as well as a method for preparing it comprising the following steps:

an aqueous mixture of the precursors of the elements of the catalyst is prepared in proper contents so as to reach the stoichiometry,

after setting of the pH of the mixture to 5.5-8.5, said precursors are reacted through a hydrothermal reaction in an autoclave at a temperature from 100°C to 600°C, for 5.5 hours to 48.5 hours, and then

the catalyst is retrieved.

Such a preparation requiring long reaction times, the authors have developed a method for producing a catalyst of the aforementioned type, by replacing the hydrothermal reaction hereinabove with a microwave-assisted hydrothermal reaction. They have discovered that, while allowing reducing the reaction duration considerably, the obtained catalyst has unexpected characteristics, conferring better properties thereon, in particular a higher reactivity.

Thus, the disclosure, in one aspect, concerns a method for producing a multiphase mixed-oxide catalyst comprising at least one active phase based on bismuth molybdate and one co-catalyst based on iron molybdate and at least one amongst the two elements cobalt and nickel, said method comprising the following steps:

preparing a mixture of the precursors of said mixed oxides in a solvent,

making said precursors react through a microwave-assisted hydrothermal reaction in two steps, a first microwave-assisted hydrothermal reaction and a second microwave-assisted hydrothermal reaction, between which the pH of the reaction mixture obtained from the first microwave-assisted hydrothermal reaction is set to 8-8.5, and

isolating the mixed oxides to obtain the catalyst.

By microwaves according to the disclosure, it should be understood intermediate radiations between infrared and radio waves, namely waves whose frequency is comprised between 800 and 3000 MHz. In practice, since all wavelengths are not authorized, preference will be given, yet without the disclosure being restricted thereto, to domestic microwaves used in industrial applications with a vacuum wavelength of about 12 cm, namely a frequency of about 2450 MHz, as well as microwaves used essentially in industrial applications, with a vacuum wavelength of about 33 cm, namely a frequency of about 915 MHz.

The method is described hereinafter in more details, the following features may be considered separately or in any combination.

According to a particular implementation of the method of the disclosure, said precursors are reacted through a microwave-assisted hydrothermal reaction in two steps, namely: a first microwave-assisted hydrothermal reaction and a second microwave-assisted hydrothermal reaction, between which the pH of the reaction mixture obtained from the first microwave-assisted hydrothermal reaction is set to 8-8.5.

This catalytic system which may be obtained according to the above-described method, comprises the following advantageous features, considered separately or in any combination:

the active phase meets the following stoichiometry $Bi_xMo_yO_z$ where $2 > x/y > 0.5$ and z is comprised between 6 and 12; preferably this stoichiometry is selected amongst the following ones: $Bi_2Mo_3O_{12}$, $Bi_2Mo_2O_9$ and Bi_2MoO_6;

the active phase is activated by at least one alkali metal, preferably at least potassium; advantageously, only this phase is activated by an alkali metal;

the co-catalyst meets the following stoichiometry $Fe_xCo_{1-x}MoO_4$ where x is a decimal number such that $0 < x < 1$, preferably such that $0.5 \leq x \leq 0.9$;

the active phase content is lower than or equal to 50 weight% with respect to the weight of the catalytic system, preferably it varies from 10% to 45%.

The disclosure concerns any use of a catalytic system as defined hereinabove, in particular for at least one amongst the following catalytic reactions: the oxidation of propene into acrolein, the oxidative dehydrogenation of butene into butadiene, the oxidation of isobutylene into methacrolein, the ammoxidation of propene into acrylonitrile and the ammoxidation of isobutylene into methacrylonitrile.

In order to illustrate the implementations of the different objects of the invention, some terms/expressions are defined.

By mixture of the precursors of mixed oxides in a solvent, it should be understood in particular a solution or a suspension of said precursors in the solvent.

By isolation of the catalyst, or of any of its phases, in particular the active phase or the co-catalyst, it should be understood all treatment operations well known to those skilled in the art, such as retrieval from the liquid hydrothermal reaction medium, washing, drying, and any other treatment leading to the separation of the catalyst or of any of its phases, for the use thereof in a catalytic reaction.

CLAIMS

[Claim 1] A method for producing a multiphase mixed-oxide catalyst comprising at least one active phase based on bismuth molybdate and one co-catalyst based on iron molybdate and at least one amongst the two elements cobalt and nickel, said method being characterized in that it comprises the following steps:

- preparing a mixture of the precursors of said mixed oxides in a solvent,
- making said precursors react through a microwave-assisted hydrothermal reaction in two steps, a first microwave-assisted hydrothermal reaction and a second microwave-assisted hydrothermal reaction, between which the pH of the reaction mixture obtained from the first microwave-assisted hydrothermal reaction is set to 8-8.5, and
- isolating the mixed oxides to obtain the catalyst.

[Claim 2] The production method according to claim 1, characterized in that the catalyst comprises molybdenum oxide.

[Claim 3] The production method according to claim 1 or 2, characterized in that the catalyst is supported, said method comprising the addition of one or several support material(s), before the microwave-assisted hydrothermal reactions.

[Claim 4] The production method according to any one of claims 1 to 3, characterized in that the microwave-assisted hydrothermal reactions are performed at a temperature from 150°C to 240°C.

[Claim 5] The production method according to any one of claims 1 to 4, characterized in that the microwave-assisted hydrothermal reactions are carried out over a time period from 2 minutes to 10 hours.

[Claim 6] The production method according to any one of claims 1 to 5, characterized in that the active phase of the catalyst meets the following stoichiometry $Bi_xMo_yO_z$ where $2 > x/y > 0.5$ and z is comprised between 6 and 12; preferably this stoichiometry is selected amongst $Bi_2Mo_3O_{12}$, $Bi_2Mo_2O_9$ and Bi_2MoO_6.

[Claim 7] The production method according to any one of claims 1 to 6, characterized in that the active phase of the catalyst is activated by at least one alkali metal, preferably at least potassium.

[Claim 8] The production method according to any one of claims 1 to 7, characterized in that the co-catalyst meets the following stoichiometry $Fe_xCo_{1-x}MoO_4$ where x is a decimal number such that $0 < x < 1$, preferably such that $0.5 \leq x \leq 0.9$.

[Claim 9] The production method according to any one of claims 1 to 8, characterized in that the catalyst meets the formula $Mo_mCo_nNi_pFe_qBi_rM_s$ where M is an alkali metal, m, n, p, q, r and s are natural or decimal numbers, with m varying from 1 to 5, n and p varying independently of one another from 0 to 1 with n+p different from 0, $0 < q \leq 1$, $0 < r \leq 3$ and $0 < s \leq 0.2$.

[Claim 10] A method for producing a multiphase mixed-oxide catalyst comprising at least one active phase based on bismuth molybdate and one co-catalyst based on iron molybdate and at least one amongst the two elements cobalt and nickel, said method being characterized in that it comprises the following steps:

- preparing a mixture of precursors of the active phase in a solvent, on the one hand, and a mixture of precursors of the co-catalyst in the same solvent or in another solvent, on the other hand;
- reacting separately through a microwave-assisted hydrothermal reaction, the precursors of the active phase and the precursors of the co-catalyst;
- isolating the active phase and the co-catalyst, respectively; and
- assembling the active phase and the co-catalyst to obtain the catalyst.

[Claim 11] The production method according to any one of claims 1 to 10, characterized in that the mixture(s) of the precursors of the mixed oxides is/are obtained in one or more of the solvents selected from water, organic solvents and any combination of said organic solvents together or with water.

[Claim 12] The production method according to claim 10 or 11, characterized in that the catalyst is supported, said method comprising the addition of one or several support material(s), and/or the catalyst comprises molybdenum oxide, said method comprising the addition of molybdenum oxide, the addition of said support material(s) and/or of the molybdenum oxide being carried out during the synthesis or the assembly of the active phase and of the co-catalyst to obtain the catalyst.

[Claim 13] The production method according to any one of claims 1 to 12, for the production of a multiphase mixed-oxide catalyst intended for at least one amongst the following catalytic reactions: the oxidation of propene into acrolein, the oxidative dehydrogenation of butene into butadiene, the oxidation of isobutylene into

methacrolein, the ammoxidation of propene into acrylonitrile and the ammoxidation of isobutylene into methacrylonitrile.