Storage conditions

C-PREG 400 4.0 should be stored as received in a cool dry place or in refrigerator. After removal from refrigerator storage, prepreg should be allowed to reach room temperature before opening the polyethylene bag, thus preventing condensation.

Shelf life

Storage life, months	12 months @ -18°C from manufacturing date
Out life, days	15 days at RT

Handling safety

Observe established precautions for handling the material. It is recommended to use clean protective gloves in order to protect the operators and avoid contamination of the components. Safety Data Sheet (SDS) of the resin mixture is available upon request and can be obtained from Nano-Tech S.p.A. or Petroceramics S.p.A. offices.

Processing guidelines

The resin system crosslinks by means of a condensation process. Do not completely seal the release film. Allow the release of vapors during curing.

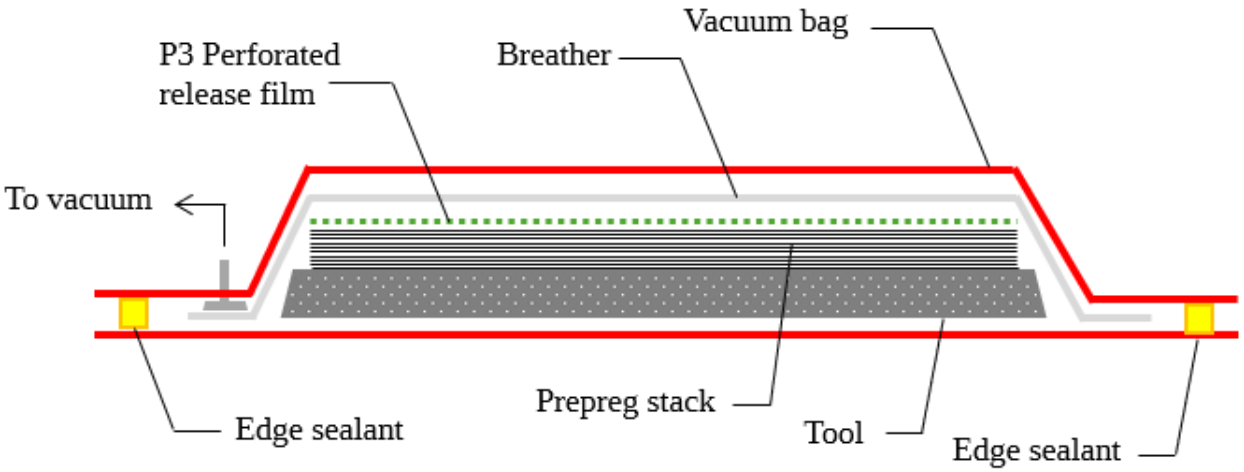
High temperature ancillary materials that withstand at least 200 °C are highly recommended.
Laminate curing sequence, both for autoclave and OoA processes, is shown in the following figure.

Tools: Both composite and aluminium tools are suitable for C-PREG® 400 processing.

Tool preparation: Clean and dry tools should be treated with release agent prior to laminating.

Do not use water-based or silicone-based release agents.

Debulking: Debulking, 3 to 5 plies, is recommended for laminates thicker than 2 mm.



Please consult C-PREG® 400 Handbook for detailed information. Please contact our technical support staff for further information both at Nano-Tech S.p.A. and/or Petroceramics S.p.A.