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Review

Recent development in the synthesis, modification and application of $Mg(OH)_2$ and MgO: A review

Agnieszka A. Pilarska [a,b], Łukasz Klapiszewski [a], Teofil Jesionowski [a,*]

[a] Poznan University of Technology, Faculty of Chemical Technology, Institute of Chemical Technology and Engineering, Berdychowo 4, PL-60965 Poznan, Poland
[b] Poznan University of Life Sciences, Institute of Food Technology of Plant Origin, Wojska Polskiego 28, PL-60637 Poznan, Poland

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ABSTRACT

Magnesium hydroxide and magnesium oxide are compounds with favourable and unique properties, leading to a broad range of opportunities for their use in science, and above all in practical applications.

This review describes methods of synthesising both $Mg(OH)_2$ and MgO, including precipitation, solvothermal and hydrothermal processes, the sonochemical technique, the sol-gel, electrochemical and microwave methods, and paths based on calcination of magnesite, carbonatisation, and chemical vapour deposition.

This comprehensive literature study provides extensive information on the properties and applications of these compounds and methods by which they may be obtained and modified. Reference is made to possibilities of using magnesium hydroxide as, among others, an antibacterial agent, a neutraliser of pollutants in fresh and wastewater, and a component of membranes, but the greatest detail is given in relation to the use of $Mg(OH)_2$ as a flame retardant. Magnesium oxide, in turn, is characterised as an antibacterial agent and as a fire-resistant and insulating material. Particular attention is given to questions relating to the use of MgO as an adsorbent, as an active catalyst, and as a catalyst support.

The latest developments in methods of modification of magnesium hydroxide and magnesium oxide, divided into those carried out using organic compounds and those using inorganic compounds and metals, are also presented.

A critical assessment of the current state of knowledge is presented, as well as indications of new directions for further research into the development of magnesium hydroxide and magnesium hydroxide.

This review is a source of scientific as well as practical information on the possible applications of $Mg(OH)_2$ and MgO at the present time and methods of obtaining them, in the light of available and applied research techniques and discoveries made to date in the field of advanced powder technology.

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* Corresponding author.
E-mail address: Teofil.Jesionowski@put.poznan.pl (T. Jesionowski).

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1. Introduction

The rapid rate of technological progress is creating a need to use advanced and innovative materials. The micrometric, and particularly nanometric, materials that have developed over recent years have become a key scientific field for the creation of innovative solutions, as well as a stimulus for wide-ranging research involving evaluation of the properties and the use of environmentally friendly chemical compounds. Such compounds undoubtedly include magnesium hydroxide and magnesium oxide.

Both $Mg(OH)_2$ and MgO belong to a group of compounds with a unique nature, in view of their large number of favourable properties and possible practical applications. The very great importance of these compounds is reflected in the number of scientific publications concerning them: a Scopus database search on November 28, 2016 returned 34,657 results for "magnesium hydroxide", and 127,596 for "magnesium oxide".

Magnesium hydroxide is particularly distinguished by its antibacterial activity, nontoxic nature and thermal stability, which make it a widely renowned means of reducing the flammability of polymeric materials [1–6]. Magnesium oxide, in turn, is noted for – among other things – its flame-resistance, dielectric resistance and mechanical strength. The chief field of application of MgO in recent years, apart from its use in ceramics [7–9], has been in catalysis and processes involving adsorption [10–15]. This fact is explained by, among other things, the unique microstructural properties of magnesium oxide: its porosity, its large surface area, and the presence (alongside defects in the crystalline structure) of so-called acid-base sites, which produce its surface reactive. $Mg(OH)_2$ and MgO, have an exceptionally diverse morphology of particles: from needles, platelets, rods, and spheres to "flowers" and "stars", which very often make them suited for use in the production of modern and advanced materials [16–21].

The basic point of reference for this literature review is research concerning specific functions of $Mg(OH)_2$ and MgO and the possibility of their application, as well as methods of obtaining those compounds. These questions, as will be seen by studying the contents of the work, are treated in an integrated manner, giving them great practical value. The described products, obtained on both laboratory and industrial scales, offer defined properties, and the innovative technologies developed using them are the subject of growing interest both among scientists and in industry. Most generally, the aim of the research is to create possibilities for optimum and wide-ranging use of $Mg(OH)_2$ and MgO in technologies and biotechnologies, particularly in environmental protection, construction, electrochemistry, pharmaceuticals, medicine, chemistry (organic, inorganic and hybrid material) and biochemistry.

Apart from the most common applications of magnesium hydroxide and oxide as listed above, further interesting proposals for the use of these compounds continue to be made. For example, magnesium hydroxide may serve as a component of membranes, as a drug stabiliser with prolonged action, and as a chemical sensor [17,22,23]. The future of this compound is thus linked with advanced biotechnology, including in the medical and pharmaceutical fields, and it will find more and more frequent applications not only in synthetics, but also in natural materials [24–26]. In the case of MgO, good knowledge of the compound's microstructure leads to spectacular studies concerning its use in attractive next-generation energy storage devices [27], or as a sorbent for carbon, gold and certain chemical compounds [28–32]. Research is carried out with regard to processes of capture, storage and utilisation, as well as adhesion energies. Although these are the most general recent trends in research relating to applications of $Mg(OH)_2$ and MgO, the basis for the exploitation of these enormous possibilities will still be the methods used to obtain and modify those compounds (or systems containing them). In this review various methods are described for obtaining magnesium hydroxide and its calcinate, ranging from precipitation, sonochemical, sol-gel, electrochemical and solvo- and hydrothermal methods to those using microwaves, a vapour phase deposition or raw minerals [33–39]. Space is also given to methods of modifying the surfaces of $Mg(OH)_2$ and MgO to change their basic physicochemical and dispersive-morphological properties and surface chemistry [40–43]. The path to success, as most studies demonstrate, is the obtaining of nanoproducts with specific particle morphologies and with hydrophobic properties. Modifications using organic and inorganic compounds are now an inseparable part of the process of synthesis. They lead to changes in the properties of magnesium hydroxide and oxide themselves and of systems synthesised using them. There are also many studies in which $Mg(OH)_2$ and MgO are themselves used as modifiers, for example as fillers or adsorbents.