FINAL REPORT

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FINAL PUBLISHABLE SUMMARY REPORT

Due to the high anisotropy of their shape, carbon nanotubes exhibit a very low percolation threshold, forming continuous paths at a very low loading. One of the aims of the project was to evaluate the effect of alignment on the performance of the networks of carbon nanotubes. Since liquid crystals have proved to be able to transfer their orientational order onto embedded nanotubes and since their degree of order can be easily changed, they appear to be the ideal candidates to test the alignment-dependent behaviour of carbon nanotube networks. The alignment ability has been demonstrated for lyotropic as well as for thermotropic liquid crystals, showing to be a feature not of a specific type of molecular structure but of this class of materials *per se*. It is therefore attractive to employ a liquid crystal host that influence the alignment of carbon nanotubes as a general route for studying the relation alignment-conductive properties. However, there are liquid crystals with conductive properties thus it is even more interesting to use those that on one hand can provide organization of CNTs and on the other contribute to form conductive paths between not touching tubes. They would, in this way support the conduction of the network bridging the possible gaps. Moreover, liquid crystals are optically transparent thus they don't disturb the optical transparency of the composite films.

Among the different types of liquid crystals, discotic liquid crystals exhibit conducting properties making them organic semiconductors. The name reflects the molecular shape, being of disk-like form. These molecules can form columns, along which electrical current can flow, while being hexagonally packed in the direction perpendicular to the columns. In the nematic liquid crystals phase, that possesses only orientational order, the transferred alignment of carbon nanotubes was orientational, along the common liquid crystal direction. In columnar phases the common direction is the one of the columns. The study of the alignment of columnar phases of discotics in thin films is therefore of great importance in this project because it should affect the alignment of carbon nanotubes as well as the formation of additional conductive paths. This study constitutes the first step towards the realization and control of films of organized LC-CNT composites.

The organization of discotics in open geometries, e.g. on substrates and air as other interface, is an open research issue. We have studied the dependence of the alignment on film thickness of hexapentyloxytriphenylene discotic liquid crystal. We have used this discotic because it is known to align relatively easily and uniformly in a cell geometry, e. i. in films sandwiched between two glass plates. In this geometry the columns form perpendicularly to the substrates running continuously between them. Photoconductivity was measured in this configuration. The open configuration has interfaces with difference surface tensions, influencing the induced alignment. We have seen in polarizing optical microscopy that for thicker, drop-casted samples the stable configuration is with columns perpendicular to the substrate like observed in cell geometries. However, when the film thickness is reduced, by controlling the LC concentration in solvent, the alignment of spin-coated films becomes planar and with a self-organized fibrillar structures. The alignment was stable as proved by monitoring the orientation after thermal treatment. Moreover, the stability of the structure was reflected also in the broadening of the temperature range of existence of the observed phase. Different film thicknesses, between 5 and 50 nm, were realized all showing fibrillar structures and more uniformly organized when the thickness was reduced. Optically the films were not visible due to the reduced thickness, making them attractive for the integration with carbon nanotube networks. The self-organization of these fibrilles, aligned along a common orientation, was on a scale of tents of micrometers, as detected by atomic force microscopy. The fibrillar structure together with the large scale organization of these discotic films make them very attractive candidates for the realization of functional carbon nanotube networks.

Further steps could not been pursued because of the stop of the project due to the move of the researcher to another institution abroad.