# Synthesis and applications of alkaline earth metal oxides - A Review

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***Abstract*: In the growing field of variety of materials were synthesis and utilized in different applications in the field of science and technology. In the past few years, many researchers have made a wide range of alkaline earth metal oxides, which have a wide range of uses due to their low cost and toxicity. Because of their low price, affordability, and large reserves in nature, alkaline earth metal oxides (AEMOs), which are found in group IIA of the periodic chart, have gotten a lot of attention. This research article describes synthesis of alkaline earth metal oxides like MgO, CaO, SrO, BaO, and BeO using both bottom-up and top-down methods. This review paper uses earlier work by many researchers to report on the various synthesis, characterization methods and applications of AEMOs. This research article will definitely be helpful in the future. Those researchers are working on a new class of material, AEMOs, and its applications.**

***Keywords: alkaline earth metal oxides, characterization techniques, bottom-up and top-down approaches.***

## 1. Introduction:

AEMOs are very useful for studying the magnetism that comes from p-orbitals [1]. Nanomaterials (nanocomposites) that are made of metal oxides are a diverse group of materials in terms of their electrical structure, mechanical, chemical, and electromagnetic properties. Nanocomposites made from them are being used more and more in applied ecology, especially as adsorbents and for photocatalysis. They are also being used to make environmental monitoring systems [1, 2]. Adsorption materials made of nanosized metal oxides have a large specific surface area, high capacity, rapid kinetics, and specific attraction for a variety of pollutants [3]. AEMOs are a type of earth that has a high alkalinity. The utilization of metal oxide nanocomposites in photocatalytic processes allows for the oxidation of organic substances that are not biochemically degraded, with the pretreatment of aqueous solutions being the most promising. Furthermore, chemical and structural modifications, doping of heteroatoms, and the development of nanocomposites can all be used to modify metal oxides, making them more attractive and hence more researchable [4, 5]. They are also known for having a high recycling rate and good stability, making them useful in a variety of applications. As a result, metal oxides are employed in a wide range of applications, including heavy metal removal, hazardous gas detection, fabric coating for wearable electronics, and photocatalytic degradation of organic pollutants [6, 7].

In recent years, many researchers have made a wide range of AEMOs, which have a wide range of uses because they are inexpensive and not hazardous [8]. Because of their low price, affordability, and large reserves in nature, AEMOs, which are found in group IIA of the periodic chart, have gotten a lot of attention [9]. As homogeneous catalysts, Alkaline earth metals (AEMs) like beryllium (Be), magnesium (Mg), calcium (Ca), strontium (Sr), barium (Ba), and radium (Ra) are often employed. The surfaces of AEMOs, such as MgO, CaO, SrO, and BaO, demonstrate chemical basicity. The basic site on these alkaline earth metal oxides consists of strongly basic $O_2$ centers; little work has been done beyond identifying the strongly basic sites on alkaline earth metal oxides [5–8].

The group II alkaline earth metals calcium (Ca), strontium (Sr), and barium (Ba) are some of the most common elements on Earth. They can be found in both the sea and the earth's crust. Even though we use them every day, there hasn't been much we can do with them in organic synthesis so far. Some of the most useful things about these elements are (i) their low electronegativity, (ii) their stable +2 oxidation state, which means they can potentially form two covalent bonds with anions, and (iii) their large ionic radius, which lets them occupy a wide range of coordination sites. Furthermore, the alkaline earth metals, found between the group I and group III elements, show mild but significant Lewis acidity, which can be harnessed to control coordinated molecules via a Lewis acid-base interaction [9–13]. Taken together, these characteristics make the metals Ca, Sr, and Ba very promising components of highly functionalized acid-base catalysts. In this account, we describe the development of chiral alkaline earth metal catalysts for asymmetric carbon–carbon bond-forming reactions [14, 15].

Due to the many ways they can be used in materials chemistry, inorganic materials are both fundamentally interesting and technologically important [16].There is a lot of evidence that the shapes of inorganic nanomaterials have a big effect on their properties. Because of this, designing and making nanostructures with different shapes and sizes on a large scale is important for both basic science and technology [17–20].

## 2. Literature survey:

There are different methods for synthesis of AEMOs, and its composites. Here we tried to describe a summary of these methods, and in the separate section, their explanations are expanded one by one.

Shakban et al. [18] wrote about a wide range of structures with different properties and the introduction of alkaline earth metals (AEMs).The author also talks about different ways to make AEMs, such as chemical bath deposition, aerosol-assisted chemical vapour deposition, and the sol-gel method. The authors also briefly talk about how calcium copper sulfide ($CaCu_2S_2$) is made using the sol-gel method.

Taglieri, G., et al. [19] made alkaline earth metal hydroxides NPs using an innovative, one-step, and environmentally friendly ion exchange process. By using this novel method, the authors synthesized Ca $(OH)_2$ and $Mg(OH)_2$, Sr(OH), and $Ba(OH)_2$ hydroxide NPs from calcium and magnesium to strontium and barium sources, respectively. The morphology of magnesium and calcium hydroxide NPs in the form of hexagonal lamellas, characterised by base dimensions, has been shown by TEM images, according to the authors. They discovered a rod-like shape in strontium and barium hydroxide nanoparticles, with lengths ranging from 30–250 nm to 50–600 nm and thicknesses varying from 30–60 nm. The synthetic approach examined here ensures the ability to manufacture all alkaline-earth metal hydroxides in a simple manner, overcoming the disadvantages associated with existing methods. The authors' process is also promising for large-scale manufacturing of alkaline-earth metal hydroxides, which might make them more useful in a wider range of applications.

Alavi, M.A., and Morsali, A. et al. [20] reported the properties of barium carbonate. It is a mineral that is used to make barium salts, pigment, optical glass, ceramics, electric condensers, and barium ferrite. It is also a substance used in industry to make barium salts, pigment, optical glass, ceramic, electric condensers, and barium ferrite. In the modern electronic industry and the glass industry, strontium carbonate is a significant raw ingredient. Because strontium carbonate only has one crystal phase, it has been extensively investigated as a model system for bio-crystallization. The authors also presented various properties and applications of CaO and MgO. Both are versatile materials that continue to pique researchers' curiosity in the field of materials science. Pure CaO is an anisotropic catalytic oxide with a cubic lattice structure that is frequently researched as a component in catalytic powder materials or cements. CaO is a dopant that can stabilize cubic zirconia and change the refractive index of silicate glasses smoothly. CaO and its ternary alloys might be considered interesting dielectric gate materials, demonstrating good mechanical and radiation resistance due to their broad band gap, high dielectric constant, and ability to form solid solutions and ternary crystalline phases. Because of its low heat capacity and high melting point, magnesium oxide is an excellent material for insulation. Nano-MgO is a versatile material that has been used in a variety of applications. MgO has recently been shown to have good bactericidal properties in aqueous conditions due to the generation of superoxide ($O_2$) anions on its surface. Because of its large surface area, abundance of crystal defects, and positively charged particles that can result in strong interactions with negatively charged bacteria.

Devi K et al. [21] used the SILAR method to make a thin film of Mg-doped ZnO and said it could be used as an ethanol gas sensor. At room temperature, the crystal size is smaller because of the magnesium doping, and the optical bandgap is wider because of the doping. Response time of 13 seconds and recovery time of 20 seconds were said to be very fast by the author.

Balta A K, et al. [22] developed thin films of MgO and ZnO composite microscope glasses by spin coating technique. The doping concentrations of MgO from 0 to 100% were taken. The doping concentration of MgO influences the particle sizes and shapes, as reported by the author.

Maemoto T, et al. [23] used pulsed laser ablation and multiple targets of ZnO-MgO to deposit ZnO-MgO thin films on $Al_2O_3$ substrates and then studied the optical and structural properties of the thin films. Wurtzite phase with (002) peak orientation were recorded from XRD. In optical effects, band gaps in the range of 3.27 eV to 3.95 eV were investigated.

Idris MS et al. [24] gown thin films of ZnMgO by pulsed laser deposition technique. The authors studied the optical properties of ZnMgO thin films and investigated the influence of dopant on the transmittance of the films.

Xu et al. [25] used reverse micelles of Triton X-100, cyclohexane, and water to make $BaCO_3$ nanowires. Reverse micelle, also called microemulsion, is a type of micro reactor that can divide reactants into nanometer-sized sections in water. It is used more and more to make nanowires and nanorods. The shape, size, and size distribution of reverse micelle nanowires and nanorods can be modified by varying the reaction temperature, surfactant, additives, surfactant concentration, and water to surfactant mole ratio.

Momchilova et al. [26] employed the microemulsion method to prepare nano-sized $BaCO_3$ particles, and microemulsion was used as a specific microreactor to limit the nanoparticle growth. The reaction conditions determine the form of the microreactor. This approach improves the homogeneity of the chemical composition at the nanoscale and makes it easier to make nanoparticles of similar size. Nanoparticles' unique features make them ideal for microelectronics, ceramics, catalysis, medicine, cosmetics, piezoelectric materials, conductors, and other applications.

Kim et al. [27] examined the development of MgO nanowires on Au-coated substrates after annealing. Before growing the MgO structures by thermal evaporation of $MgB_2$ powders, they gave the Au-coated substrates a thermal annealing treatment. By adjusting the pre-deposition annealing temperature, they were able to create MgO nanowires. The nanowires produced were cubic MgO structures with sizes ranging from 40 to 200 nm.

Tao, Y. et al. [28] prepared a novel cataluminescence gas sensor based on MgO thin film. The authors reported that the ethylene glycol ether sensor showed high sensitivity and specificity. With detection limits of 1.0 ppm and 1.4 ppm, the linear ranges of cataluminescence intensity versus ethylene glycol ether concentrations were 2.0–2000 ppm for 2-ethoxyethanol and 2.0–1500 ppm for 2-methoxyethanol, respectively. The response time was found to be less than 5 seconds.

Balta, A.K. et al. [29] developed MgO and ZnO composite thin films using the spin coating method on microscope glasses. In the process, pure ZnO thin films were the starting point, ending up with MgO by doping various percentages (from 0% to 100%) of Mg with the help of the sol-gel spin coating technique.

Yang et al. [30] synthesized flower-like $SrCO_3$ nanostructures by the hydrothermal method. The morphology of the products characterized by field emission scanning electron microscopy (FESEM) shows that most of the flower-like nanostructures consist of $SrCO_3$ nanorod bundles. The TEM characterization of the above-mentioned sample shows the morphology of flowerlike $SrCO_3$ nanostructures consisting of nanorods with a diameter of 100–300 nm and length of about several micrometers.

Tang et al. [31] prepared nano-CaO by the thermal-decomposition method. They used $Ca(NO_3)_2.4H_2O$ as a precursor, NaOH aqueous solution as a precipitant, and ethylene glycol as a medium. The $Ca(OH)_2$ that was obtained through the above mixing was calcinated at 500 °C, and nano-CaO was prepared.

Wu et al. [32] investigated the self-assembled growth of MgO nanosheets arrays via a micro arc oxidation technique. They present a relatively simple method of fabricating aligned MgO sheet-like nanostructures on the surface of magnesium alloys via a promising micro arc oxidation (MAO) technology. SEM observations reveal that many sheet-like structures form on the substrate surface. The nanosheets are slightly curved and approximately 300–400 nm in width and tens of nanometers in thickness. Most of them stick together to form nanosheet arrays. A large quantity of flower-like, branched structures was also observed on the substrate.

Kim et al. [33] investigated the growth of MgO nanowires by annealing treatment of Au-coated substrates. They applied a thermal annealing treatment to the Au-coated substrates before growing the MgO structures by thermal evaporation of $MgB_2$ powders. They obtained MgO nanowires by controlling the pre-deposition annealing temperature. The produced nanowires were cubic MgO structures with diameters in the range of 40–200 nm.

According to a literature survey, the synthesis of alkaline earth metal oxides is possible using different synthesis approaches.

## 3. Conclusion and Future Scope:

Due to the significance of alkaline-earth metal oxides, they could be synthesized using many synthesis approaches. The synthesis method and used chemicals produced influences on the morphology, physical, chemical, and optical properties, as well as the shape and size of nanoparticles. In this review article, various synthesis methods, characterizations, and applications for AEMOs are described using prior research from other researchers. Alkaline earth metal oxides are a new type of material, and this study article will help researchers learn more about them and how they can be used.

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