# Reactive thermoplastic composite/Aluminium interface characterisation and optimisation

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## Introduction

Hybrid conception of metallic structure combined with fibre reinforced composite represent an interesting way for automotive application to produce lightweight structural part.

This study propose to evaluate the mechanical behaviour of a composite made of acrylic based reactive thermoplastic resin reinforced by glass fibre join with an aluminium blank. The adhesion between both components occurs directly during the polymerisation of the resin. An optimisation of the adhesion is proposed, through a mechanical surface treatment, a coating and a bulk modification.

## Surface and interface modification

In order to improve the interface properties, the Aluminium surface has been modified in particular in term of surface roughness by applying a Plasma treatment or a HCl attack. In addition to them, a silane based coupling agent has been physisorbed onto the aluminium surface.

<u>Plasma surface preparation:</u> the aluminium substrates were first plasma activated using an atmospheric plasma prototype available in the LIST facility. The plasma activation was used in a semi-dynamic DBD reactor in open atmosphere and based on an $N_2/O_2$ (80/20) mix controlled via an aerosol flow as a function of the atomization pressure.

<u>HCl treatment:</u> Chlorhydric acid was used to modify the physico-chemical properties of the aluminum substrate. To this end, manual treatment with a sheet of a lab-paper towel was performed with HCl 37%. Then the aluminum substrate was rinsed in deionized water. Surface modification is readily observable highlighting the roughness improvement and the change in extreme surface chemistry triggered by the acidic attack.

<u>Silane based coating:</u> The silane molecule [1, 2] has multifunctional groups which may react with the two dissimilar materials thereby forming a bridge in between them. Alkoxysilanes does not undergo covalent bonding with hydroxyl derivative functional groups without any requirement of prehydrolysis in contrary to SI-OH groups. Our strategy is to activate the trialkoxysilane by hydrolizing the alkoxy groups off thereby forming silanol groups well known to be more reactive. In this way a solution of isopropanol containing 1 %-wt. of 3-(trimethoxysilyl)propyl methacrylate was prepared. Aluminum substrates were treated via spraying process using the same silanol-solution with a flow of 100µL/min.

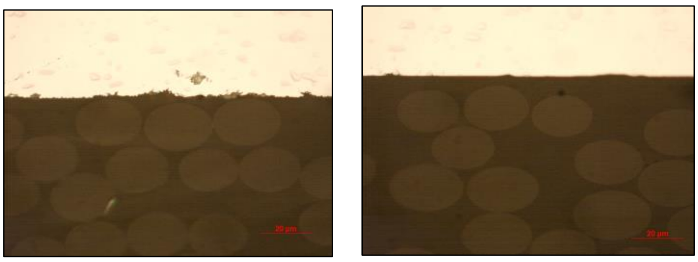

**Figure 1 : Micrographs of Elium© 150/GF & Aluminium: HCl Surface treatment (left); Silane based coating (right)**

## Experiments

The aluminium sheets are used as an insert during the infusion process. The dry glass fibre, made of five plies of 400g/m² unidirectional non-crimp fabric are place onto the aluminium substrat. Two reactive thermoplastic resin system dedicated to Liquid Composite Molding process have been evaluated: the Elium© 150 and the Elium© 151 SO [3]. As the formulation is changing, variation of the composition but also of the initiator, slight modifications of the mechanical properties are observed, but also a variation of the compatibility with the metallic substrate.

The 0.86 mm thick aluminium sheet is coupled in-situ during the infusion with 1.45 mm thick composite. After demoulding, 30 mm*15 mm samples were water-jet cut for Inter Laminar Shear Strength (ILSS) mechanical tests according as much as possible the ISO 14125 Standard.

## Results and analysis

Through the results presented in Figure 2 below, it appears that samples sprayed with Silane have significantly better mechanical characteristics compared to samples with HCl or Plasma treatments. Moreover, both HCl and Plasma have minimal effect on the behaviour of the samples; both failure modes being adhesive, and the results also being quite homogeneous for both load and displacement. For the HCl treatment, the roughness of the aluminium does not seem to be an impacting factor even if it is significantly increased (Cf. Figure 1).

Although the results are globally similar for the Silane based coated aluminium, the different samples give two different tendencies depending on the resin used: both fail within the composite, but samples with resin Elium© 150 have an overall better mechanical resistance, whereas Elium© 151-based samples are more ductile, with the resin even showing some signs of plastic deformation before failing. This slight difference can be explained by the nature of the resins: similar load/displacement curves for both resins have shown the same difference in behaviour, with Elium© 151 being more ductile but less resistant than Elium© 150. Overall, resin Elium© 151 seems to have a better compatibility with aluminium than Elium© 150. Complementary durability tests have to be performed in order to highlight this tendency.

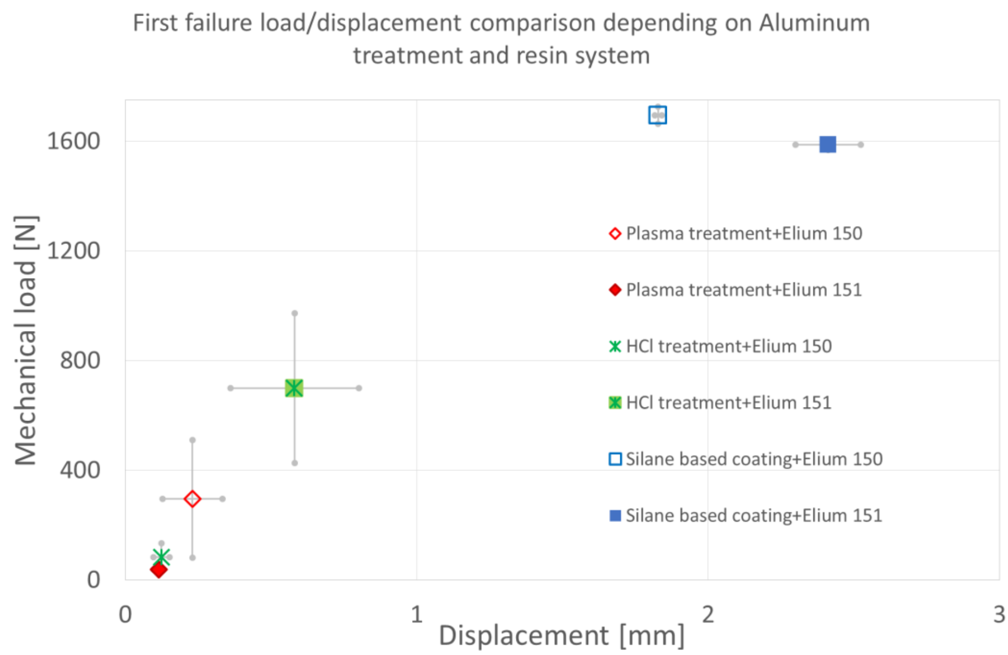


**Figure 2: ILSS result comparison**

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