Electrical conductivity measured in chains of carbon atoms

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As strings of monoatomic thickness, chains of sp^1-hybridized carbon atoms constitute the logical one-dimensional phase of carbon. They have been proposed theoretically since a long time until they have been observed in electron microscopy studies. However, electrical measurements on these monoatomic chains have not been feasible. Now, by using a measuring system with an STM tip in a TEM specimen stage, we were able not only to produce carbon chains but also to pass a current through them and so to measure their electrical properties for the first time [1].

Contacts between transition metal tips and graphitic deposits were established while an electrical bias was applied between the two components. By slowly retracting the tip, graphene ribbons were pulled out of the deposit. Occasionally, chains of carbon atoms were seen to unravel from the graphenic material so that an atomic chain spanned between the electrodes. The observed chains had lengths of up to 10 – 15 atoms and lifetimes of some seconds under observation in the electron beam of the TEM. This allowed the monitoring of the current through the system and the measurement of current-voltage curves during their observation. The formation of the chains was accompanied by a characteristic drop in conductivity of the system. The overall conductivity of the chains on the order 10^{-7} – 10^{-9} A at applied voltages up to 1 V was much lower than predicted theoretically for an unperturbed chain. Comparison with DFT and many-body perturbation theory shows that both the contact resistivity and strain in the chains determine their conductivity. Strain transforms the chain from cumulene, with double bonds throughout the chain, to polyyne with alternating single-triple bonds. Furthermore, the strain has a decisive influence on the bandgap of the chain. This is also indicated by different I/V-curves resulting from measurements on different chains. A unique cumulene or polyyne configuration is unlikely to exist due to varying strain and the stabilization of dimerization under stress.

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Reference:

[1] O. Cretu, A. R. Botello-Mendez, I. Janowska, C. Pham-Huu, J.-C. Charlier, F. Banhart, *arXiv* 1302.5207