RESEARCH PARKS

INTERNATIONAL JOURNAL ON ORANGE TECHNOLOGY

https://journals.researchparks.org/index.php/IJOT e-ISSN: 2615-8140 | p-ISSN: 2615-7071

Volume: 4 Issue: 7 |Jul 2022

Investigation of the Use of the Magnetic Field Method in the Obtaining of Superactive Additives

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Annotation: Among the unique features of microwave heating, it is possible to name the heating of samples in the entire volume of the substance, and accordingly, it was found that it is possible to heat it uniformly, at high speed, at low inertia, and to selectively heat individual components of the mixture of substances. In addition, the use of microwave processing makes it possible to obtain well-crystallized powders from low-defect, oxide materials. Microwave processing of inorganic mixtures is one of the promising ways to increase the speed of solid-phase processes. Due to the special properties of microwave heating, the use of electromagnetic energy opens wide opportunities for the synthesis of powders of inorganic compounds with controlled properties.

Keywords: Magnetic, microwave, energy.

Over the past 10-15 years, many works have been published on the synthesis of individual and multi-component oxide compounds using microwave radiation. As for catalysis, the use of microwaves is possible in the preparation and initial activation of catalyst samples.

Processing in the microwave field is carried out at a temperature of 100-250 °C for 0.5-24 hours. In addition, probably due to the low microwave absorption capacity of titanium oxide, the microwave effect does not affect the phase composition of titanium dioxide formed under hydrothermal conditions. After microwave treatment, the titanium dioxide suspension is dried. The method of obtaining nanoparticle materials using a microwave electromagnetic field, in contrast to conventional thermal heating, preserves the size of the particles in their original form, contributes to the absence of agglomeration and synthesis of the outer part of the sample.

The advantages of microwave hydrothermal synthesis are high rates of phases and processes in the microwave field due to the characteristics of heat supply and acceleration of nucleation under the influence of "non-thermal" effects. A known method of activating metal oxide catalysts for the synthesis of carbon nanomaterials is also calcination of a solution based on the thermal decomposition of a metal oxide water solution under the influence of microwave fields at a frequency of 2.45 GHz for 5-40 s.

The authors of this method note that the use of a microwave field to activate the catalyst during the preparation stage of the metal oxide catalyst can increase its activity and the specific efficiency of carbon nanoparticles. The synthesis of zirconium-based catalyst powders with copper oxide attached to the surface using the sol-gel method is presented. When microwave heating is used, copper oxide spreads more evenly on the ZrO2 surface, which in turn leads to an increase in the acidity index of the catalyst. After preparing a suspension of mixed metal salts, the drying process is carried out by traditional methods, in particular, moisture is removed in the oven by dry method, sublimation method or rotary drying nozzles.

In 1965, M. L. Levinson used carbon material as a heat energy converter for the dehydration process in the electromagnetic field of the microwave range, and in this he achieved the temperature required for heating. Microwave drying is used in the preparation of supported metal oxide catalysts. Thus, microwave radiation is

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widely used in the preparation of catalysts for the production of vinyl acetate in the gas phase from ethylene, acetic acid and oxygen. The catalyst is a metal mixture of palladium, gold and hydroxide attached to a porous support. At different stages of catalyst preparation, it is irradiated with a microwave field. In the same way, in the preparation of the exhaust gas treatment catalyst, precious metals are used as aluminum carrier under the influence of microwave field.

The use of microwave electromagnetic radiation to remove the solvent from the catalyst involves rapid drying of the catalyst suspension, and catalyst-degrading processes are also used in the preparation of finely dispersed catalyst by drying. Thus, it is possible to prepare a catalyst for the partial oxidation of propylene and isobutylene using an electromagnetic effect on the suspension. Metal salts (molybdenum, bismuth, iron, alkali metals) dissolved in an aqueous solution of nitric acid are dried in a microwave oven in the frequency range from 600 to 2.5 GHz. When the radiation frequency exceeds 2.5 GHz, the particle size also increases. After microwave drying, this catalyst is crushed and calcined.

Currently, many devices have been developed that allow drying of catalysts in a microwave electromagnetic field. For example, China's Henan Young Zhee River Industry offers microwave devices of various designs, mainly for drying micro spherical catalysts. The devices operate at a frequency of 2.5 GHz and an output power of up to 180 kW. They allow drying of both individual chemical components and the resulting catalyst precursor. According to the conducted research, after the stage of separation of salts into oxides, in order to obtain a catalyst with high thermal stability, the catalyst is calcined at a temperature of 400-700°C for 3-4 hours.

When using microwave heating, it is possible not only to reduce the synthesis time of multi-component oxide products with different crystal structures, but also to significantly reduce their synthesis temperature in many cases. The oxide phases synthesized using the electromagnetic field of the microwave range are not inferior to the functional properties of the control samples obtained by conventional heat treatment.

Most of the scientific works in this regard are devoted to the synthesis of aluminum, titanium and zirconium oxides in the electromagnetic device of the microwave range. Thus, information is given about the breaking temperature of AI2O3 powder falling to 400°C when exposed to radiation at a frequency of 28 GHz. The methods of obtaining an aluminum-chromium catalyst for dehydrogenation of hydrocarbons when adding oxide content to the microwave plasma are proposed.

The main principle of the proposed methods is the alloying of powders of the catalyst components (pure aluminum or its oxide and carbonyl or chromium oxide) in a low-temperature air plasma. The catalyst is removed from the reactor with argon carrier gas in a dust-gas flow. There is a known method of catalyst activation for the production of lower olefins by pyrolysis of hydrocarbons, according to which the catalyst material is treated with dual-polarized (polarized) microwave fields before entering the reaction zone at a temperature of 660-860°C.

As a result of the synthesis of metal oxides, a highly active surface catalyst is formed, which is a ferromagnetic alloy consisting of chromium, aluminum, molybdenum and nickel. Microwave irradiation is used in the preparation of catalyst for the dehydrogenation of aluminum-chromium hydrocarbons. In the aforementioned scientific work, the positive effect of the microwave field on the phase composition of the aluminum carrier of the MITALOX brand was studied. Modification of the aluminum carrier under the influence of an electromagnetic field allows obtaining a carrier with improved properties due to the changes caused by microwave heating.

According to the results of X-ray phase analysis, various formations of metastable phases of aluminum oxide (γ-, η-, θ-AI2O3) were observed during the electromagnetic processing of the carrier, which positively affects the properties of the future catalyst, because metastases phases have a highly developed surface and wide temperature and will have a phase gap. In addition, microwave treatment of the carrier gives the particles a sphericity due to hydrothermal processes occurring on the surface.

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The use of microwave influence in the process of preparation of heterogeneous catalysts allows to obtain catalysts with a more even distribution of particles in some cases of their use. Thus, the step of microwave treatment of the absorbing catalyst to obtain alkylene oxide allows to obtain a finely dispersed layer of silver metal on aluminum with a particle size of 2 to 100 nm. The essence of the catalyst preparation method is to impregnate the carrier with a solution containing silver compounds or its ions, dry it, and then irradiate it in a microwave oven with the formation of small silver particles on the carrier.

Under the influence of microwave radiation, important physico-chemical processes such as dehydration, decomposition of salt and hydroxyl precursors, synthesis and sintering of multi-component compounds can be carried out. The result of exposure to the electromagnetic field and the method of using microwaves depend on the dielectric properties of the substances that make up the catalyst. By changing the composition of the catalyst precursor (in the presence of weak and strong sorbents), the maximum temperature of the mixture can be controlled. To use microwave heating, semiconducting or ionically conductive substances or salts with solvate groups (usually water) are chosen as starting reactants. In addition, it should be noted that for some supported metal oxide catalysts exposure to a microwave field can produce "non-thermal" effects of obvious interest.

The methods of preparation of metal oxide catalysts presented in the review show the developing direction of practical use of microwaves in catalysis. The presence on the market of manufacturers of microwave systems designed to affect the components of catalysts, in particular, microwave hair dryers, means that the methods developed for the preparation of catalysts under the influence of a microwave field are used in industry.

It is known that the rate of solidification of the water-binding mixture and the strength achieved in the initial and subsequent periods of the system depend on the following factors: the properties of the starting materials, their composition in this mixture, additives and temperature conditions of physico-chemical processes.

When studying the problem of solidification of binders, the main attention is paid to chemical and physicochemical processes, in particular, to the mechanism of interaction with water. In addition, their effect on the microstructure of hydrated neoplasms and the entire system in general is taken into account, which in turn ensures the physical and mechanical properties, as well as the strength of this system. A number of physical phenomena important for force synthesis and strain regulation, as well as endurance, are underappreciated.

The properties of composite materials largely depend on the properties of the components that make up their composition. Therefore, by changing the properties of the components of composite mixtures, it is possible to change the properties of the latter. The main components of inorganic soluble mixtures are binder, aggregate and mixed water.

The main goal of modern materials science is to create energy-saving technologies for the production of materials with high strength properties. Currently, various methods of changing the properties of mixture components, in particular, mixed water, are known. Usually these processes are called activation. In all methods of water activation, the effect of heat on its molecules can be reduced. Obviously, it is impossible to create materials with the desired properties without studying the nature, mechanism, and kinetics of activation processes. There is no unified theory of activation processes in special literature. Usually each of them is considered in the fields of science and technology. The most common methods of activation of water used as a mixing fluid for the production of gypsum and gypsum-sand compositions include activation using mechanical, ultrasonic, magnetic, thermal, electrochemical and nanosecond electromagnetic pulses. Many studies have been devoted to the study of the effect of magnetic fields on water changes. The information presented in these studies is so contradictory that it is very difficult to systematize and apply them in construction and composite materials production technology, including the gypsum cement system.

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Research on microwave-field interactions with gypsum binders is still poorly understood, and the main parameters of water treatment and aggregates for gypsum mixtures remain unknown. The use of microwave technologies to activate the components of gypsum mixtures is a new method, which indicates that there is insufficient information about these processes. The physico-chemical nature of microwave activation, the idea of scientific substantiation of the hydration and structure of plaster binders became the subject of the work. The purpose of the work was to study the effect of microwaves on the hydration of components of gypsum mixtures and the formation of the structure of gypsum binders.

The ability to control the processes of wetting and forming the structure of gypsum binders by microwave treatment of the components of the gypsum system is developed and scientifically based. The laws of the effect of the activated microwave water field on the hydration and structure of gypsum binders were determined, in which the microwave energy absorbed by the diffusion of water, the speed of physicochemical processes, the duration of individual cycles, the change in setting time, and the total duration of the hydration and structure of calcium sulfate dihydrate were determined.

The relationship between the energy activation properties of mixed water and the values of technological processes was determined - acceleration, decrease in hydration, the usual state and distribution of gypsum crystals, a decrease in the size of the crystal lattice of calcium sulfate dihydrate and, as a result, an increase in the strength of gypsum systems by 1.7-2.5 times as a result of scientific research. found the proof

The appearance of charged clusters and free ions in water explains the increase in electrical conductivity of the microwave field irradiated by water. Due to hydrogen bonds, water molecules form clusters among themselves. Clusters are not individual molecules, in general they work in water. The size of these clusters, that is, many properties of water depend on the number of molecules in them (the smaller the clusters, the lower the surface tension of water and its viscosity). Each water molecule can participate in four hydrogen bonds at the same time. Water has a wide and constant spectrum of different molecular structures. In this case, both five and six hexagons are formed without dominating each other with equal success.

Clusters constantly form and collapse with random thermal changes in the liquid. Thus, under the influence of microwave energy, the electrical conductivity of water increased depending on the absorbed energy, the water was ionized, the maximum value of the absorbed microwave energy reached 2.7 kDj/mol, a crack appeared between the clusters, and monomolecular compounds were formed. With increasing microwave exposure, an increase in electrical conductivity was observed, because water molecules have a large dipole moment, so they oscillate when exposed to a microwave field, which helps attract molecules and thus organize the entire system. At this stage, the allegory of hydration water ions falling into clusters was observed.

Various types of radiation (γ-radiation, electron and neutron beams, IR-microwave or sound waves, UV-rays, visible light rays) are widely used to obtain materials, as well as to initiate and stimulate chemical processes. In recent years, much attention has been paid to the study of the effect of microwaves on matter, in particular, the effect of microwave heating on various materials production processes and catalytic reactions.

Since 1995, the number of published scientific works on this topic has increased significantly. Despite the fact that the first objects of research were supported by metal catalysts, until today, the efforts of researchers are mainly focused on the use of mixed oxides similar to cytal, perovskite, due to their catalytic activity and the ability to receive electromagnetic radiation energy. With some exceptions, single-mode generators operating at a frequency of 2.45 GHz are used to heat the catalysts. Previously, multi-mode systems, in which a large number of different types of vibrations (modes) are generated simultaneously, were mainly used for the preparation of catalysts.

In relation to catalysis, microwave technologies can be used both for the preparation and initial activation of catalysts and for the direct catalytic process. Ferro- and paramagnetic metal particles dispersed in the liquid

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reaction medium were used, which should contribute to the acceleration of the reaction, since most organic reagents and solvents hardly absorb the microwave field.

Many inorganic substances (oxides, sulfides, carbides, some salts containing oxygen) have the ability to intensively receive MT-radiation and simultaneously heat various inorganic materials, including those used in synthesis, to temperatures of 1000°C and higher. The advantage of such heating is, in particular, to avoid uncontrolled changes in the composition of the initial charge and to carry out synthesis uniformly over the entire volume of the initial charge. In the implementation of such syntheses, both mixtures consisting of components capable of receiving MT radiation and heating under its influence, as well as mixtures that absorb only one or more of all initial reactants in MT radiation, are used. Sometimes, to ensure the desired heating temperature, a chemically inert material that intensively absorbs MT-radiation or a material that does not absorb MT-radiation and provides a decrease in the process temperature is additionally introduced into the charge.

As far as we know, he analyzed the methods of activation of composite binder and concrete mixtures. In addition to the use of various chemical modifiers in the binder, the grinding of dry construction mixtures, magnetic activation of mixed water, treatment of cement mortar with electrical charges, etc., are important. Different grinding devices were compared, which allows to grind the binder to different fineness. Among the non-reagent methods of activation of construction mixtures and their components, the processing of high-voltage electric charges is the most promising.

As it can be seen from the mentioned technical-technological analysis, the use of the most modern and progressive technologies, including MT wave fields, is very effective in obtaining heat-resistant and fire-resistant building materials and constructions. Therefore, in this scientific and research work, the problem of production of energy-saving, environmentally friendly technologies of obtaining heat-resistant and fire-resistant construction materials by taking activated additives based on man-made industrial waste, ash, stone, cement dust, phosphogypsum, etc. was studied. Based on the technology of vacuum processing of heat-resistant concrete based on the vacuum compaction of the concrete mixture with a composite binder to make a brick stove trolley. The effect of vacuum processing of the mixture on the technological properties of heat-resistant concrete in a composite binder and planetary mill (Activator-4M) made of Portland cement, as well as the composition was developed and the technological properties of concrete were studied.

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