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Review

Morphology, large scale synthesis and building applications of copper nanomaterials

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HIGHLIGHTS

- Copper nanomaterials.
- Large scale synthesis which is essential for construction.
- Building applications.

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ABSTRACT

The superior physical properties of nano-enhanced building materials are becoming more accessible in modern construction, especially since such materials promise better durability and substantial conservation of energy when applied on the large scale. Although copper nanomaterials (CuNMs) have been widely studied and adopted in the fields of electronics, catalysis and biology, they have yet to be studied and reported from a building materials perspective. Herein, we introduce CuNMs and their novel enhancements to phase change materials (PCMs), resins, anticorrosion, anti-fungal/bacterial coatings and other nanofluids in the context of the built environment's. Other than emphasizing the significant contributions of CuNMs to the built environment, this review also outlines the processes of producing CuNMs on the large scale and the various morphologies that can be obtained.

Contents

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Nomenclature

AA	Aminoacid	MP	Microparticle
ABA	Ascorbic acid	NP	Nanoparticle
APP	1-Amino-2-propanol	NM	Nanomaterial
BZ	Benzoin	OYA	Oleylamine
CNT	Carbon Nano Tube	OYA	Oleic Acid
CNF	Carbon Nano Fiber	PA/PANI	Palmitic Acid /Polyaniline
CuNCs	Copper Nano Crystals	PCM	Phase Change Material
CuNMs	Copper Nano Materials	PCC	Polymer-Cu Composite
CuNPs	Copper Nano Particles	PEG	Poly(ethylene glycol)
CuNWs	Copper Nano Wires	Ppy	Polypyrrole
CSTR	Continuous Stirred Tank	PVP	Poly(vinylpyrroli-done)
CTAB	Cetyltrimethyl Ammonium Bromide	PW	Paraffin Wax
DEA	Diethanol Amine	SAED	Selected Area Electron Diffraction
DDA	1-Dodecylamine	SEM	Scanning Electron Microscope
DIZ	Diameter of Inhibition Zone	SO	Sodium Oleate
DSC	Differential Scanning Calorimetry	TBAB	Tert Butylamine borane
EC	Electrical Conductivity	TC	Thermal Conductivity
EDA	Ethlyenediamine	TEM	Transmission Electron Microscopy
EDS	Energy Dispersive X-ray Spectrometry	TES	Thermal Energy Storage
etac	ethyl 3-oxobutanoate	TD	Tetradecanol
FCC	face centered cubic	TG(A)	Thermogravimetry (Analysis)
FESEM	Field Emission Scanning Electron Microscope	t-TMSS	Tris(trimethylsily)silane
GL	Gelatin	TS	Thermal Stability
GLC	Glucose	XPS	Xray Photoelectron Spectra
HDA	Hexadecylamine	XRD	X-ray Diffraction
HNA	Hydroxy-1-naphthaldehyde		
HRTEM	High Resolution Transmission Electron Microscopy		
ML	Mass Loss		

1. Introduction

The novel application of nanotechnology in building materials allows for interesting new opportunities in applications and enhancement to its characteristics. Carbon and metal/metal oxide based nanomaterials (NMs), such as carbon nanotube/carbon nanofiber (CNT/CNF), Au, Ag, Cu, TiO_2, SiO_2, ZnO, and so on have been incorporated into various building materials (concrete, steels, plastics, coatings, paints) to improve strength, hardness, corrosion resistance, hydrophobic and antibacterial/fungal properties of building materials.

The unique and sometimes totally different physical and chemical properties of materials at the nanoscale have been employed to improve the primary properties or enable new functionalities of traditional construction materials (e.g. paints, concrete, glass, wood, metals and plastics) [1–3]. For example, the addition of TiO_2 NPs has been shown to improve the strength of concrete by accelerating chemical reactions during initial hydration. "Green-Building" paints incorporating Ag and Cu NPs have been developed and shown outstanding antimicrobial properties [4]. ZnO and CuO NPs enhanced the resistance of black pine wood against mould and fungi [5]. Automotive glass coated with NiO NPs based film has shown improved electrical and optical properties [6]. Studies have also shown that uniform nanoscale dispersion of metal alloyed with MX (M = Cr or Nb; X = C and N) through steel prevents creep [7]. CNT reinforced plastics demonstrate improved mechanical, thermal and electrical properties [8]. Also, nanomaterials offer the potential to further reduce the environmental impact and energy intensity of structures, as well as improvements to safety [9]. Lee et al. stated in 2010 that the widespread use of nanomaterials and nanotechnology for building applications is likely to increase tremendously and propel the construction industry because of the (1) significant enhancements imparted to conventional building components materials, (2) extremely small amounts of nanomaterials are required as nanoadditives, (3) rapid development of new building applications harnessing unique properties, (4) decreasing cost of base nanomaterials as they are produced in larger quantities, (5) great increase surface area-to-volume ratio of nanosized materials, (6) rapid development of large-scale low-cost techniques of nanofabrication [10].

Nanometals have been widely researched and applied to building materials, providing superior properties [11,12]. For instance, (1) Ni NPs increases the compressive strength of concrete by over 15% [13], (2) Ag NPs can be endow paints with antimicrobial properties [14], (3) Ag nanofilms possess the IR reflectivity of 60 and 90% in the visible and infrared region and is used as energy conser-