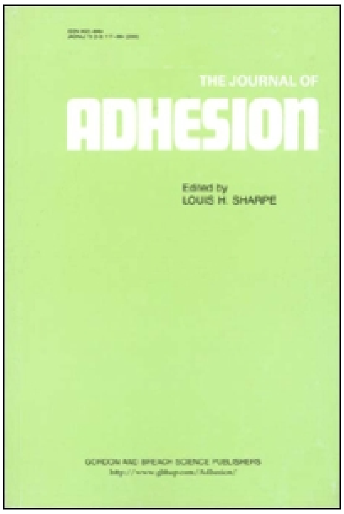

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Adhesion on Carbon-Fibre-Reinforced Plastics

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Long Abstract

Adhesion on Carbon-Fibre-Reinforced Plastics†

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KEY WORDS Adhesion to CFRP; boundary zone; carbon fibre reinforced plastics; durability; epoxy matrix; prebonding treatments.

INTRODUCTION

The adhesion on CRFP-laminates is technically often used but the microscopic mechanisms are not yet completely understood. Besides the task to characterize the surfaces closely enough, the principal problem to predict the mechanical, physical and chemical properties of the boundary zone remains unsolved. More of less only the "try and error" method leads to the development of adhesive bonding processes, which satisfy the demands of aircraft structures concerning quality, reproducibility and durability. Experiments with varying substrates, surface pretreatments and adhesives show that all these parameters have a distinct influence on the mechanical performance of the bonds.

† *This is the long abstract of a paper presented orally at the Tenth Annual Meeting* of The Adhesion Society, Inc., Williamsburg, Virginia, U.S.A., February 22–27, 1986.

EXPERIMENTAL

i) Material: The CFRP-laminates were made out of two different unidirectional epoxy matrix resin prepregs from CIBA-Geigy LTD. (Duxford, GB). Both the conventional 125°C curing Fibredux 913C-TS-5-35 and the toughened 180°C curing Fibredux 6376C-T400-5-35 were processed to 1 mm thick sheets with a $(0°/+45°/0°/-45°)_{sym.}$ structure, the 0° layer being the bonding surface.

Two RT-curing paste adhesives from Hysol, Dexter Division (Pittsburg, CA, U.S.A.) were used. These were the EA 934 NA as a proven standard metal bonding material and the EA 9321, which showed the best performance in screening tests. For a minor number of experiments also the 120°C curing film adhesive AF163-2K from the 3M-Company (St. Paul, MN, U.S.A.) was applied.

ii) Bonding Procedures: The curing cycles were performed in accordance with the manufacturers' data sheets.

The surface treatment varied mechanical, physical and chemical methods. Basis for comparisons was the peel-ply technique, which means that just before the application of the adhesive the peel ply was removed from the bonding surfaces.

Mechanical pretreatments were executed with different abrasives ranging from Scotchbrite 7558, type S (3M) to heavy sanding with SiC and Corundum grinding papers.

Physical pretreatments covered the usage of corona discharge. Chemically the surfaces were treated with different solvents and etching agents.

iii) Testing Procedures: As a mechanical property only the tensile shear strength was tested at different temperatures by using single overlap shear specimens.

Besides the initial reference values additional tests were performed after exposure in a hot/wet environment (70°C/70% r.h.) or 70°C warm water for 14 to 30 days until saturation. The completion of the absorption of water was indicated by extra traveller specimens. The bonding surfaces were characterized by optical microscopy and/or DRIFT spectra (Infrared spectroscopy).

RESULTS (SUMMARY)

Most decisive were the mechanical tests after a wet exposure. Depending on the substrate, the standard peel ply technique leads to rather different results (Figure 1), which indicate the easier to bond properties of the 913 material.

The performance of bonds with 6376 laminates can be significantly increased by a mechanical surface pretreatment. Most successful was a medium heavy sanding procedure using a "Scotch-briting" process with the addition of extra abrasive powder containing quartz and tensides (Figure 2). With this procedure about 40% of the bonding surface area consists of resin free fibers. Very convincing, especially on such optimized surfaces, is the performance of the EA9321 adhesive.

Not so successful were the physical and chemical pretreatments. Although we obtained extremely high values by etching the surface

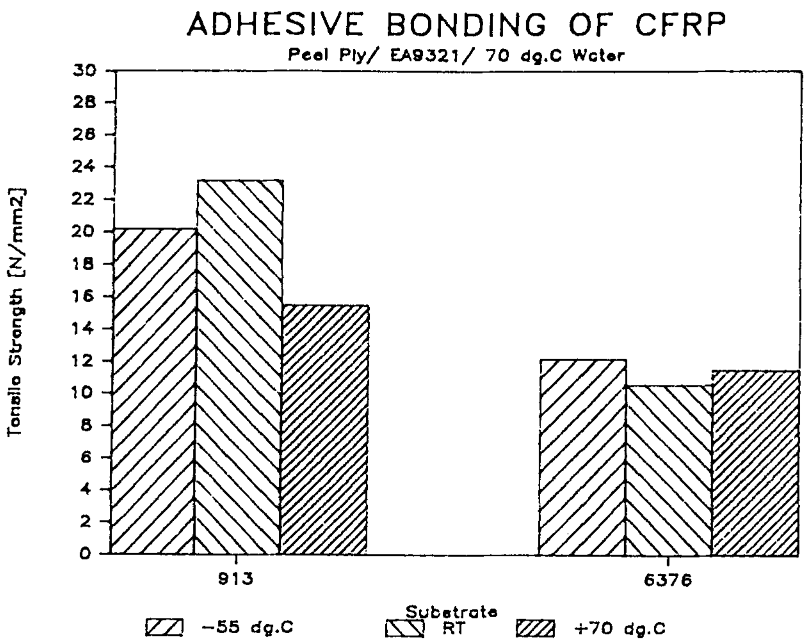

FIGURE 1.

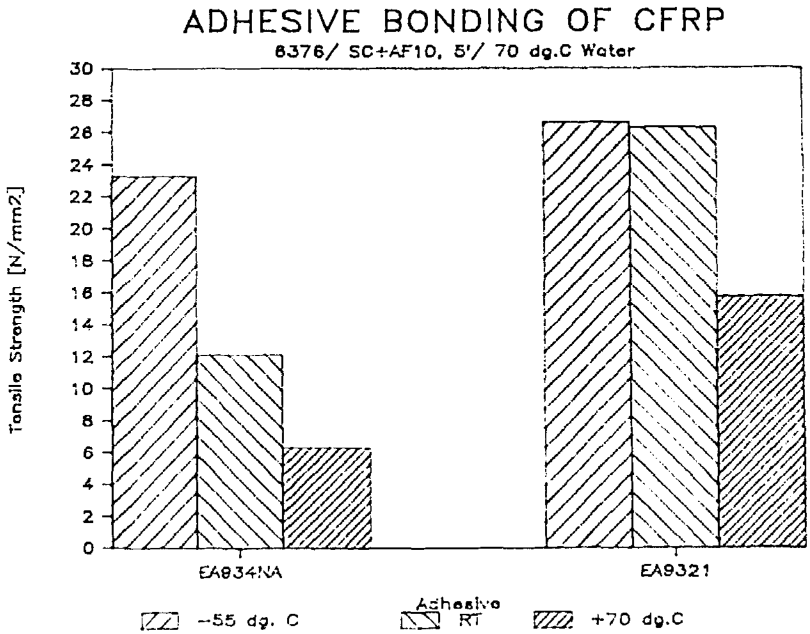

FIGURE 2.

with nitric acid (Figure 3) such bonds behave very poorly with a catastrophic adhesive failure mode after hot/wet exposure. Not so extreme, but similar, were the experiences with other etching chemicals and the corona discharge treatment, even when application parameters like temperature, time, concentration or energy were optimized in screening tests.

The pretreated surfaces could be distinguished from each other by optical microscopy and DRIFT spectroscopy. This gives one the ability to develop a test procedure in order to confirm a correct pretreatment process. On the other hand no criteria were found, which predict generally a successful bonding result.

CONCLUSIONS

An optimized bonding process for CFRP still needs the experimental optimization of the combination of substrate, surface pretreatment and adhesive.

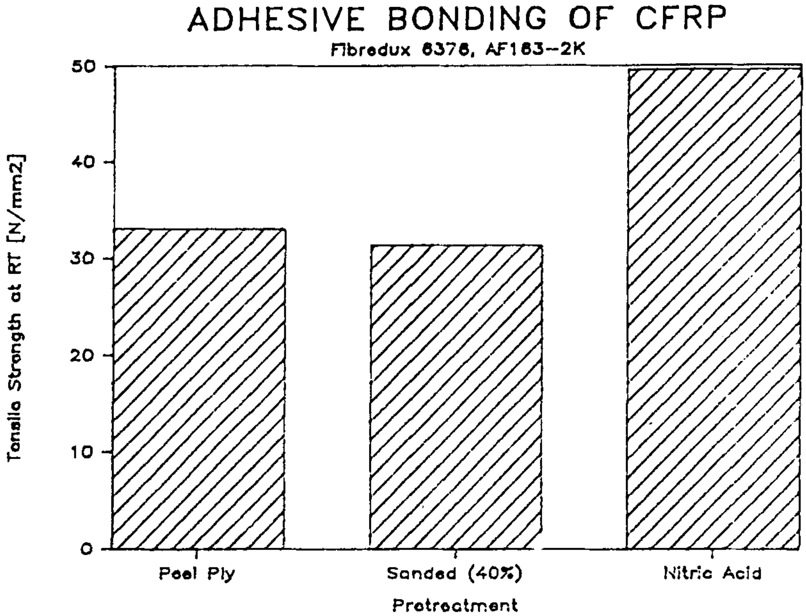

FIGURE 3.

Some of the obtained results indicate that even with RT-curing adhesives it may be possible to bond CRFP structurally, but a full qualification needs further durability testing.

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