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Designing fire safe composites

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Composites are increasingly used in transportation (railway, aircrafts,…) and their applications are more and more oriented toward structural parts. However the fire risk linked to the use of such organic materials has to be strongly reduced to keep this attractiveness and hence flame retardant solutions have to be used to fire proof them. A classical way to achieve fire performance is to incorporate fire retardants (FRs) in the bulk of the polymeric matrix of the composites at loading between 15 and 40wt%. However with such an approach, flammability properties of the composites will be achieved at the expense of their outstanding mechanical properties. To overcome those drawbacks, different innovative approaches have been developed recently in our group and two of them will be presented in the talk.

The first one consists in applying an intumescent coating on the exposed surface of the composite (2D epoxy/carbon fibers) used in aeronautical applications. The efficiency of this method will be demonstrated in term of fire performances comparing a coated and an uncoated sample. The fire test is performed according to ISO 2685 standard with a flame temperature of 1100°C and a thermal flux of 116 kW/m². Figure 1 shows the advantage of using a fire protective coating. A decrease of the temperature measured at the backside of the composite linked to the formation of a protective char is indeed observed. In addition, this kind of composite must also resist to the environmental conditions while maintaining its ability to resist to fire. The durability of the coating exposed to various ageing conditions will be thus discussed.

a)

Sample	backside T (°C)
Uncoated	430
Coated (300µm)	334

Figure 1 – a) Fire resistance properties, b) Composite sample with intumescent coating before a fire test, c) Composite sample with an intumescent coating after a fire test

The second approach is based on the modification of the fibres of the composite using sol-gel FRs finishing. 4 plys PA11/flax fabrics laminated composites have been prepared and the fabrics have been fully FR treated or only partially (the top ply only) using precursors containing silica and phosphorous. The materials were characterized using electron probe microanalysis (EPMA) X-ray mapping (figure 2) demonstrating that the FR treatments are homogeneously present on the fibres. The influence of the type of precursor on the FR properties of the treated textiles and of the final composites has been evaluated by cone calorimetry at 35kW/m². Decrease in the flammability was observed also when the upper ply was the only FR treatment.

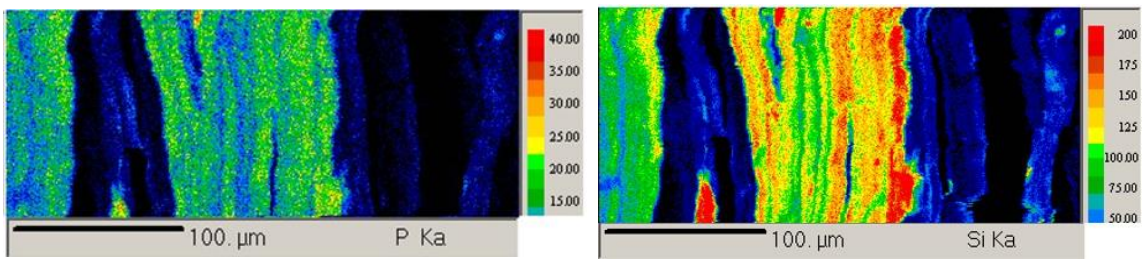

Figure 2 – EPMA P and Si mapping on fibers treated with Si and P containing precursor