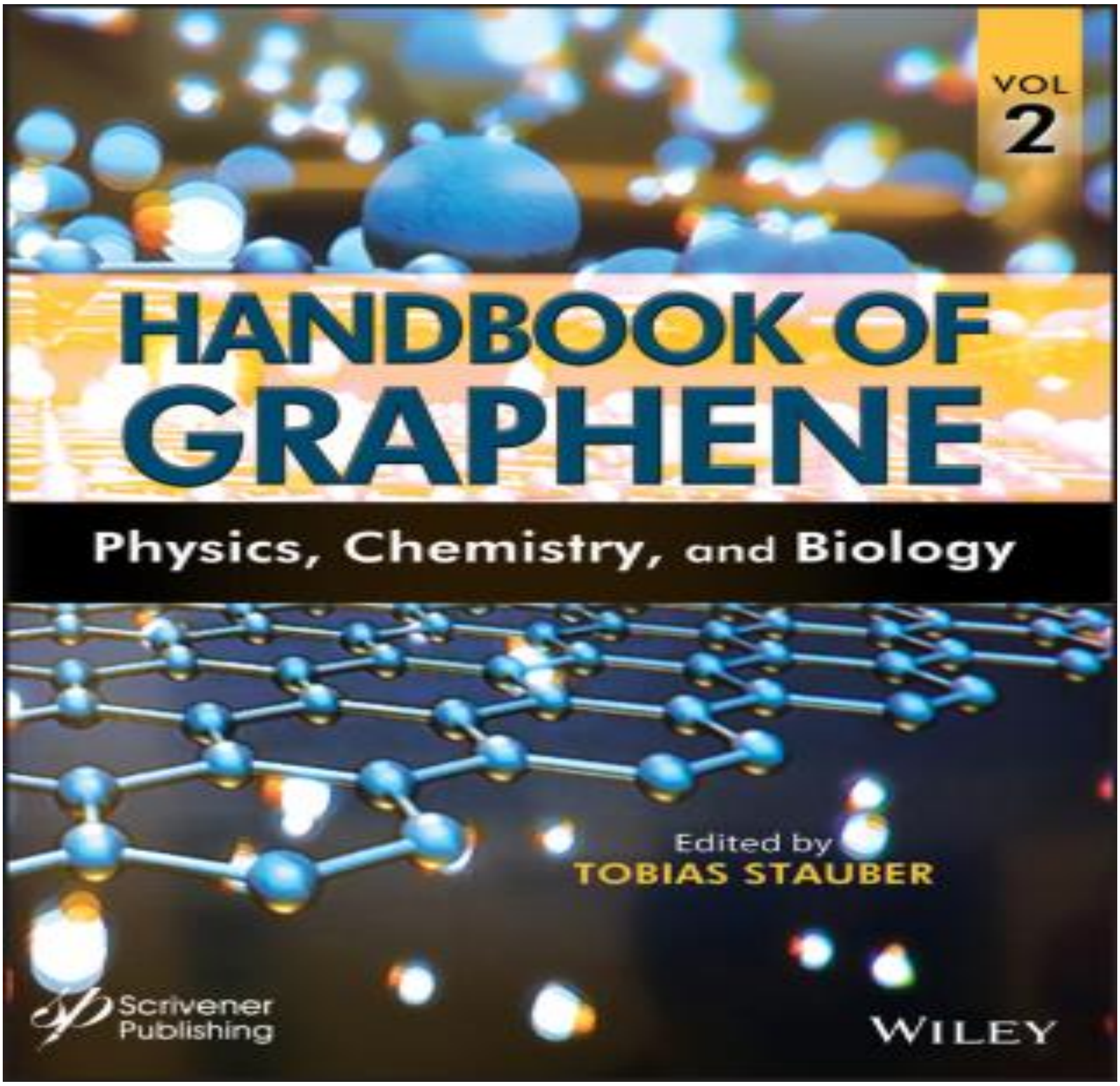

Chapter 19

Nature of Graphene, Its Chemical Structure, Composites, Synthesis, Properties, and Applications

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Abstract
In recent times, graphene, a super-carbon-based nanomaterial, has spurned research interests because it is the most important of the list of available carbon nanomaterials, has distinct properties, has significant impact in human lives, is biodegradable, and finds application in various disciplines, including physics, chemistry, engineering, biomedicine, biotechnology, etc. It is a two-dimensional monolayer material characterized by sp^2 hybridized carbon atoms arranged in a honeycomb lattice/hexagonal array. Its usefulness or functionality is enhanced by the ease with which it undergoes chemical modification to suit a particular application. The new technology behind the synthesis of graphene and its derivatives is benign (green), which complements its wide use. For future applications, its prospective use requires detailed understanding of the technology behind its formation. Its kinetics, anticorrosion properties and photoluminescence mechanism, and how they compare favorably with those of carbon and polymer nanodots (nanoparticles) are also currently being experimented. There are enormous justifications why graphene has gained alarming interest in the fields of science and engineering and some of them include its outstanding carrier mobility, transconductivity, ultimate thickness, and stability. In this chapter, the following subsections shall focus on the nature, chemical structure, properties, synthesis, and applications of graphene and its composites.
Keywords: Anticorrosion properties, chemical modification, graphene, nanocomposites, transconductivity

19.1 Introduction

Graphene is a super carbon allotrope with unique properties that are responsible for its recent attraction as a potential material for the advancement of technology. In this chapter, the nature of graphene, its physicochemical properties, its chemical structure, its synthesis, and applications are discussed. Graphene is a special material comprising of a planar sheet of carbon atoms looking like a honeycomb (Figure 19.1); it is the foundation block for graphitic materials and can be folded into buckyballs/fullerenes (i.e., the third allotrope of carbon), one-dimensional nanotubes, or converted/clustered into graphite. According to Thielemans ***et al.*** [1], it is the hardest ever measured material with a Young modulus value of 1 TPa and tensile strength of 130 GPa. Its distinct electronic properties (i.e., absence of localized charges, quantum effect, and super-high mobility) are as a result of its pi-electrons, which form its conduction and valence bands; the points where these two bands are superimposed in graphene are called Dirac points. Graphene is known to have high electrical conductivity, which is a result of the presence of fast moving electrons in its crystal lattice when the electrons are exited via thermal application or by current influx into the material. Graphene can be transported with high carrier mobility of approximately 15,000 $cm^2/m\ s$ at 298 K over very short wavelengths of approximately 4×10^{-6} m. Its high surface area makes it a useful material for making sensors since the entire material plays a significant role in the sensing of signals and other particulates, molecules, atoms, and ions/species. Other areas of application include transistor design, electrochemical cells, capacitors, biosensory devices for detecting enzymes, ferromagnetism, nanoelectronics/nanocomposites of polymeric materials, and materials that are known to exhibit photoelectric effect such as light emitting diodes (LEDs), and also as capacitive sensors in touchscreen devices of android phones.