Tailored Growth of 1D Carbon Nanostructures via Chemical Vapour Deposition and their Application in Advanced Nanocomposite Materials

Costas A. Charitidis[1]
Aikaterini-Flora A. Trompeta[1]

[1] Research Lab of Advanced, Composite, Nanomaterials and Nanotechnology (R-NanoLab), Materials Science and Engineering Department, School of Chemical Engineering, National Technical University of Athens, 9 Heroon Polytechniou str., Zographou, GR-15780, Athens, Greece

charitidis@chemeng.ntua.gr

Carbon nanostructures and specifically nanotubes and/or nanofibres, are important materials in nanotechnology as a prime example of one-dimensional structures. Further development of this technology, as well as the use of these nanomaterials in a wide range of applications, depends on the availability of these nanomaterials at reasonable prices and feasible quantities. The aim of this work is the tailored growth of nanotubes and/or nanofibres in a range of demanding applications that are mainly used in the construction sector, exploiting their unique properties. The synthesis the carbon nanostructures, their proper chemical modification which has been selected according to the application, and finally the evaluation of the properties of the final nanocomposite material in which the nanomaterials are used, have been considered.

For the tailored growth of the fibrous carbon nanostructures, thermal chemical vapor deposition technique (T-CVD) has been chosen, which is preferable for the synthesis of large amounts of carbon nanotubes, as it allows easy control of parameters and is accompanied by lower energy requirements [1]. Two main routes of developing one-dimensional structures have been considered: the supported catalyst approach where, acetylene is used as carbon source, and catalysts are synthesized in house with transition metals and porous substrates, as well as the floating catalyst approach, in which both the precursor compound and the carbon source are simultaneously introduced into the reactor in vapour form [2]. The results from the use of the produced nanostructures in a range of applications are presented. In particular, nanotubes and/or nanofibers are first tested in polymer nanocomposites [3], such as epoxy resins [4] and organic coatings [5], in cement mortars [6], and finally in electronic applications (e.g. supercapacitors) [7].

References

[1] C.A. Charitidis, et al., Manufacturing nanomaterials: from research to industry. Manuf. Rev. 2014, 1, 11.

[2] A.F. Trompeta, et al., Towards a holistic environmental impact assessment of carbon nanotube growth through chemical vapour deposition, J. Clean. Prod. 2016, 129, 384–394

[3] A.F. Trompeta, et al., Assessing the Critical Multifunctionality Threshold for Optimal Electrical, Thermal, and Nanomechanical Properties of Carbon Nanotubes/Epoxy Nanocomposites for Aerospace, Aerospace 6 (1), 3, 2019

[4] S. Termine, et al., Novel CNTs grafting on carbon fibres through CVD: investigation of epoxy matrix/fibre interface via nanoindentation, MATEC Web of Conferences 304, 01014, 2019.

[5] E.P. Koumoulos, et al., Investigation of MWCNT addition into poly- dimethylsiloxane-based coatings, Plast. Rubber. Compos. 2016, 45:3, 106- 117

[6] E.K. Karaxi, et al., Fabrication of carbon nanotube-reinforced mortar specimens: evaluation of mechanical and pressure-sensitive properties, MATEC Web of Conferences, 2018

[7] P. Bondavalli, et al., Deposition of graphene and related nanomaterials by dynamic spray-gun method: a new route to implement nanomaterials in real applications. Journal of Physics: Materials 2 (3), 032002, 2019