Chapter 6
Corrosion Resistance Potential of Metal–Matrix Composites Reinforced With Carbon Nanofibers and Carbon Nanotubes

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ABSTRACT

Carbon nanotubes are attractive and promising fillers due to their chemical inertness and high mechanical, electrical, and thermal properties. From the conjugation of carbon nanotubes with inorganic hybrid, it is expected to obtain nanocomposite coatings that combine high anti-corrosion efficiency with improved mechanical stability. This book chapter presents a concise review of microstructure and corrosion behaviour of different nanotube composite coatings. In the first section, the authors briefly explain the science behind the corrosion and corrosion resistance of nanotube composite coatings, followed by a selection of current state and recent advances on promoted nanotube composite coating: Al, Cu, Mg, Fe, Ni, Mg–Zn, Mg–Al, NiCo, and ZnCo-carbon nanotube composite and based matrix composites coatings. Recent development of graphene reinforced metal matrix nanocomposites has been studied. Challenges needed to be rectified before the synthesis of metal-matrix nanocomposites. Finally, the authors discuss the relevant topics, highlighting recent progress and unresolved questions.

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1. INTRODUCTION

A material made up of more than one component is called a composite. Nanocomposite materials typically comprise a matrix supporting one or more fillers that are particles, sheets, and fibers with dimensions less than 100 nm and with a high surface-to-volume ratio. Nanocomposites are lighter, stiffer, less brittle, more scratch-resistant, more recyclable, more flame retardant, less porous, and better conductors of electricity than normal composite materials. Adding nanofillers such as carbon nanotubes to composite makes the material longer lasting and more resistant to wear and tear and breakage without affecting the surface quality or transparency.

Owing to the high heat resistance and low flammability of some nanocomposites, they are suitable for use as insulators and wire coverings. Nanocomposites containing additives as well as filler components can show substantially improved properties such as decreased permeability to gases, water, and hydrocarbons; improved thermal stability and flame retardancy and reduced smoke emissions; and better chemical resistance, surface appearance, electrical conductivity, and optical properties. Nonporous nanocomposites are used in the packaging of foods and drinks, vacuum packs, and to protect medical instruments: they have high durability, strength, or recyclability (Singh 2019 & Caseri 2003).

Nanocomposites have unique properties at the nanoscale level. They are widely utilized in various fields such as in water treatment, supercapacitors, electroconductive scaffolds, anticorrosive/antiballistics, optoelectronic devices, solar cells, hard coatings, biosensors, nanodevices, and green energy generation.

Nanocomposites are composites with at least one component of nanoscale dimensions. They have been described as the materials of the 21st century and offer new technology and business opportunities for all sectors of industry. Nanocomposite materials may be classified on the basis of their matrix materials: metal matrix nanocomposites (Fe–Cr/Al_2O_3, Ni/Al_2O_3, Co/Cr, Fe/MgO, Al/carbon nanotube [CNT], and Mg/CNT), ceramic matrix nanocomposites (Al_2O_3/SiO_2, SiO_2/Ni, Al_2O_3/TiO_2, and Al_2O_3/SiC), and polymer matrix nanocomposites (thermoplastic/thermoset polymer/layered silicates, polyester/TiO_2, polymer/CNT, etc.). Nanocomposite systems have particular sizes at which significant changes in their properties may be expected, such as catalytic property at <5 nm, making hard magnetic materials soft at <20 nm, refractive index changes <50 nm, producing supermagnetism and other electromagnetic phenomenon at <100 nm, strengthening and toughening at <100 nm, and modifying hardness and plasticity at <100 nm (Kamigaito, 1991).

Tribological coating of tools for hard and dry cut operations such as drilling, turning, and milling has been made efficient by the development of nanocomposites (Lim et al. 2002, Voevodin and Zabinski 2005). Polymer nanocomposites based on carbon bucky fibers provide lightweight bodies for cars. In aerospace, electronic, and military domains, metal- and ceramic-based nanocomposites are highly utilized in battery cathodes, microelectronics, sensors, catalysts, structural materials, and in electronic, optical, magnetic, and energy conversion devices. Example metal nanocomposites include Fe/MgO for catalysts and magnetic devices, Ni/TiO_2 for photoelectrical applications, Al/SiC for aerospace, naval, and automotive structures, Cu/ Al_2O_3 for electronic packaging, and Au/Ag for optical devices and light–energy conversion (Sternitzke, 1997& Choa et al. 2003). CNT-based ceramic nanocomposites are utilized in aerospace and sports goods, composite mirrors, and automotive spares, and are also useful for flat-panel displays, gas storage devices, toxic gas sensors, lithium-ion batteries, and conducting paints. They are highly useful in engineering and biomedical applications. However, they are of limited use industrially because of challenges in processing and their cost (Andrews & Weisenberger 2004, Peigney et al. 2000, Alexandre & Dubois 2000). Hammouda et al. (2011) reported the use of zinc as an anticorrosive agent

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