

PHENOLIC RESIN CARBON FIBRE COATINGS FOR THE PRODUCTION OF  
CARBON FIBRE REINFORCED CARBONS  
WITH PHENOLIC RESIN AS MATRIX PRECURSOR

M.Müller, K.-M.Beinborn, K.J.Hüttinger  
Institut für Chemische Technik  
Universität Karlsruhe, D-76128 Karlsruhe

### INTRODUCTION

The problem of the coating of carbon fibres used for the production of carbon fibre reinforced carbon with phenolic resin as matrix precursor is illustrated in another paper of this conference [1]. Coating the fibres with an extremely thin polysiloxane layer is shown to have a very strong effect on the strength of the composites after carbonization and graphitization treatment. The present paper is concerned with the same problem, but with phenolic resin instead of polysiloxane coatings. The investigations with this coating are based on the fact, proven in the initial stage of the investigations by contact angle measurements, that the adhesion of a phenolic resin matrix to a cured phenolic resin coating is weaker than to a surface activated carbon fibre.

### EXPERIMENTAL

The studies on phenolic resin coatings were performed with the Tenax HTA-fibre from AKZO, Germany. The fibre was surface-treated, but not finished. For both, the fibre coatings and the composite matrix, the phenolic resin RP 226 from Bakelite, Germany, was used. It is a medium quality novolak with 9 % hexamethylenetetramine as curing agent ( coke yield 60 % ).

The fibres were coated by dipping into solutions of the resin in dry methanol ( ultrasonic apparatus, 30 s ). The coating was dried at room temperature and cured at 210°C in air. The same procedure was used for infiltration of the coated fibres with the matrix, but infiltration time was 120 s. UD-composites with a fibre volume fraction of 60% were pressed with the following temperature cycle: r.t. to 95°C, 10 K/min; 95°C, to 120°C, 7 K/min; 120°C, to 160°C and 160°C to 180°C, 4 K/min.

The residence times at the various temperatures were 30, 30, 120 and 720 min.

The flexural strength of the green, carbonized and graphitization treated composites was determined by the 3 point bending test, acc. to DIN 53452 [2]. The cross section of the composite samples was 6x2 mm, the length 100 mm and the distance between supports 80 mm.

### RESULTS

The main results are compiled in Figs. 1 (a)-(c). They show the flexural strength of the composites after curing (Fig.1(a)), carbonization (Fig.1(b)) and graphitization treatment (Fig.1(c)) in dependence of the concentration of the resin solution applied for coating of the fibres (coating solution). The thickness of the coatings was such thin that it could not be determined neither gravimetrically nor by scanning electron microscopy.

In the cured state of the composites the flexural strength is increased by the phenolic resin fibre coating from 1000 MPa (non-coated fibre) or 1300 MPa (fibre with commercial epoxy finish), respectively, to 2300 MPa. This maximum value was found with the most diluted coating solution. The low flexural strength value of 1000 MPa for the non-coated fibre is unusual, but clearly reproduced. A value of 1300 MPa was found with the same fibre but from another spool [3]. As the fibre strength was found to be constant from spool to spool, the different values can only be explained by the extent of surface treatment [4].

After carbonization at 1000°C (5 hours), a maximum flexural strength of about 400 MPa was found but, as compared to the cured composites, at a slightly higher concentration of the coating solution (Fig.1(b)). As observed with the cured composites, still higher concentrations are less effective. After graphitization

treatment at 2100°C the maximum flexural strength value is increased to 800 MPa, it is found at a still higher concentration of the coating solution. Without the phenolic resin coating of the fibres or with commercially finished fibres the flexural strength values are much lower. It is noteworthy that the maximum flexural strength values of 2300, 400 and 800 MPa of the cured, carbonized and graphitization treated composites are the same as obtained in the preceding study with the same carbon fibres, but with an optimized polysiloxane coating [1].

### SUMMARY

Phenolic resins, carbonized and graphitization treated, show a strong shrinkage up to 15 %. In a carbon fibre reinforced composite this shrinkage can cause a severe damage of the matrix and the fibres, if the resin strongly adheres to the carbon fibre surface. The results show that this problem can at least partially be overcome by a reduced and optimized adhesion of the phenolic resin to the carbon fibre surface.

### ACKNOWLEDGEMENT

Financial support of this study by the German Research Foundation ( DFG ) is gratefully acknowledged.

### REFERENCES

1. K.-M. Beinborn, K.J. Hüttinger; this conference.
2. DIN 53452, Deutsche Industrie Norm, Beuth Verlag, Berlin, (1977).
3. K.-M. Beinborn, M. Müller, K.J. Hüttinger; *Carbon*, accepted for publication.
4. U. Zielke, K.J. Hüttinger, W.P. Hoffman; *Carbon*, to be submitted; see also this conference.

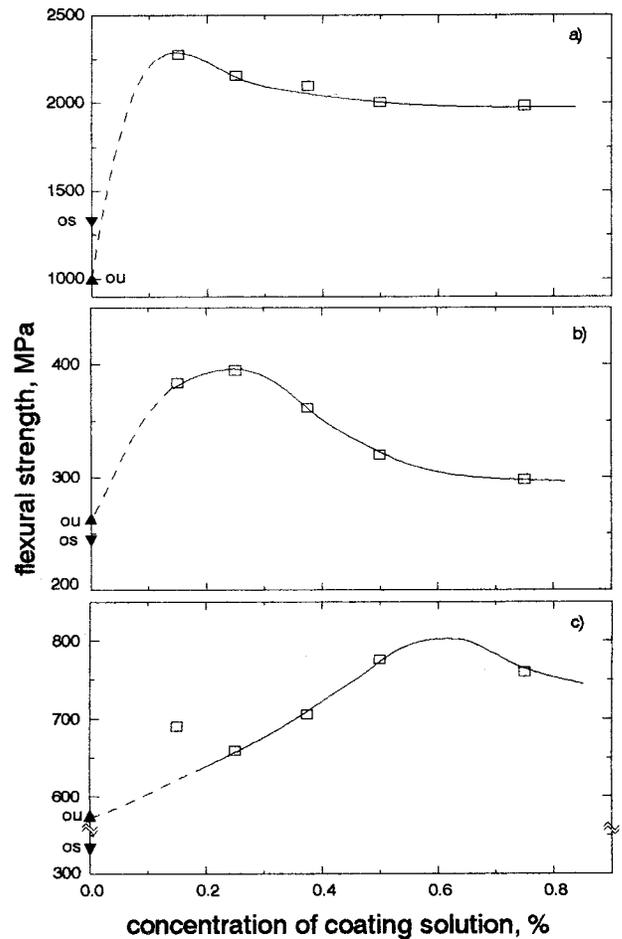


Figure 1 Flexural strength in dependence of the phenolic resin concentration in the solution used for the coating of the fibres. (a) cured, (b) carbonized, (c) graphitization treated. ou: commercially surface-treated, unsized; os: commercially surface-treated and sized.