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Fullerenes and carbon nanotubes at high pressure: Towards new functional materials

The application of pressure in the range of 10-12 GPa to fullerenes at temperatures of about 1000 °C is used to synthesize materials with outstanding properties including hardness exceeding that of diamond [1]. However, the “hard” p, T synthesis conditions hinder the practical use of these materials. Therefore characterization of structural and physical properties of C\textsubscript{60} and C\textsubscript{70} in the polymeric state and phase transitions between different polymeric structures of fullerenes is important to understanding the formation of these ultra-hard carbon-based materials. This presentation will review the results of our recent studies of the spectroscopic and thermal properties of polymeric phases of C\textsubscript{70}, including dimers (C\textsubscript{140}) and one-dimensional (zig-zag) chain polymers [2]. We describe a special effort [3] which was dedicated to testing the predicted transformation of 2D C\textsubscript{60} polymer into a 3D metallic phase at high pressure [4]. Polymeric forms of fullerenes have potential for use in molecular electronic devices. We have measured electron tunnelling in single-electron transistors made from C\textsubscript{140} and observed its strong coupling to the stretching (inter-cage) vibrational mode [5]. The results are discussed in terms of the Franck-Condon model.

We will report on our high-p studies of another molecular form of carbon - carbon nanotubes (CNTs) – which have enormous potential for materials synthesis due to their outstanding physical properties. We will discuss a possibility of CNTs polymerization and demonstrate an example of double-walled (DW) CNTs that high pressure is a very suitable tool for probing structural stability and tuning vibrational and electronic properties of CNTs. Finally, we present our recent data on synthesis and characterization of CNT- and fullerene-based composite materials.

References: