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A new large – Scale synthesis of magnesium oxide nanowires: Structural and antibacterial properties

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ABSTRACT

Large-scale one-dimensional magnesium oxide (MgO) nanowires with diameters of 6 nm and lengths of 10 μm have been successfully synthesized by a new facile and simple reaction. This production was performed via a microwave hydrothermal approach at low temperature growth of 180 °C for 30 min. The structure of as synthesized MgO nanowires were investigated by means of X-ray diffraction (X-ray), Fourier Transformation Infrared Spectroscopy (FTIR), Field Emission Scanning Electron Microscopy (FE-SEM), Transmission Electron Microscopy (TEM), Selected Area Electron Diffraction (SAED) and Energy Dispersive X-ray (EDS). The antibacterial behavior of MgO nanowires concentration in solid media against Gram negative and Gram positive for different bacteria has been tested in details. The results show that the MgO nanowires have bacteriostatic activity against *Escherichia coli* and Bacillus sp. The antibacterial activity increases with increasing MgO nanowires concentration. Furthermore, the presence of one-dimensional MgO nanowires has high antibacterial efficacy and damages the membrane wall of bacteria. Finally, this study offered the prospect of developing ultrafine nanoscale devices utilizing MgO nanowires and implementing their useful potential in biological control.

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1. Introduction

Recently, fabrication of one-dimensional (1D) materials at the nanometric scale such as, nanowires, nanorods, nanotubes, nanosheets, nanoribbons, nanorings, and nanobelts were able to create new and enhanced structural and physicochemical properties [1–5]. Furthermore, these materials have great potential serving as building components for future nanotechnology devices compared with their bulk parent counterparts [1,2]. The desirable properties of materials can be tailored by the control of dimension, size, microstructure, and composition of material, often achieved using synthesis methods [3–6]. Every day, human beings, animals and plants fall under the threat of microbes in their living environment [7,8]. Currently, multiple drug resistance is developed by pathogenic bacteria due to the indiscriminate use of commercial antimicrobial drugs, commonly used in the treatment of infectious diseases [9,10]. In addition to this problem, antibiotics are sometimes associated with adverse effects on the host including hypersensitivity, immune-suppression and allergic reactions [2,11–13]. With increasing antibiotic resistance, a motivation for looking at other sources of antibacterial active nanomaterials was developed. Antibacterial agents organic and/or inorganic are of relevance to a number of industrial sectors including environmental, food, synthetic textiles, packaging, healthcare, medical care, as well as construction and decoration [9,13]. A severe limitation to the use of organic antibacterial material is their extreme oxidation sensitivity and instability, which frequently becomes a barrier to the use of organic materials as antibacterial agents [14,15]. In fact, inorganic materials, such as metals and metal oxides, have attracted lots of attention over the past decade due to their ability to withstand harsh process conditions [6,7]. Applying metal oxides, such as TiO_2, ZnO, Fe_2O_3, and MgO are of particular interest as they are not only stable under harsh conditions but also generally regarded as safe materials to human beings, animals and plants [8,9,16]. Nano-structured MgO is an essential minerals for human health and is an exceptionally important materials that has a unique ability to destructively adsorb different gases [17,18], including chemical warfare agents, surrogates, catalysis, additive in refractory, toxic waste remediation, paint, flame retardants, polymer reinforcement agents, and superconductor product and antibacterial materials [9,10,19]. The traditional method for preparing MgO is the thermal decomposition of either magnesium salts or magnesium hydroxides, which results in an inhomogeneous morphology and crystallite size as well as a low surface area [15,20]. Many synthetic strategies have used different physical and chemical transformation techniques to synthesis one-dimentional MgO with high surface area and enriched surface chemistry. These techniques include aerogel [21], thermal evaporation [22], chemical vapor deposition [23], laser ablation [18], vapor–solid process [16], sol–gel [3], hydrothermal method [7], epitaxial growth [9], nonepitaxial growth [6], direct chemical transformation [4], solid-state interfacial diffusion reaction [2], and so on.

To the best of our knowledge, no reports on the synthesis of MgO nanowires by the use of magnesium acetate with urea in microwave hydrothermal process are available in literature. In this regards, we first report the synthesis of one-dimensional MgO nanowires by a microwave hydrothermal method using magnesium acetate with urea as precursors. The antibacterial properties of MgO nanowires are examined in details. It is suggested that the one-dimensional MgO nanowires may find potential application in the design of nanotechnology devices and antibacterial agents.

2. Experimental section

2.1. Synthesis of MgO nanowires

All chemical reagents used in the experiments were analytical grade without further purification. The method of synthesizing large-scale one-dimensional magnesium oxide nanowires by directly reacting magnesium acetate and urea in microwave hydrothermal technique is as follows: 6.44 gm of magnesium acetate was dissolved in 75 ml distilled water and magnetic stirred for 30 min at room temperature. Simultaneously, a 1.2 gm urea in 25 ml water was added; drop wise into this aqueous magnesium acetate solution under vigorous magnetic stirring for 5 min. Further, the above solution was loaded into a 100 mL Teflon-lined autoclave. Finally, the autoclave was sealed and maintained