Sustainable two-step functionalization of carbon fibers with polyethyleneimine and investigation of curing kinetics in composites

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INTRODUCTION

Carbon fibers derived from PAN possess high mechanical properties, making them excellent high-performance fillers. However, pure adhesion and low interfacial shear stress between CFs and resin can invalidate the mechanical properties of carbon fiber-reinforced polymer (CFRP) composites

AIM

Increase the adhesion between CFs and the matrix in CFRP

HOW TO DO THIS?

Increase CF's wettability towards the resin by:

- Increasing the CF's surface area
- Enhancing CF's chemical reactivity
- Creating a covalent grafting between CFs, the sizing, and the resin

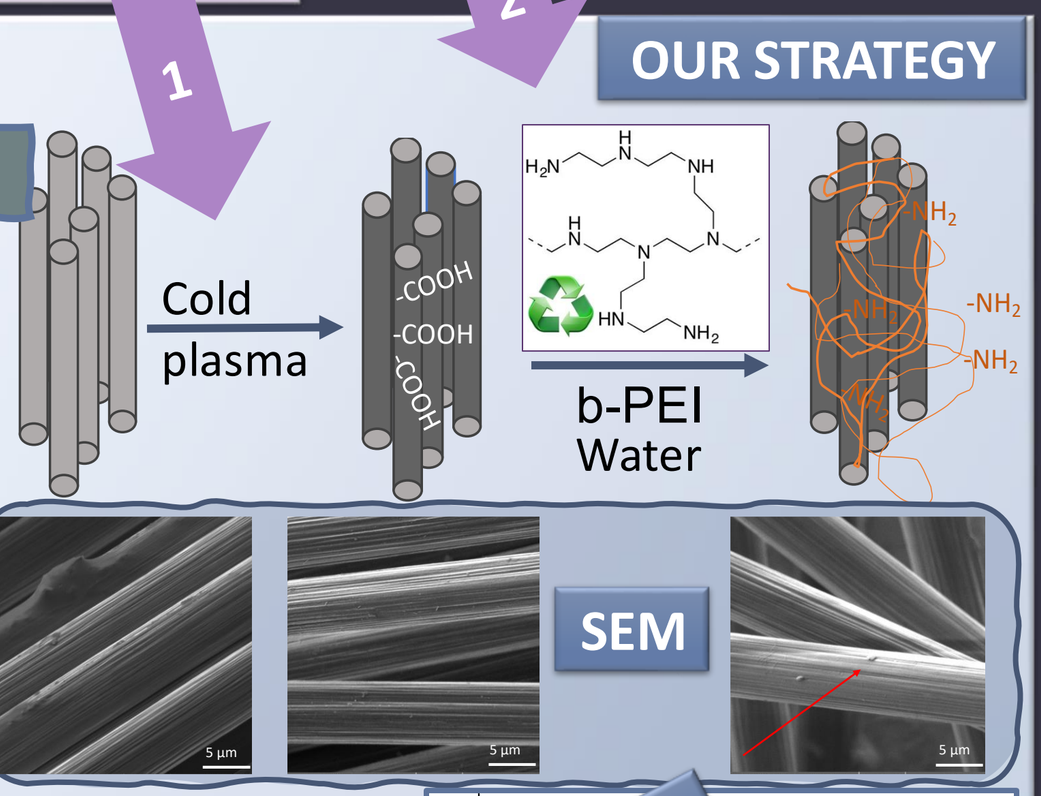
Dry methods

- High-energy irradiation
- Ozone treatment
- Thermal treatment
- Plasma treatment

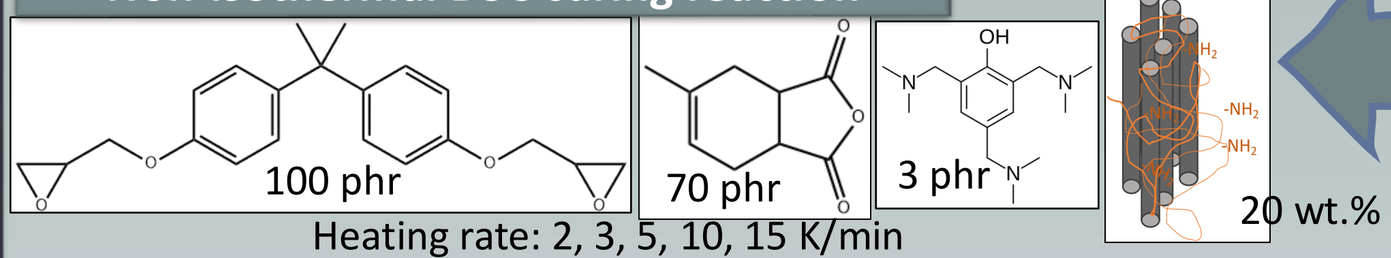
Wet methods

- Electrochemical treatment
- Acid treatment
- Sizing

OUR STRATEGY

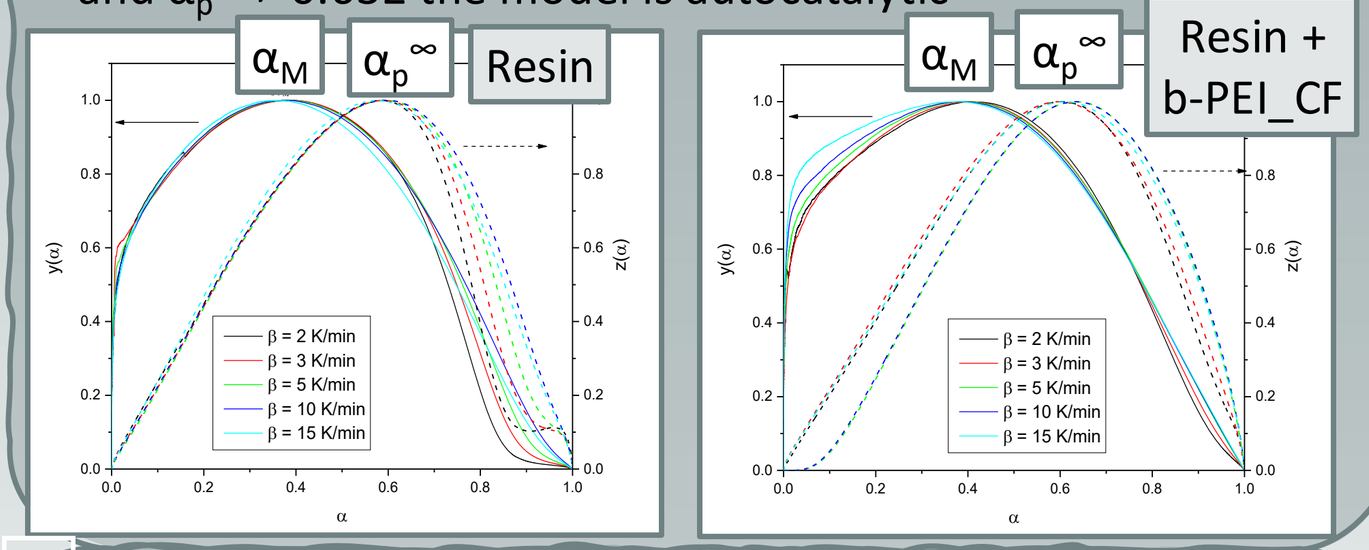


Non-isothermal DSC curing reaction



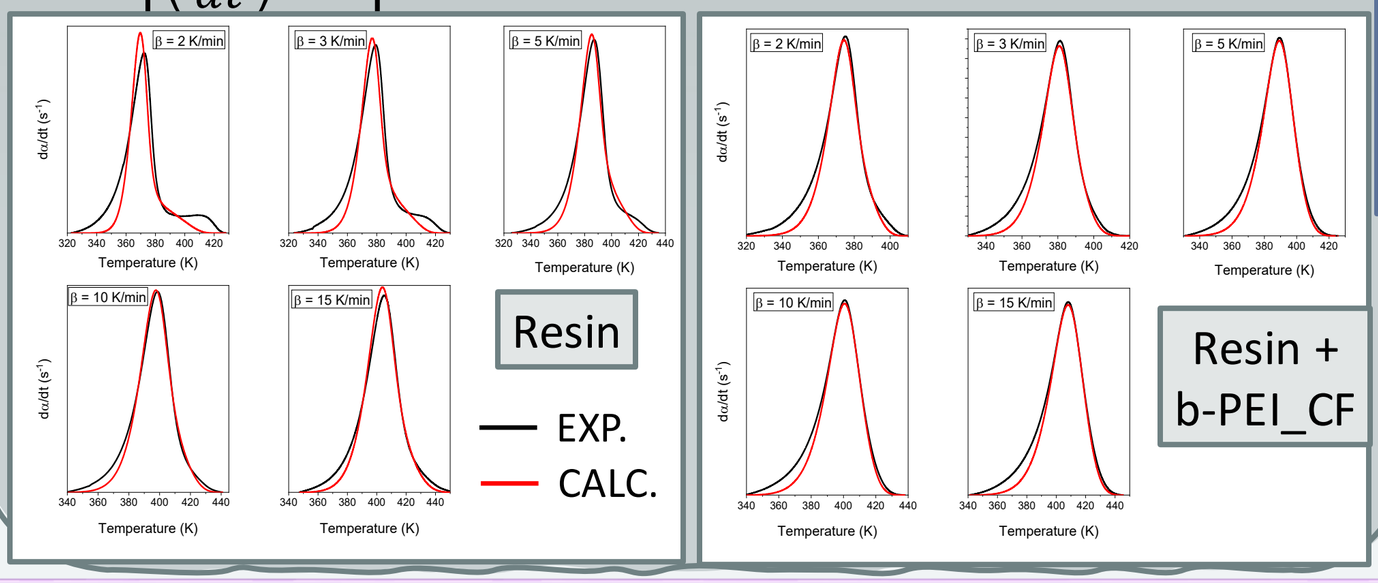
Heating rate: 2, 3, 5, 10, 15 K/min

1 Malek's method for defining a kinetic model: if $0 < \alpha_M < \alpha_p^\infty$ and $\alpha_p^\infty \neq 0.632$ the model is autocatalytic



2 Kinetic equation applying the autocatalytic model

$$ln\left[\left(\frac{d\alpha}{dt}\right)e^{\frac{E_\alpha}{RT}}\right] = \ln(A) + n\ln[\alpha^p(1-\alpha)]$$



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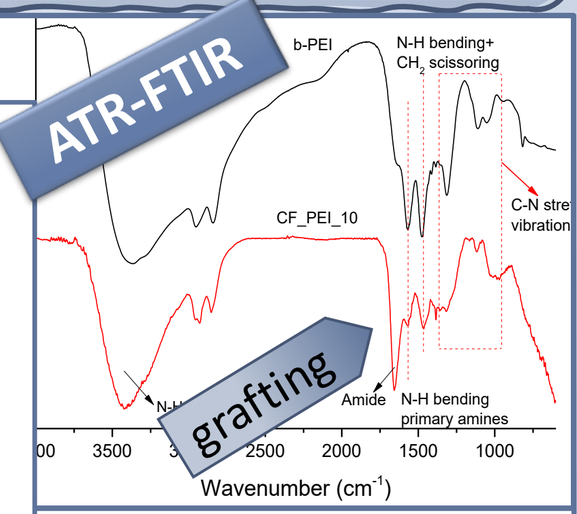
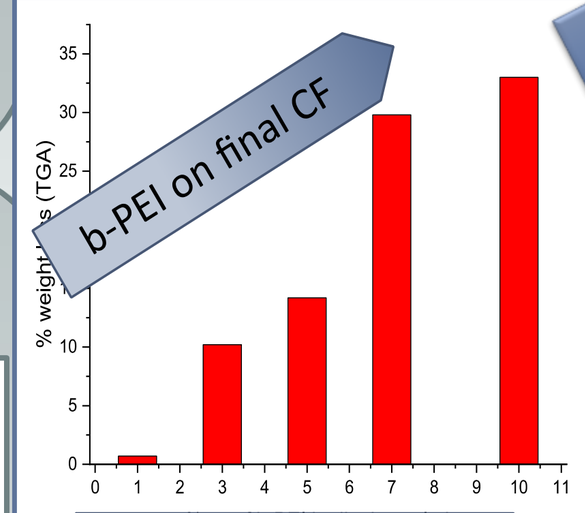


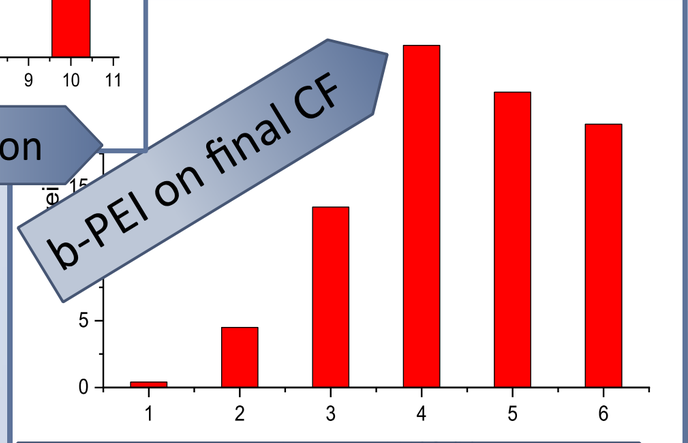
b-PEI on final CF



b-PEI in sizing solution

Optimization of sizing grafting

b-PEI on final CF



CONCLUSIONS

First part

- A green, waste-free two-step process was developed to functionalize CFs.
- The degree of b-PEI grafting can be tuned by adjusting process parameters.

Second part

- Non-isothermal DSC methods were used to study the curing kinetics of the epoxy/anhydride system
- Resin + 20 wt.% CFs_b-PEI → faster curing and lower activation energy than pure resin

ACKNOWLEDGMENTS

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