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SUSTAINABLE & COST EFFICIENT
HIGH-PERFORMANCE COMPOSITE STRUCTURES
DEMANDING TEMPERATURE
AND FIRE RESISTANCE

Polyfurfuryl alcohol based resins for fire resistant and high temperature applications

Hans Hoydonckx
Mathias Kelchtermans

SuCoHS Webinar

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SuCoHS project, Grant Agreement N° 769118

TransFurans Chemicals

- World leading producer of furan chemicals located in Geel Belgium
- + 40 years of production of biomass based chemicals from agro-waste: Furfural and Furfuryl alcohol with annual capacity of 40 000MT.
- Full integration by the use of sugar cane bagasse produced by CRC (DR)
- Innovator in the development poly-FA as thermoset resin system.

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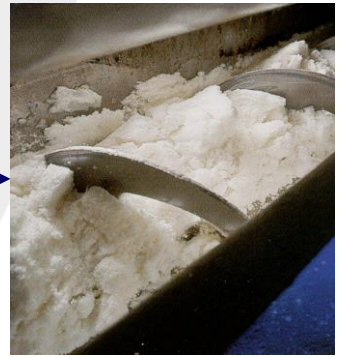
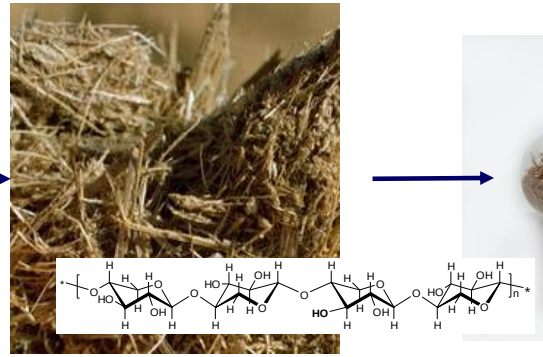
Furfural Chemistry : Utilization of agrowaste as feedstock

SUGARCANE

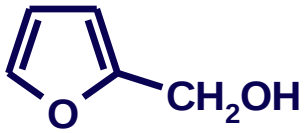


SUGAR



BAGASSE

FURFURAL



FURFURYL ALCOHOL

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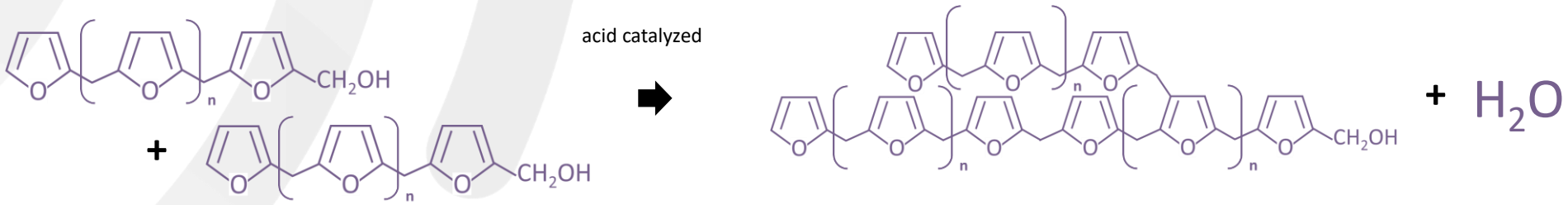
Polyfurfuryl alcohol thermoset/ PFA

1



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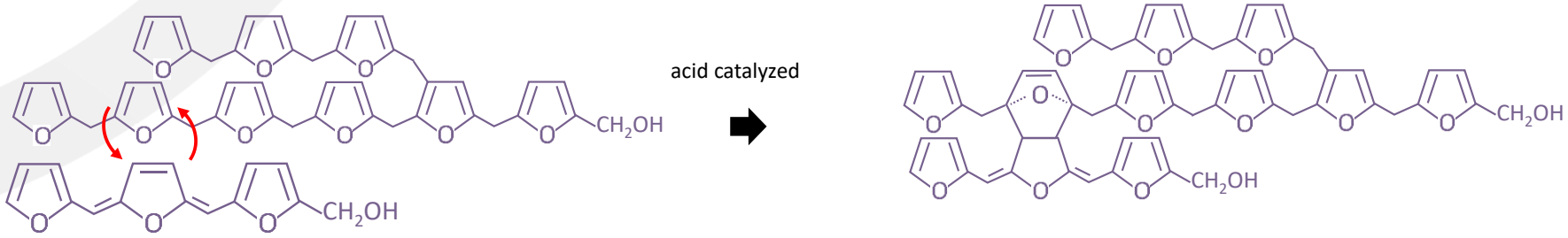

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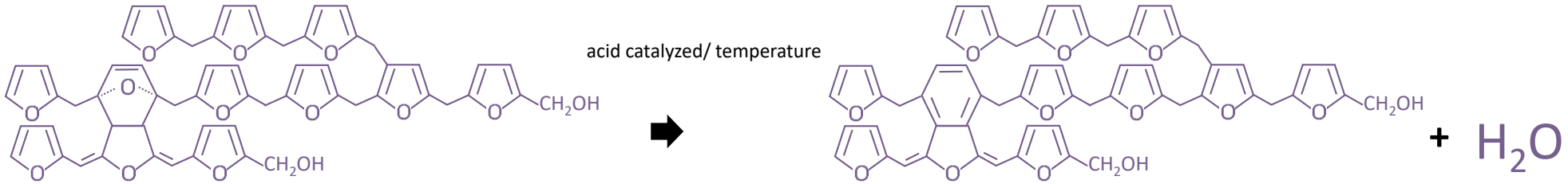

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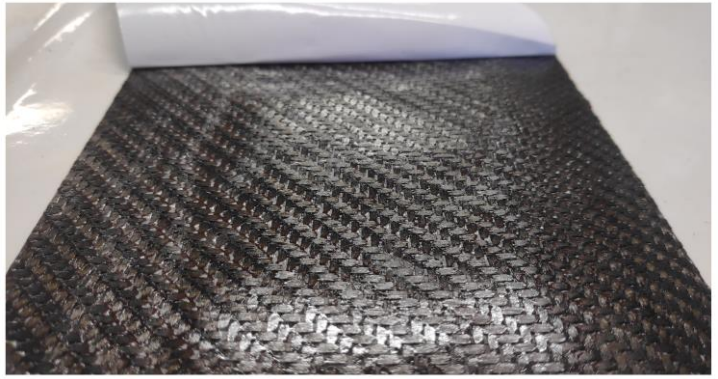
Fire resistant composites in aerospace

PFA resins applied in form of prepregs

Various moulding techniques using:

- hot compression consolidation
- vacuum bag consolidation
- autoclave consolidation



- **CF/PFA composites with enhanced fire performance**
- **High temperature performance**
- **Application in automated fiber placement**

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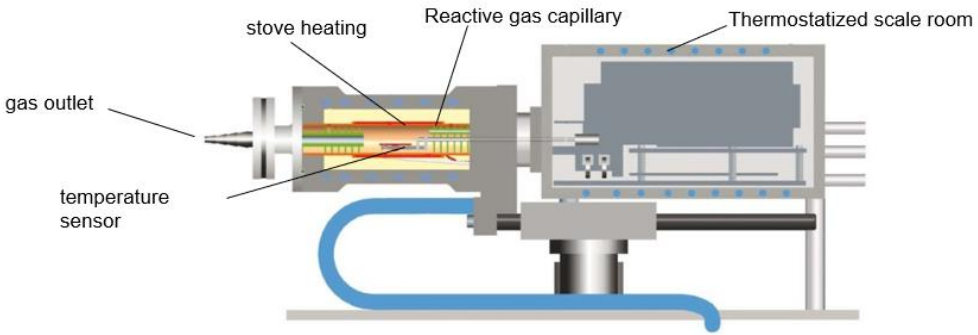
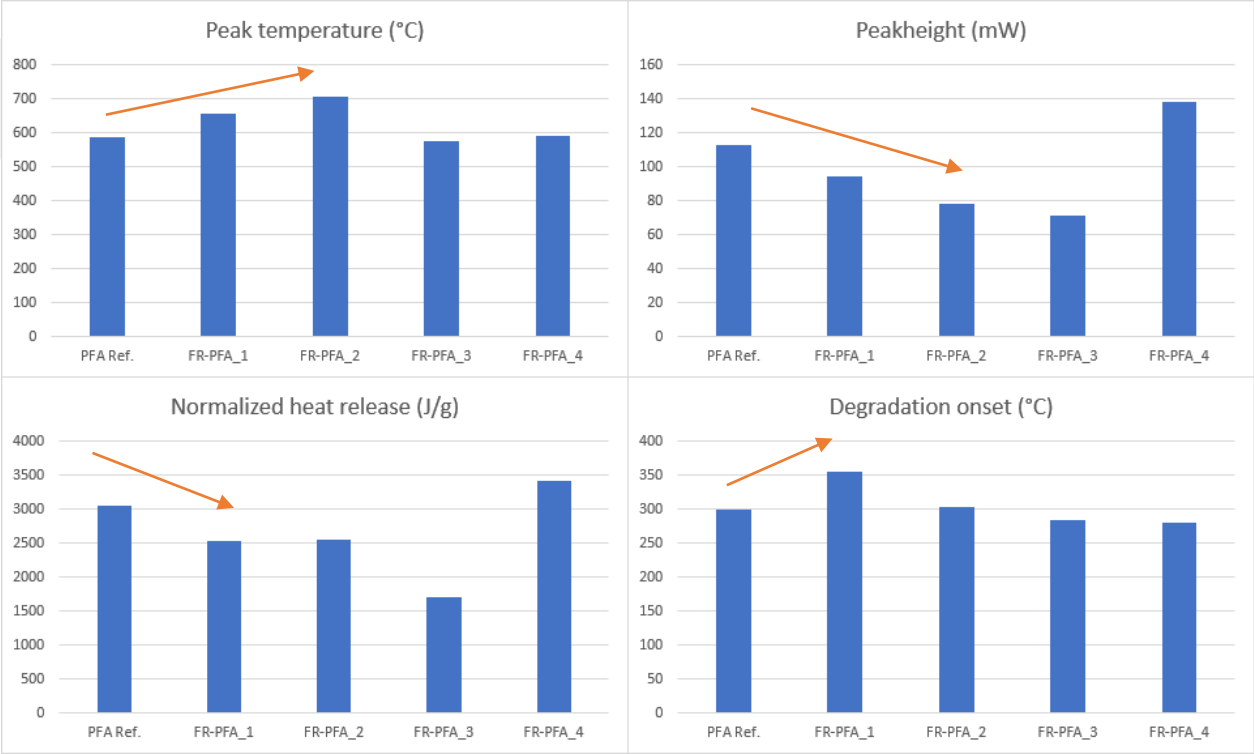
CF/PFA composites with enhanced fire performance

- Modification PFA resin formulation for improved FR
- Strategy development for bottom-up evaluation thermal and fire resistant properties:
  - Thermal properties in oxidative atm. (TGA/DSC)
  - Cone calorimetry (a/t ISO 5660-1:2015 (50kW/m²)
  - FAR 25.853 (Appendix F Part IV(a) thru (h), 35 kW/m²)





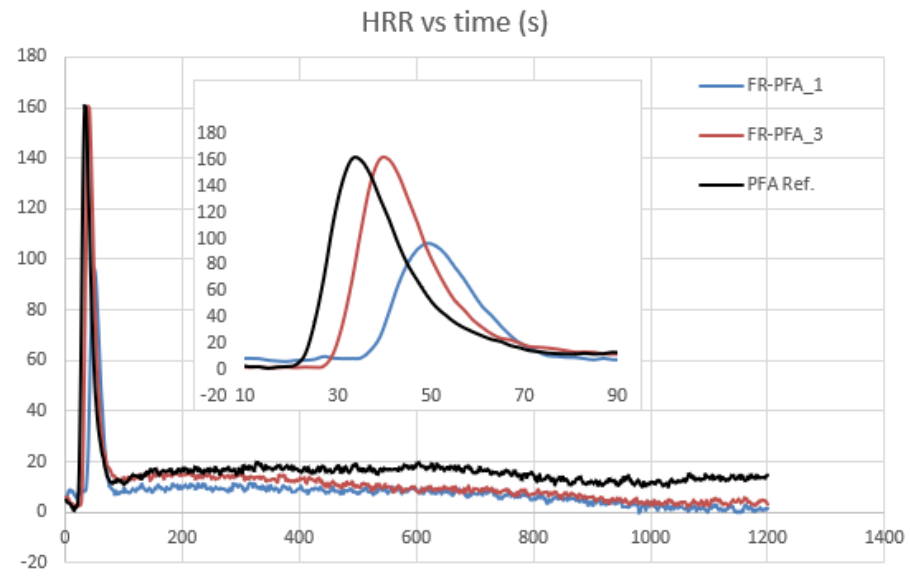
Increased peak temperature

Increased degradation onset

Decreased peakheight

Decreased heat release

CF/PFA composites with enhanced fire performance



Cone cal. Sample	Time of ignition (s)	Time of extinction (s)	MARHE (kW/m²)	q.max (kW/m²)	THR (MJ/m²)
PFA Ref.	31	941	58,1	160,9	20,9
FR-PFA_1	45	71	32,7	96,2	9,7
FR-PFA_3	39	543	51,3	160,3	13,5

FR-PFA_1 has an effective decrease in peak heat release and total heat release compared to the reference material

FAR 25.853 samples	Equipment	# plies	Cure cycle	THR < 65 kW.min/m²	PHR < 65 kW/m2	Smoke Density < 200 Ds
PFA Ref.	Vacuum bag	12	2h at 95°C and 1h at 140°C	49,7	78,8	25
				PASS	FAIL	PASS
FR-PFA_1	Vacuum bag	12	2h at 95°C and 1h at 140°C	5.3	40	10
				PASS	PASS	PASS
FR_PFA_3	Vacuum bag	12	2h at 95°C and 1h at 140°C	29.6	100.6	17.4
				PASS	FAIL	PASS

FR-PFA_1 fulfills all requirements of FAR 25.853 (Appendix F Part IV(a) thru (h))

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CF/PFA composites with enhanced fire performance

PFA Ref.

FR-PFA_1

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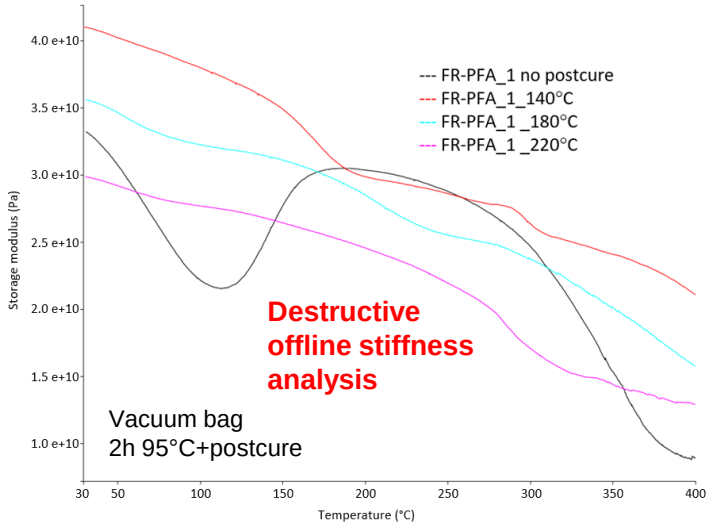
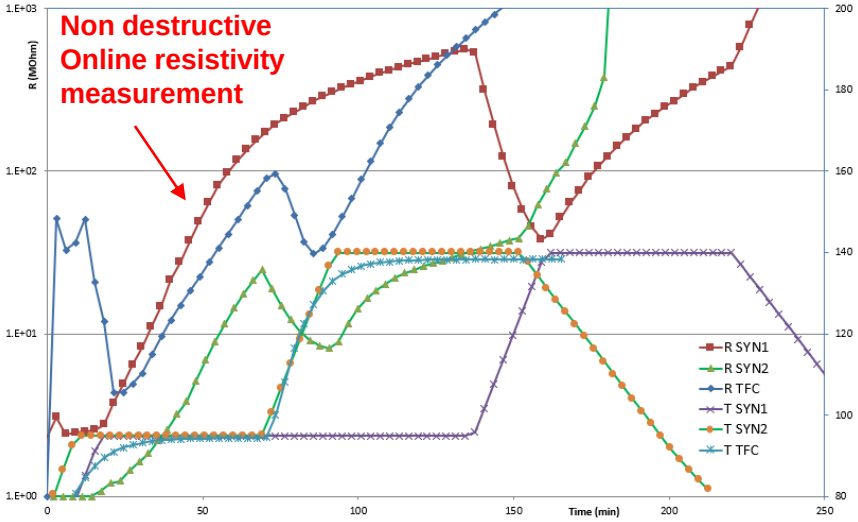
High temperature performance

- Evolution of destructive to non-destructive analysis (SYN)
- Dynamic mechanical analysis (DMA) vs resistivity measurement





- No postcure: large influence of temperature on mechanical stifness – presence of Tg
- Postcure 140-220°C: absence of large drop in the storage modulus – no obvious Tg but some residual postcure at high T

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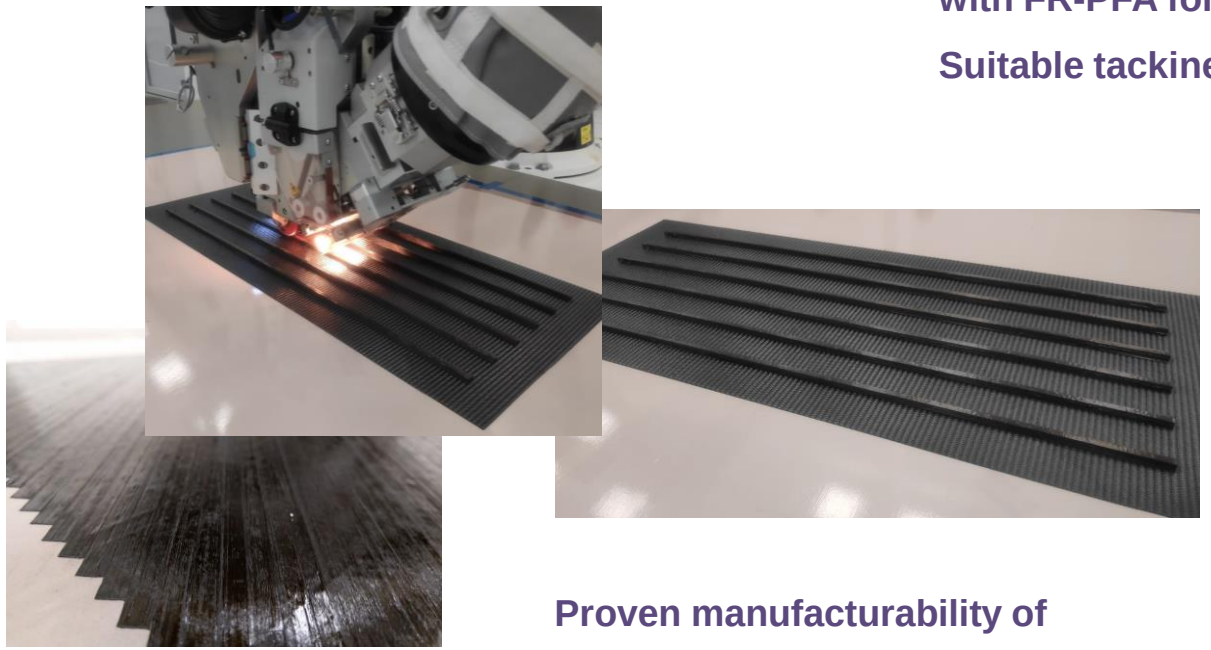
Application in automated fiber placement

Composite aircraft interior shell compliant to FAA regulations

Optimized fiber impregnation with FR-PFA formulations

Suitable tackiness achievable



Proven manufacturability of AFP processed PFA plates

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Conclusions

- Modification of PFA resin to enhance FR properties
- FR-PFA_1 has an effective decrease in total heat release, peak heat release and increase in degradation onset.
- Fulfills FAA fire testing procedure FAR 25.853 (Appendix F Part IV(a) thru (h))
- Additional postcuring (> 140°C) eliminates the presence of an obvious Tg at high temperature
- Possibility of non-destructiveonline degree of cure and Tg monitoring using resistivity measurements
- Proven AFP compatibility of CF/PFA tape with enhanced fire performance

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