MICROWAVE-INDUCED COMBUSTION SYNTHESIS OF NI-CR FERRITE NANOPOWDERS

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Microwave-induced combustion synthesis (MICS) experiments have been conducted to obtain Ni-Cr ferrite nanopowders using urea as fuel. The conventional way of producing this material is by the solid state reaction with oxides. The majority of reports in the literature discuss synthesis procedures based on conventional ceramic methods for obtaining mixed-oxide ceramic powders. These methods are inappropriate for many advanced applications due to the formation of large particles, agglomerates, poor chemical homogeneity, undesirable phases, abnormal grain growth, lower reproducibility and imprecise stoichiometric control of cations. The wet chemical methods of powder preparation seem to offer a better alternative, as they are capable of overcoming the drawbacks of the conventional ceramic method. Ni-Cr ferrites powder can be synthesized by a variety of routes: sol-gel, combustion chemical vapor deposition, precipitation and others. The properties of the powder may vary according to the different preparation methods employed. This work attempted a new method called microwave-induced combustion synthesis process (MICS) to produce Ni-Cr ferrites nanopowders. The MICS is, in the simplest sense, the exploitation of an exothermic and usually very rapid chemical reaction. The process is based on the principle that, once initiated by an external source, an exothermic reaction occurs, becoming self-sustained and resulting in the end product within a short period of time. In a conventional combustion process, e.g., “Forced Combustion”, ignition occurs due to the addition of local energy from an external source such as an electric wire, spark or flame, etc. A combustion zone is initiated locally near the ignition source and propagated throughout the mixture. On the other hand, spontaneous combustion occurs when the temperature of a considerable volume of a gas mixture is raised by containing it in hot boundaries or by subjecting it to adiabatic compression, causing the generation rate to exceed the loss rate, which in turn leads to spontaneous ignition (“Auto Ignition”).

Despite the many differences, all combustion reactions share a common denominator, i.e., the heat required to drive the chemical reaction is supplied by the reaction itself. In conventional heating, the heat is generated by heating elements and then transferred to the sample surfaces. Microwave processing of materials is fundamentally different from conventional processing in its heat mechanism. In a microwave oven, heat is generated within the sample itself by interaction of microwaves with material.

The technique is usually an easy, safe and fast way to produce ceramic powders, and its potential advantages are that it requires less energy than conventional ceramic synthesis process and that the processing time is reduced to a few minutes. In addition, the high temperature of the combustion wave may expel volatile impurities, leading to higher purity products. It has been demonstrated that this quick, straightforward process can be used to produce homogeneous, high-purity, crystalline Ni-Cr ferrite nanopowders.

Several investigations of the characteristics of Ni-Cr ferrite, such as their structure and their catalytic, electrical and magnetic properties, have been reported in the literature. However, no report has been found in the literature correlating Ni-Cr ferrite obtained by normal combustion reaction method and by microwave-induced combustion reaction. The purpose of this work was therefore to obtain the Ni-Cr ferrite nanopowders phase through the microwave-induced combustion reaction methods, and to compare the morphological characteristics of the resulting nanopowders. Control of ignition and reaction to yield nanoparticles can be accomplished with time-regulated microwave heating. The asprepared nanopowders products, characterized by XRD, SEM and BET, showed high specific surface area and have very small particle and crystalline size, with atomic level homogeneity. The results were compared to the results obtained from conventional combustion reaction and indicated that microwave assistance can permit controlled formation of Ni-Cr ferrite nanopowders.

1. R. H. G. A. Kiminami. Combustion Synthesis of Nanopowder Ceramic Powders Kona Powder and Particles, v.19, p.156-165, 2001.