Effect of solvent on the performance of epoxy-based composites obtained by photo-induced cationic frontal polymerization (RICPF)

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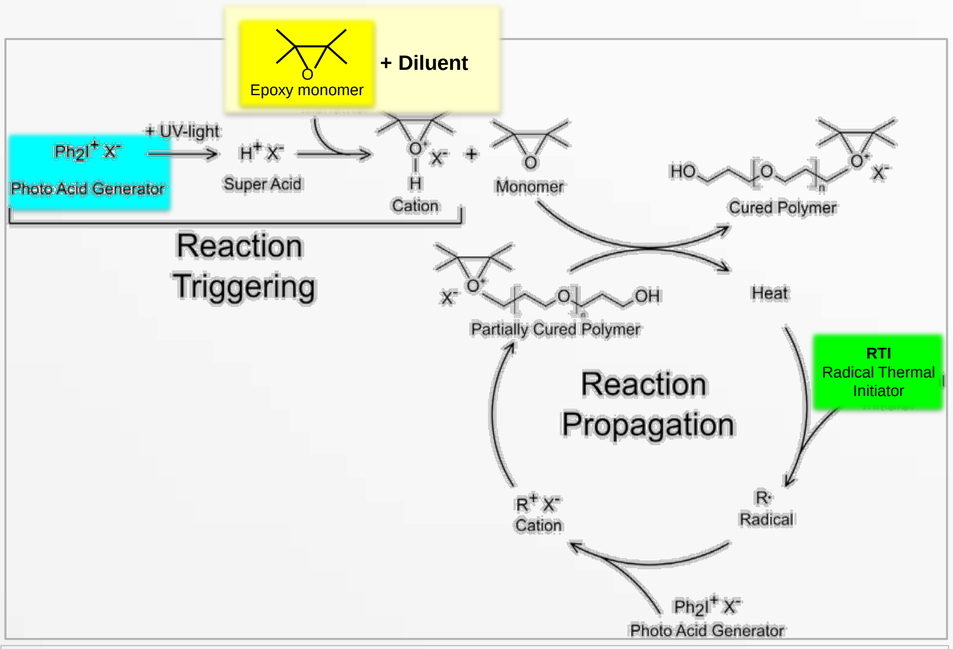
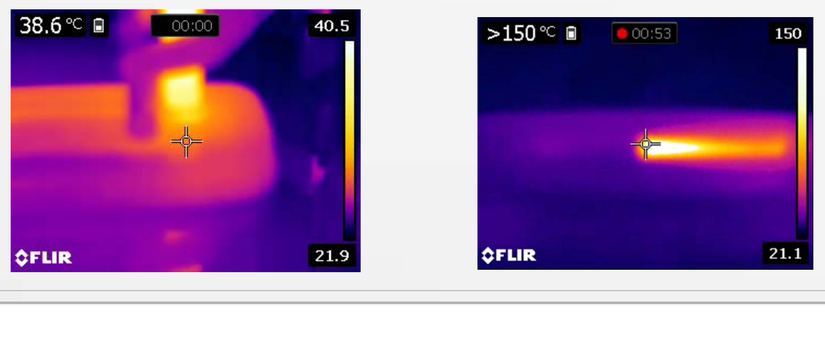
• INTRODUCTION•

The limitations of photopolymerization techniques for epoxy-based composites, such as the low penetration of light rays or the inefficiency of the process in the presence of opaque additives, have led to the need to develop new polymerization techniques. Radical induced cationic frontal polymerization (RICFP) [1] combines photopolymerization with thermal radical polymerization, achieving to overcome the aforementioned limitations. Frontal polymerization is a unique type of polymerization where the polymerization process moves from a localized initiation point and propagates in a front, typically in the form of a moving reaction zone. This can be contrasted with typical bulk polymerizations, where the process occurs throughout the material uniformly.

• RICFP[2]•



RICFP **POLYMERIZATION**



In this work, different formulations have been developed to evaluate the viability of performing RICFP at room temperature of an **commercial epoxy** resin and its composites. The formulations studied are based on a bisphenol A diglycidyl ether diglycidyl ether (BADGE) epoxy resin, in which the concentration of a diluent based on a cycloaliphatic epoxy resin, named CE, has been varied. The rheological properties of the formulations studied were determined to establish the relationship between the viscosity of the system and the viability of carrying out RICFP. Subsequently, the obtained cured resins have been characterized and the mechanical properties of the most promising formulations have been determined. Finally, composite formulations with different fibres have been evaluated.

• EXPERIMENTAL PART•

RICFP

(p-octyloxyphenyl) phenyliodonium hexafluoroantimonate (**PAG**), 2% wt

1,1,2,2-tetraphenyl-1,2-ethandiol (**TPED**), 1% wt

3,4-Epoxiciclohexilmetil 3,4-epoxiciclohexanocarboxilato (**CE**)

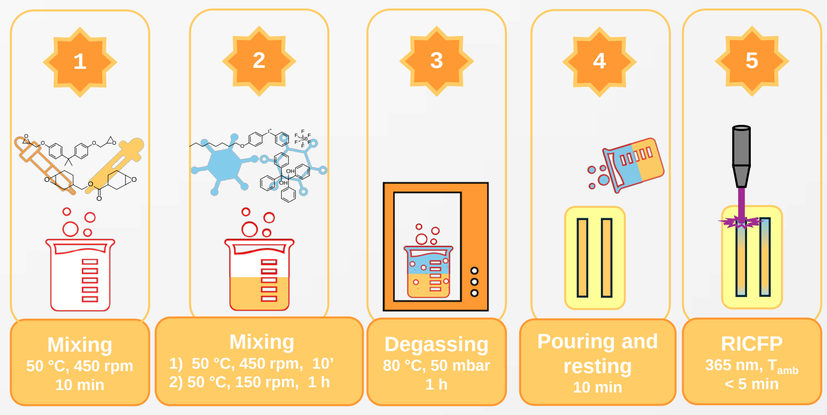
BADGE:CE
100:0
90:10
80:20
70:30
60:50
50:50

Bisphenol A diglycidyl ether (**BADGE**), ARALDITE LY564

2,2'-Dimethyl-4,4'-methylenebis(cyclohexylamine) (**ARADUR® 2954**)

THERMAL CURING
Epoxi: amine
80 ºC / 2 h
120 ºC / 2 h
170 ºC / 1 h
200 ºC / 1 h

RICFP **PROCEDURE**



CHARACTERIZATION The shear viscosity (η) was determined by flow tests using a TA Instruments AR-G2 torsional rheometer, with a plate-plate geometry of 20 mm diameter. The thermomechanical analyser, DMA Q800 (TA Instruments), was used to determine the glass transitions (T_g), with a single cantilever mode, 4 ºC/min and1Hz frequency. The mechanical properties were obtained from flexural tests (ISO 178), using an universal machine INSTRON 5565 equipped with a load cell of 5000 N and three-point bending mode.

• RESULTS•

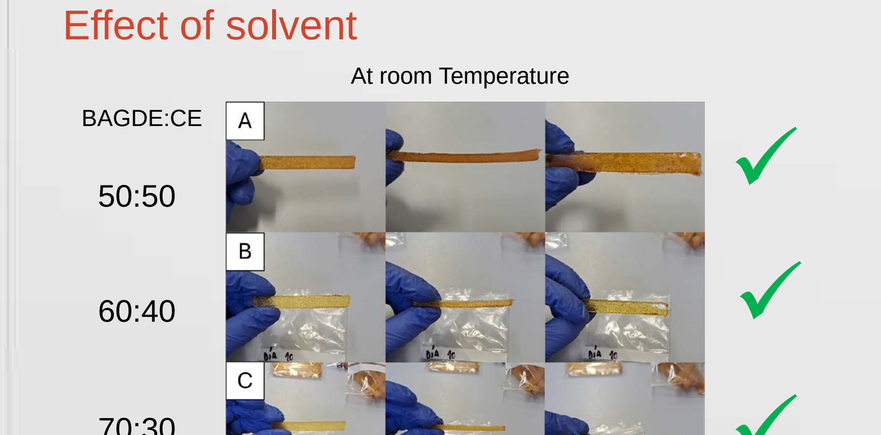
Effect of T

BAGDE (PURACE 1000) at room T fails

BAGDE (PURACE 1000) at T= 60 ºC

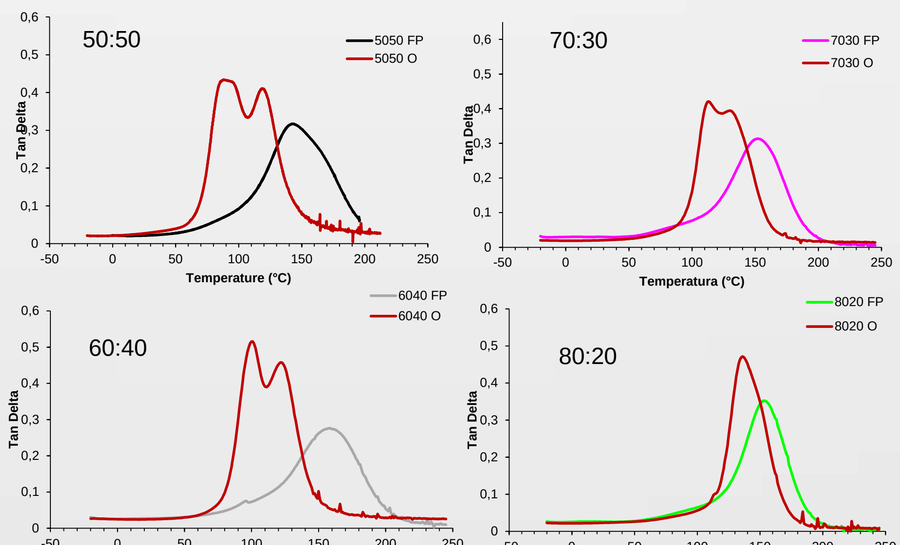
Effect of solvent

At room Temperature



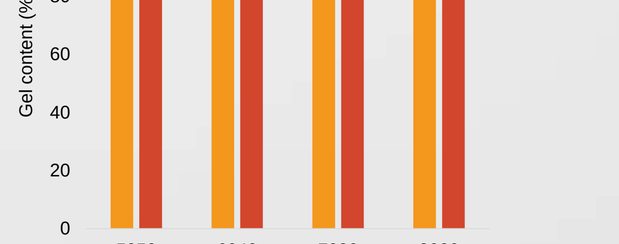
Characterization

DMTA



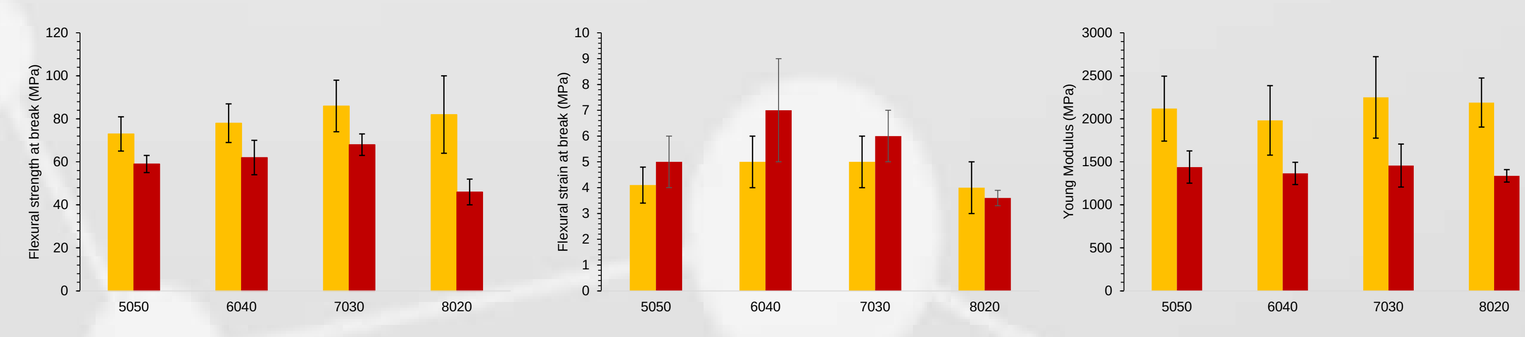
The glass transition of RICFP systems merely varies with the diluent content. However, in the epoxy:amine system, two peaks are observed, probably related to the existence of a double network.

Gel content



The gel content of RICFP systems is practically 100% regardless of the diluent concentration.

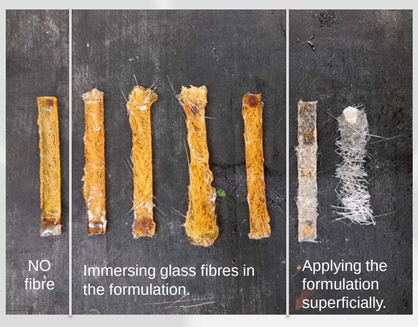
Mechanical Properties (Flexural test)



Future work

COMPOSITES

BAGDE:CE 5050 Glass Fibre



BAGDE:CE 5050 Carbon Fibre Fabric

Irradiated on B

Irradiated on A

The presence of carbon fibre causes resin degradation. Carbon fibres are good heat conductors.

• REFERENCES •

[1] Sangermano, M., Antonazzo, I., Sisca, L., & Carello, M. (2019). Photoinduced cationic frontal polymerization of epoxy–carbon fibre composites. Polymer International, 68(10), 1662-1665.

[2] Turani, M., Baggio, A., Casalegno, V., Salvo, M., & Sangermano, M. (2021). An epoxy adhesive crosslinked through radical-induced cationic frontal polymerization. Macromolecular Materials and Engineering, 306(12), 2100495.

• CONCLUSIONS •

The success of epoxy resin photopolymerization by RICFP depends on viscosity, and therefore on the diluent, for the set of initiators considered. Both the Young's modulus and the tensile strength are higher in the specimens obtained using RICP regardless of the diluent content. The good results obtained in composites open up a new and really interesting field of research for industrial scaling.

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