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UNIVERSITÀ degli STUDI di CATANIA

Thermomechanical properties of mandrels manufactured by 3D printing for the production of hollow FRP parts

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ABSTRACT

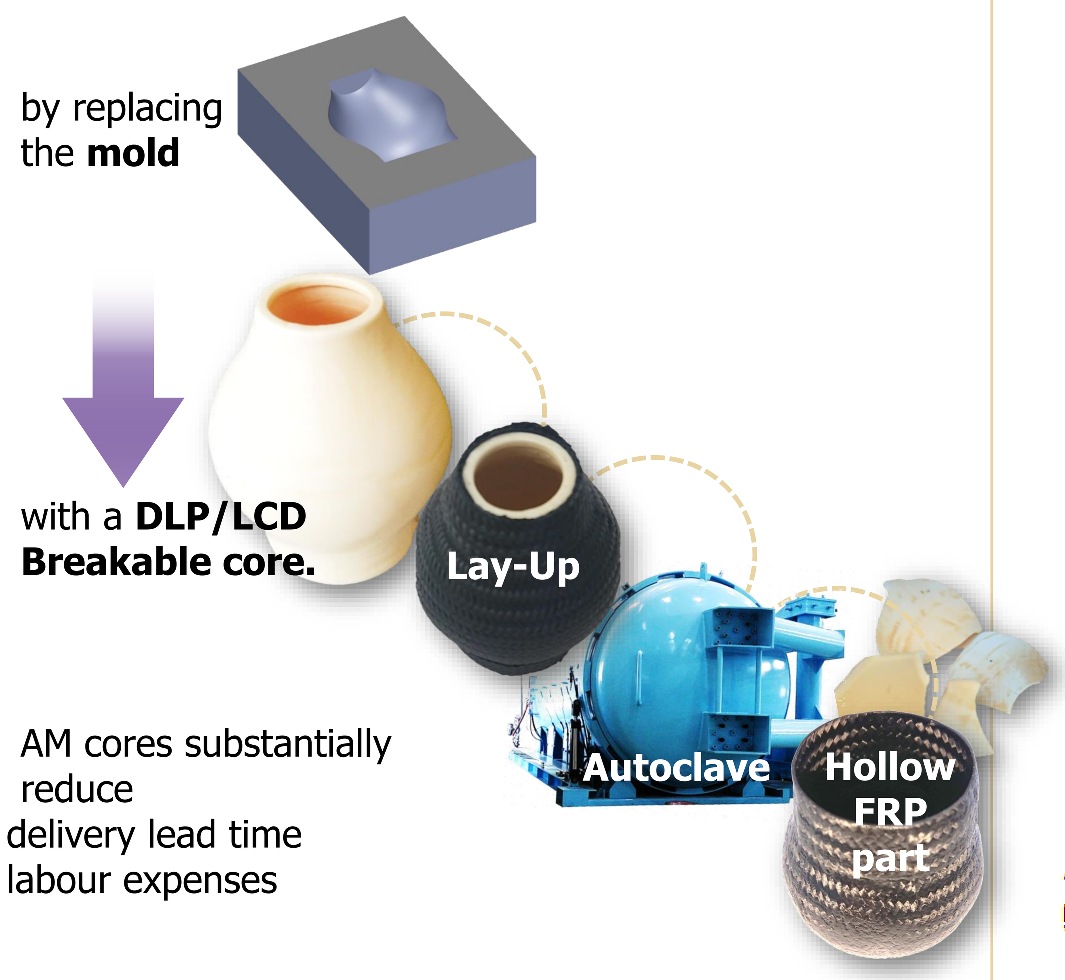
The manufacturing of hollow FRP (Fiber Reinforced Polymers) parts is carried out by using complex processes requiring extensive hand on processing or the use of tailored tools. The development of additive manufacturing technologies opened new perspective on the use of 3D printing as a production method for composite tooling [1,2]. If hollow parts are to be manufactured the use of mandrels produced by 3D printing is relevant as far as the materials used can withstand the curing temperature while allowing easy removal of the part itself after curing.

The present paper will present a novel approach developed by the authors which rely on the use of photocurable resin blends processed in a DLP/LCD printer. The thermomechanical properties of the resins are analysed by Dynamic Mechanical Analysis and Differential Scanning Calorimetry to determine the best post processing condition to guarantee the efficient use of the material as tooling for composites curing at 120-130 °C. The effect of material toughness is also discussed to show its effect on tooling removal.

INTRODUCTION

Composite parts are manufactured by winding, wrapping, molding and laying up various combinations of materials and resin systems on molds, bucks, patterns, cores and mandrels.

Producing hollow composite parts that trap the pattern provides substantial improvements for low–volume production



by eliminating the need for **making a mold** and also reducing the time required for **laying up the part**. Instead of the tedious process of laying up the two mold halves, then laying up the part in each half, and then bonding the two halves together, the composite cloth can be **wrapped around the soluble core**. After the part has cured, the core is simply **removed by breaking it.**

MATERIALS AND METHODS

- The **photocurable resin** used is named Cream Hard Daylight, a methacrylate-based system by Photocentric.

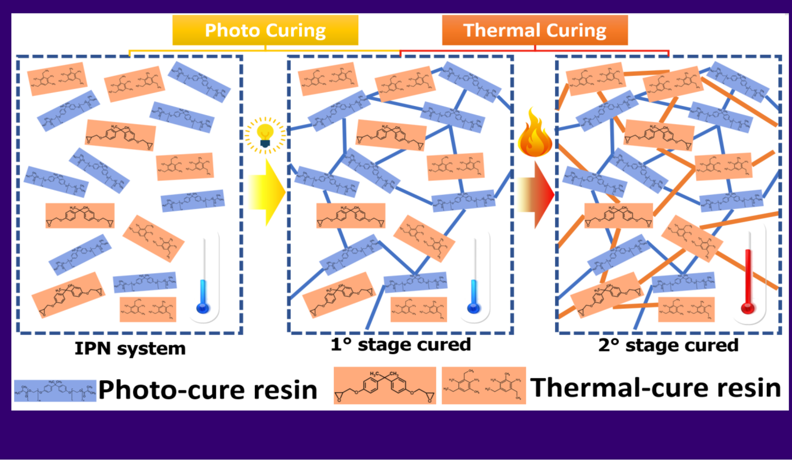
Two different **epoxy resins** have been tried for the blends: the difunctional monomer diglycidyl ether of bisphenol-A (DGEBA), Araldite GY240; the trifunctional monomer triglycidyl-p-aminophenol (TGAP), MY0510. The curing agent used is Diethyltoluenediamine (DETDA). Different blends of daylight resin and epoxy resin have been prepared with weight ratio (see table).

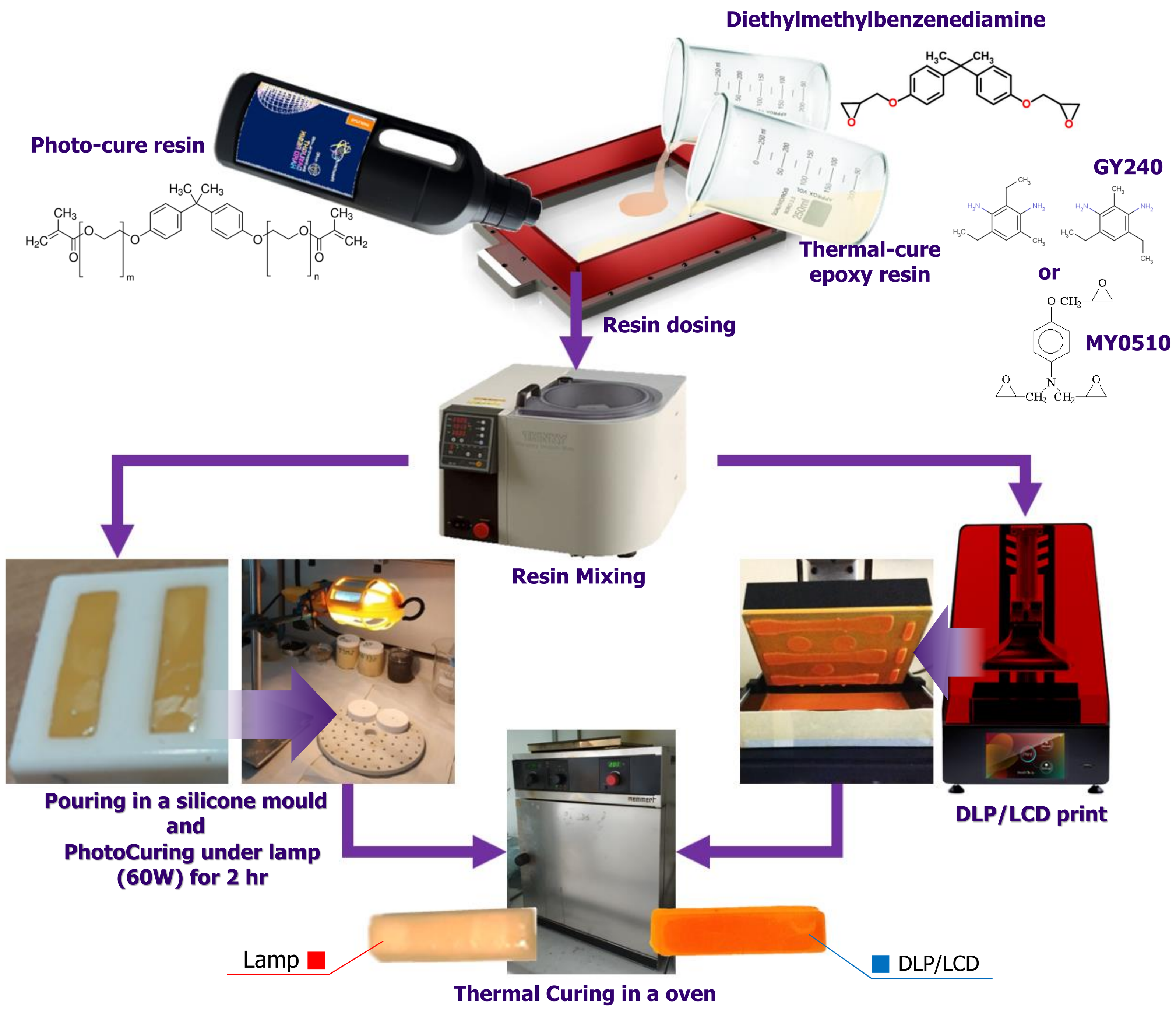
- To speed up the resin testing most of the work was perfomed by photo curing **out of** the printer the formulations before testing them in the **LCHR2 printer.**

This experimental approach was tested on neat hard cream resin before testing it on the epoxy based blends.

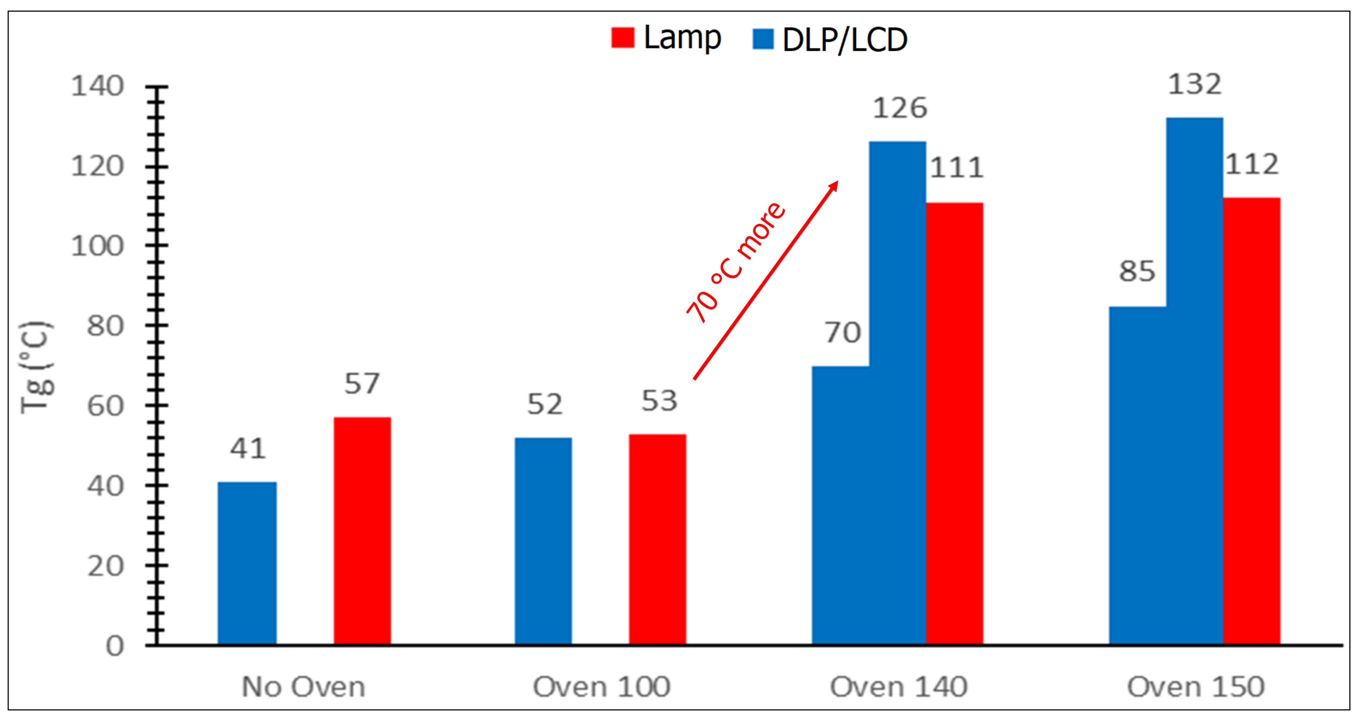
EPOXY BASED BLENDS

Sample	DayLight:Epoxy
Cream Hard	100:0
CE8020	80:20
CE7030	70:30
CE6040	60:40
CE5050	50:50
GY or MY-DETDA	0:100

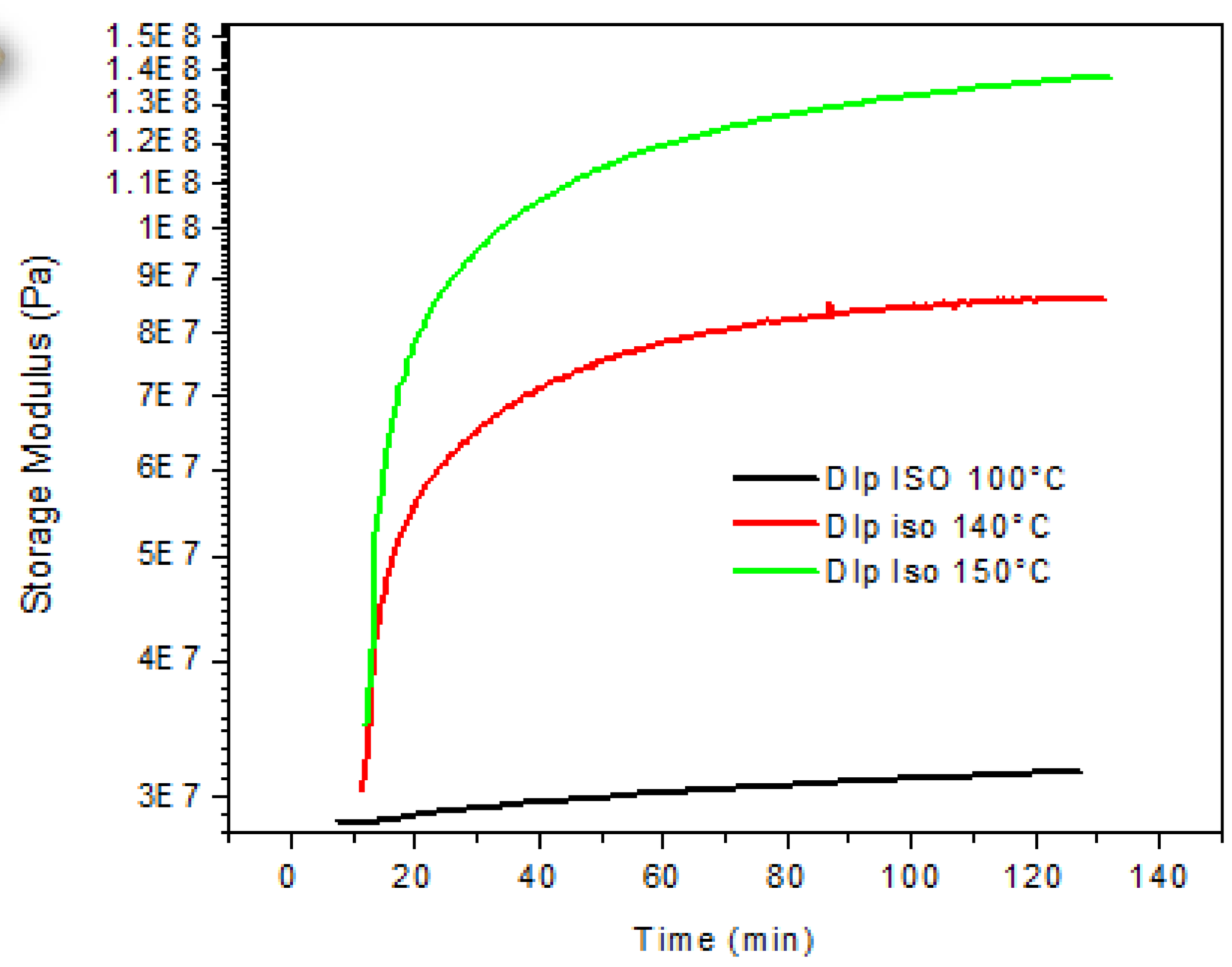


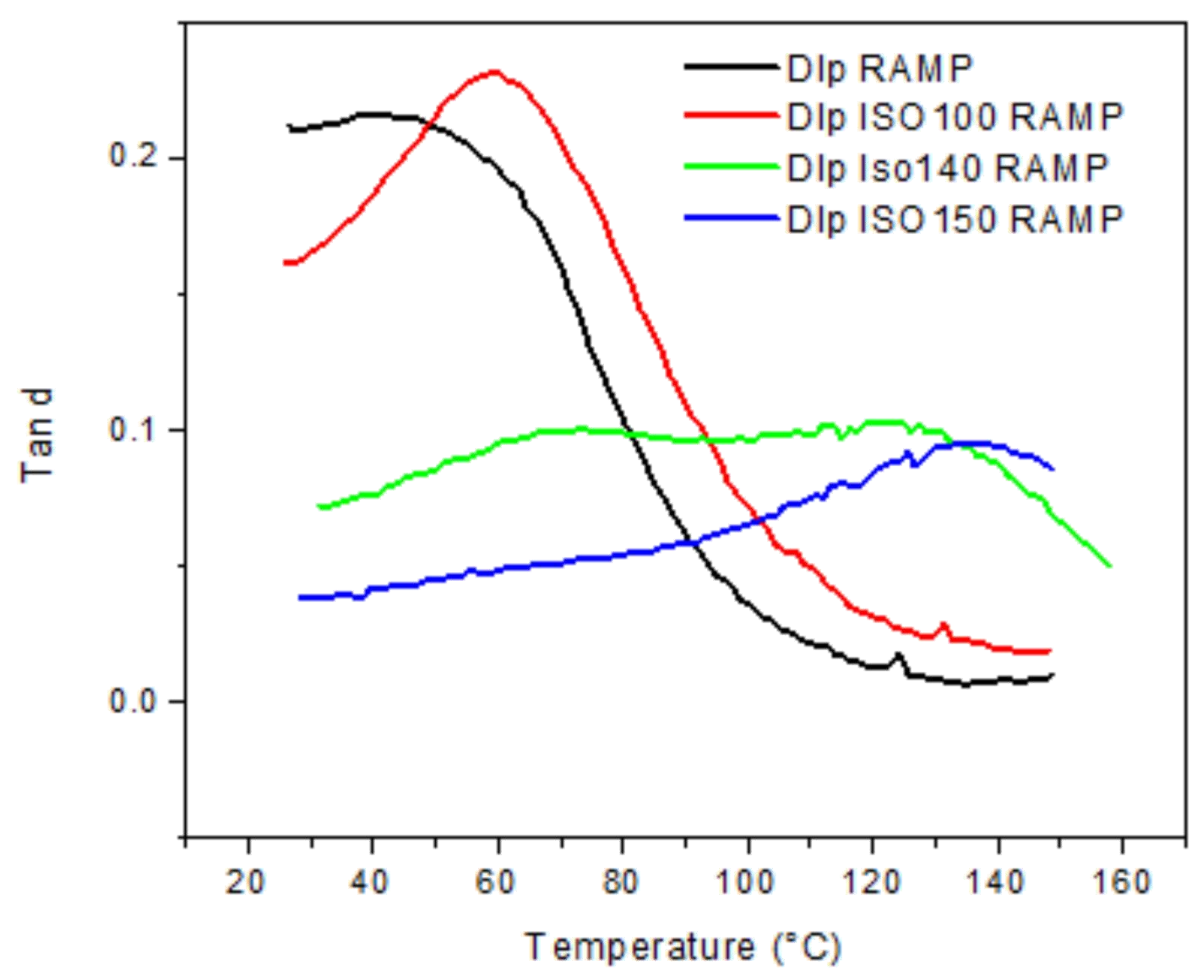


RESULTS



Glass transition temperatures of daylight hard cream for different post curing treatments.





CONCLUSIONS

In conclusion, a new **dual cure IPN system** was obtained by blending a photocurable acrylic resin and a thermally reactive epoxy resin.

Two different epoxy monomers have been used: trifunctional and difunctional monomer. The tests have shown that the behaviour of the blend is strongly different according to the epoxy monomer used. The **trifunctional monomer** has seemed to be not suitable to produce a blend with good mechanical and thermal properties. Glass transition temperature have not been affected by the epoxy concentration and the epoxy has not been able to cure totally. In contrary, the **difunctional monomer** has shown a good match with the photocurable resin. Glass transition temperature has increased with the addition of the epoxy monomer. Also, the mechanical properties have been improved. In particular, the elastic modulus has shown a lower decrease rate making the keeping the blend stiff also at higher temperatures and making it suitable for product that need to operate with high temperatures.

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