Frontal polymerization of composites

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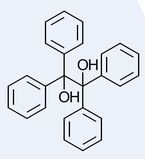
Motivation

Radical Induced Cationic Frontal Polymerization (RICFP) is a self-preserving polymerization technique applicable for different industrially relevant resins like epoxides, oxetanes or vinyl ethers. After an initial stimulus, a curing "wave" is wandering throughout the whole resin. As only this first energy input is needed, this makes it a faster and more energy-efficient curing method than the state-of-the-art methods like long curing cycles in autoclaves.

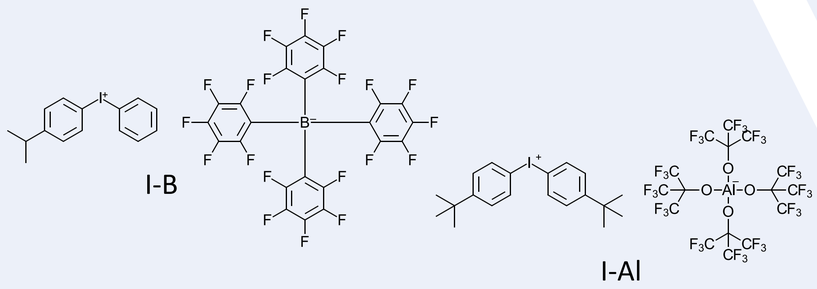
The matrix formulation

Radical thermal initiator (RTI)



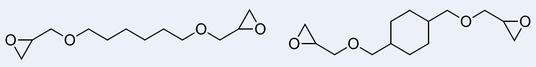
TPED

Photoacid generator (PAG) [5]



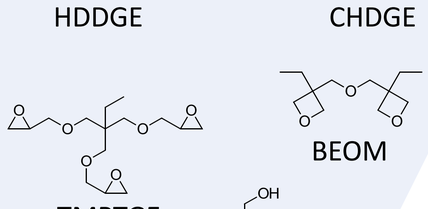
Monomer

BADGE



HDDGE CHDGE

Reactive diluents



TMPTGE BEOM

EOM

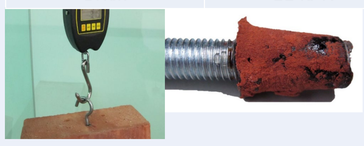
Unfilled Systems[1,2]

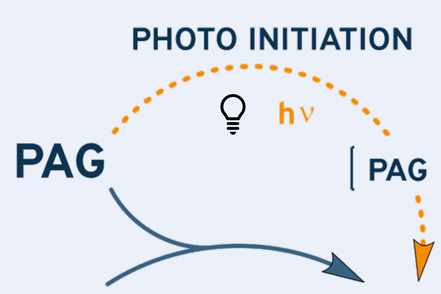
Front parameter

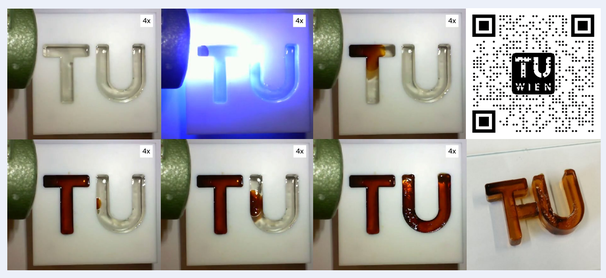
Adjustable via initiator concentration

- Front velocity: 1,7 - 15 cm/min
- Front temperature: 110 - 220°C
- Minimum layer thickness: 0,75 mm
- Pot life: > 1 month @ 50°C
- Epoxy group conversion: > 95 % (by FTIR)

Material	Pull out force
Concrete	1028 N
Brick	1145 N

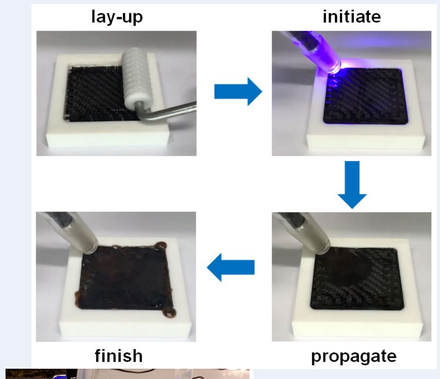


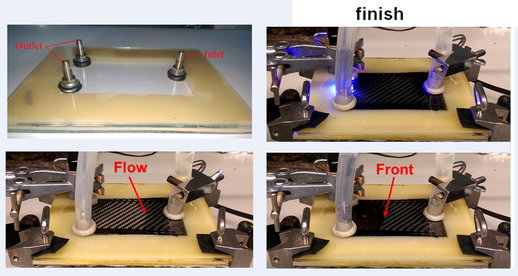


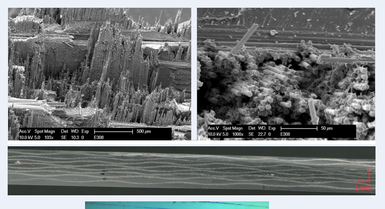


Fiber reinforced polymer composite[3]

Carbon Glass Kevlar

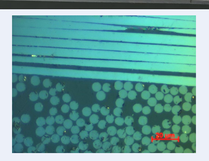






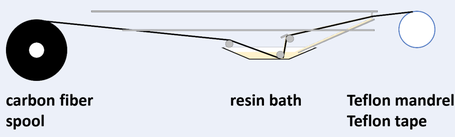
Fracture surface

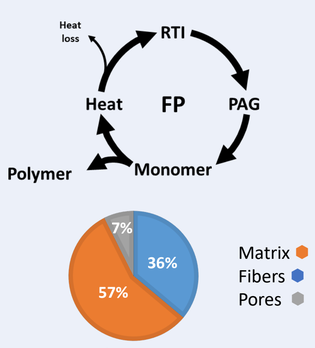
Cross section

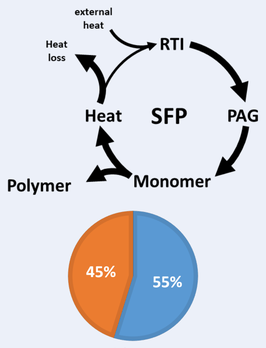


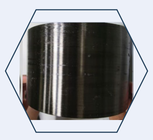
- Fibre content: 35 vol%
- Void content: < 2 vol%
- Epoxy conversion: > 97%

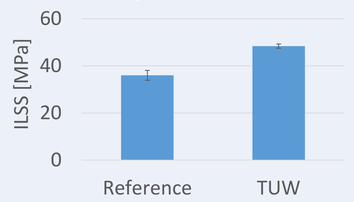
Filament winding

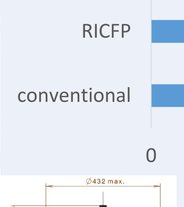












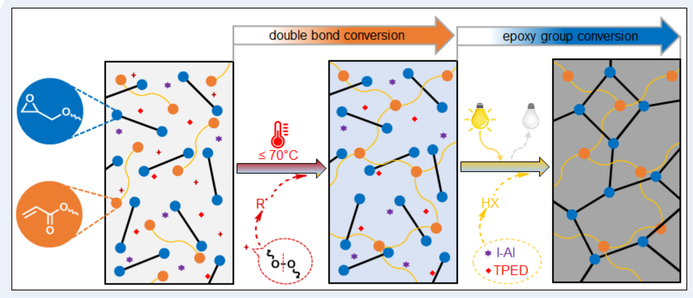
Autofrettage @ 440 bar

Prepreg [4]

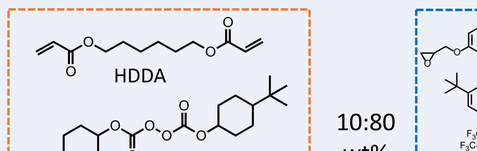
Radical polymerization
Acrylate + radical thermal initiator

RICFP
Epoxy + I-Al + TPED

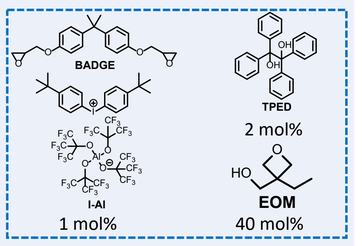
Separation of the two curing steps ⇨ Good storage stability at B-stage



A-stage B-stage C-stage



10:80 wt%



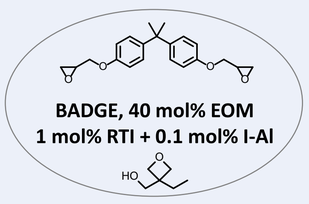
Particle filled Systems[3]

Copper

Zirconium oxide

Graphite

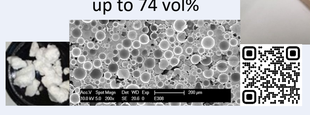
Silicon carbide



Milled carbon fibers

Glass microspheres

up to 74 vol%



Mica

Aluminum nitride

Aluminum

References

[1] D. Bomze, P. Knaack, R. Liska, *Polym. Chem.* **2015**, *6*, 8161-8167.
[2] D. Bomze, P. Knaack, T. Koch, H. Jin, R. Liska, *J. Polym. Sci., Part A: Polym. Chem.* **2016**, *54*, 3751-3759.
[3] A. D. Tran, T. Koch, P. Knaack, R. Liska, *Composites, Part A* **2020**, *132*, 105855.
[4] A. D. Tran, T. Koch, R. Liska, P. Knaack, *Monatsh. Chem.* **2021**, *152*, 151-165.
[1] N. Klikovits, P. Knaack, D. Bomze, I. Krossing, R. Liska, *Polym. Chem.* **2017**, *8*, 4414-4421.