WAXS Measurements of Multi-Walled Carbon Nanotubes

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This contribution shows the results of the WAXS measurements on functionalized and unfunctionalized multi-walled carbon nanotubes provided by FutureCarbon GmbH. The aim was to investigate their structural properties and layer distances as well as the influence of functionalization of the sidewalls via a direct covalent sidewall functionalization.

Experimental:

The measurements were carried out at the A2 beamline at HASYLAB, DESY (Hamburg, Germany) with a WAXS-detector distance of one meter and a beam wavelength of 0.15 nm. The reference sample for calibration has been a piece of PET. All samples have been prepared by giving grinded MWCNT into a thin aluminium foil and fixing it in a sample holder.

Results and Discussion:

Figure 1 shows the comparison between amine functionalized multi-walled carbon nanotubes from FutureCarbon and unfunctionalized purified MWCNT of the same batch. The signals of the two different MWCNT samples are showing two different peaks at 2Θ = 23.53° and 27.86° (d = 0.41 nm and 0.31 nm). Compared with the common known layer to layer distance of turbostratic disordered graphite layers and the distance value of CNT walls of ~0.34 nm known from literature [1,2,3] most of the walls in average have a smaller wall-to-wall distance. The appearance of the second peak is interesting. It relates with a distance of d = 0.41 nm, which is 1.2 times the literature value.

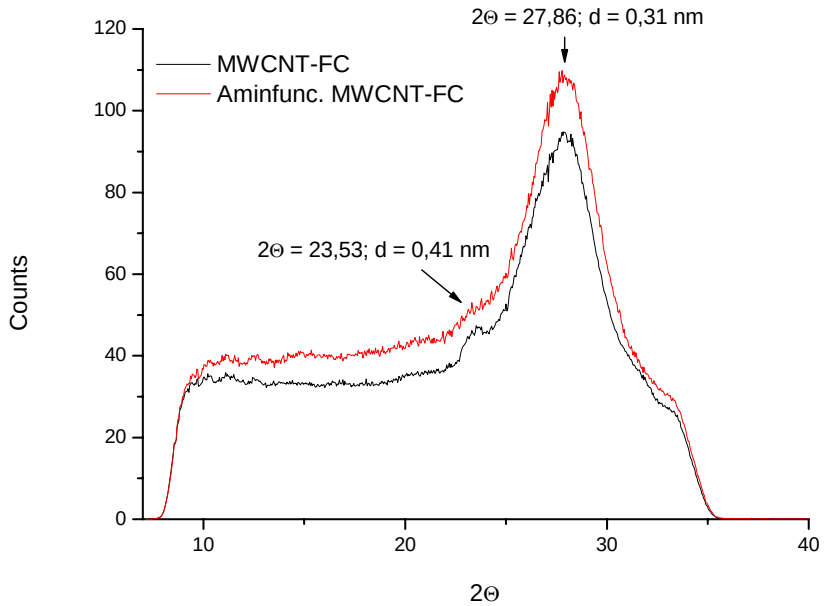

Figure 1: WAXS measurement of functionalized and unfunctionalized MWCNT

Comparing the results for the unfunctionalized MWCNT with the TEM picture (fig. 2) of the unfunctionalized sample, the small peak could be explained by a disorder of the outer MWCNT walls. These disturbed walls have a bigger layer distance than the ordered walls. The reduction of the intensity of the small peak can be tracked back to the mechanism of the functionalization, which tells us that first the defect sites, and second the non-defect sites of the CNT were functionalized [1,4]. This may lead to a reduction of internal stress and so to a realignment of the walls. A second reason may be that the imperfect walls, which can be found in fig. 1, were partially removed from the CNT surface, which leads also to a more ordered system.

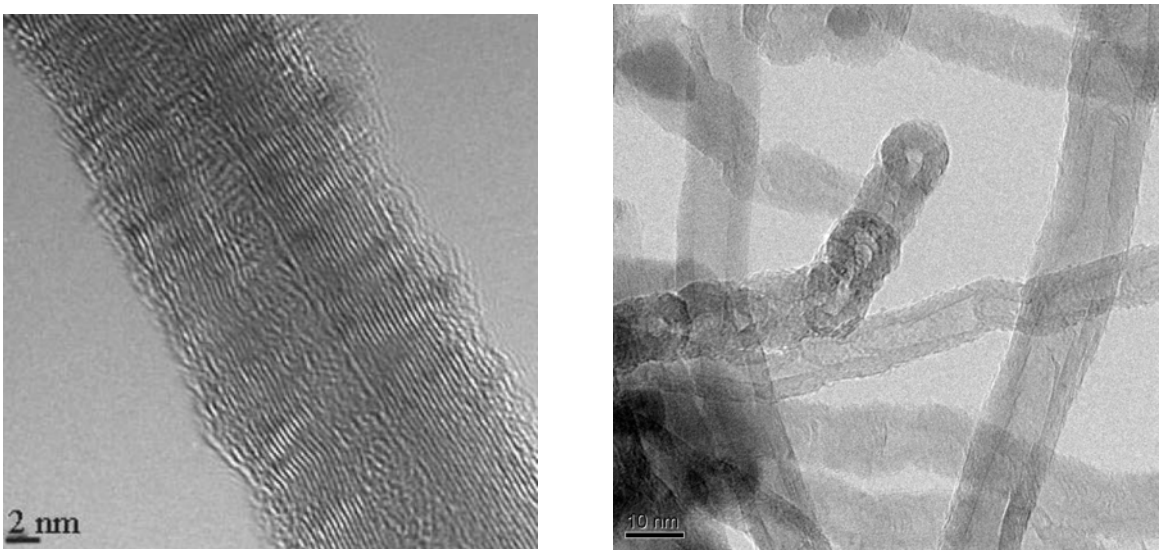

Figure 2: TEM measurement of unfunctionalized, purified MWCNT-FC

In order to prove these assumptions, and to investigate the differences between CNT with different kinds of functional groups, further measurements should be made.

Conclusion:

Based of these first studies of unfunctionalized, purified and functionalized MWCNT-FC it can be said that there is an influence of the functionalization on the structure of the MWCNT-FC. The defects and unordered structures of the CNT known from the TEM measurements can be visualized with WAXS, which additionally gives more information about structure and quality of MWCNT.

References

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