Determining the influence of material structure and sizing on the comminution behaviour of carbon fibres

J. Mahl, M. Wexler, M. Hauser, W. Baumann and D. Stapf

Institute for Technical Chemistry, Karlsruhe Institute of Technology, Karlsruhe, 76021, Germany
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Presenting author email: jonathan.mahl@kit.edu

Carbon fibres (CF) are mainly used in aerospace technology, the automotive industry, the wind energy sector and in competitive sports. Thanks to their very good mechanical properties at low density, the use of carbon fibre reinforced plastics (CFRP) can reduce the weight of components, thus saving material and energy resources during the product's lifetime. However, the manufacturing process of CF makes high demands on process control, is energy intensive and requires high investment costs for plant technology. If CF are further processed into fabrics and embedded in a plastic matrix, the price of the product (CFRP) increases again. Despite the high manufacturing costs, the demand for CF and CFRP has steadily increased in recent years and recycling of CFRP is desirable from an environmental and economic point of view.

Essential for all optional recycling processes is the homogeneous and reproducible comminution of CFK, as well as the knowledge of the dependencies of the comminution behaviour on the material properties of the CF.

For this purpose, an evaluation routine was developed, consisting of a sample preparation of the milled CF, image generation by optical digital microscopy, automatic image analysis and data post processing. This allows the automatic evaluation of up to 15,000 objects per sample and their categorization according to particles (L/D < 3), fibres (L/D > 3) and WHO fibres (L/D > 3; L ≥ 5 µm; D ≤ 3 µm), using automatic image analysis software FibreShape (IST AG, Switzerland).

In this study CF based on polyacrylonitrile and mesophase pitch were crushed in a planetary ball mill at selected specific energy inputs while varying the speed and the treatment duration (Figure 1), and the comminution behaviour was compared with the mechanical fibre properties. In another series of tests, the same CF were pyrolyzed prior to mechanical grinding to determine the influence of sizing on the comminution behaviour of the CF.

In addition, scanning electron microscopies (SEM) of the fibres were taken before and after comminution to characterize the fibres' surface and cross section.

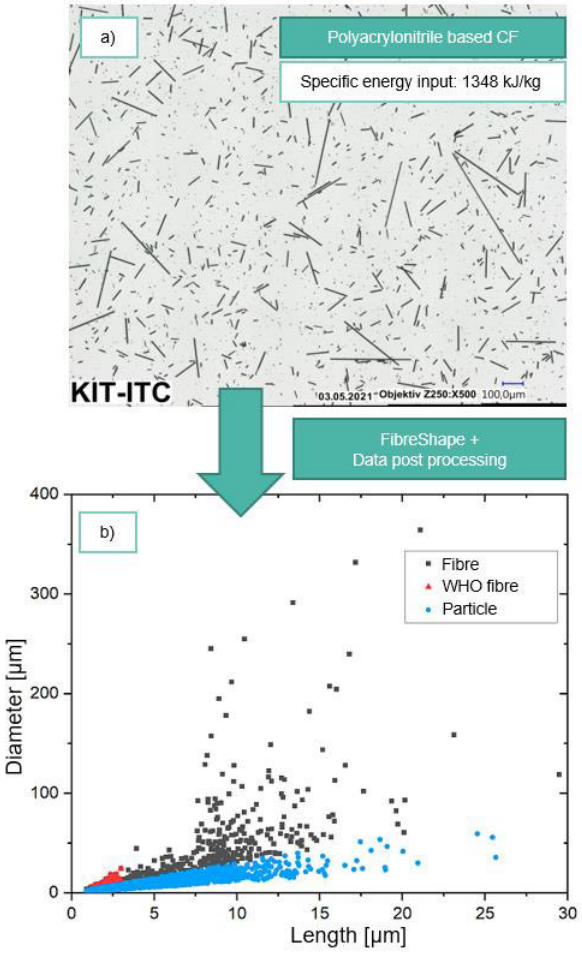

Figure 1. a) Light microscope image of a grinding sample of CF at a rotation speed of 300 rpm and a grinding time of 5 min (1348 kJ/kg). b) Evaluation of the grinding sample in terms of length and diameter of the objects.

The tests showed no correlation between the tensile strength respectively Young's modulus and the comminution behaviour of the CF, but an influence of the sizing was found. It should be mentioned that respirable fibre fragments were generated in all comminution tests, which should be taken into account with regard to health hazards in the mechanical treatment of CF.

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