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METHOD FOR PREPARING A CATALYTIC METAL FOAM AND USE THEREOF

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This invention relates to a method for preparing a catalytic metal foam and to a method for utilizing said material.

Heretofore, a catalytic material in the form of a metal sponge has been prepared by leaching a 50% aluminum-50% nickel alloy with a 25% warm caustic soda solution. The sponge thus obtained is a black pyrophoric material dispersed in a solution which when used as a catalyst provides a large surface area compared to that of catalysts previously used.

The present invention provides a method for preparing a catalytic metal foam which due its structure provides a much greater surface area than the aforementioned catalytic metal sponge.

The method of the present invention consists of melting a metal alloy consisting of nickel and a metal or metals which can be easily removed from said alloy by leaching, vaporizing or other suitable means, causing a stream of molten metal alloy to flow into a pool of metal alloy, introducing into the interior of the pool a material adapted to effect foaming of the alloy, heating the body of molten metal alloy and material adapted to effect foaming to form a body of molten metal containing discrete cellular bubbles distributed therethrough, cooling the body and then treating said body in a manner as to remove the removable metal or metals from the alloy to provide a catalytic metal foam.

The catalytic metal foam thus treated may then be utilized to catalyze an organic reaction by the addition of said foam thereinto. The catalytic metal foam of the invention is utilized as a catalyst for hydrogenation and other reactions in which a nickel catalyst is suitable.

By "metal alloy foam" I mean a body consisting of gas containing discrete cells distributed in a metal matrix in a generally uniform manner, each cell being entirely enclosed and generally being not connected to any neighboring cell. Metal foam should not be confused with metal sponge which consists of interconnected cells which communicate in a metal matrix.

By "catalytic metal foam," I mean a body of porous catalytic nickel which before treatment was a nickel-metal alloy foam.

An object of the present invention is a method for catalyzing an organic reaction utilizing a metal foam catalyst.

Another object is a method for preparing a metal foam catalyst.

Another object is a method for hydrogenating an organic solution by immersing in an organic solution a metal foam catalyst.

Another object is a new and novel catalytic material.

Further objects will become apparent from the following detailed description in which it is my intention to illustrate the applicability of the invention without thereby limiting its scope to less than that of all those equivalents which will be apparent to one skilled in the art.

The invention is adapted to use a metal alloy foam consisting of nickel and a metal or metals which may be

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easily removed from the alloy. Metals which may be used in the alloy with nickel include aluminum, magnesium, zinc and cadmium.

The alloys preferred for use in the method of the invention include those having a substantial temperature difference, preferably of 200° to 400° C., between the solid phase temperature and the liquid phase temperature as shown in phase diagrams. However, a wide temperature difference is not always necessary. In order to obtain a superior foam used in preparing catalytic metal foam, it is helpful to utilize metal wherein its solid phase may be caused to predominate to cause decreased fluidity; the metal being foamed at the temperature at which this occurs, such temperature being between the solid and liquid phase temperatures.

While the particular nature of the material adapted to effect foaming and the apparatus for introducing the material adapted to effect foaming are not a part of the invention, it may be mentioned that suitable materials and apparatus are disclosed in Serial No. 637,735, filed February 1, 1957. An example of a suitable material is a hydride-containing metal powder.

The metal alloy to be used in preparing catalytic metal foam may be melted in a suitable furnace and then may be poured into a heated vessel where the material adapted to effect foaming may be added.

Metal alloy foam suitable for use in preparing catalytic metal foam may be produced continuously or in a batch process. For preparing catalytic metal foam in a batch process, the metal is first heated in a furnace or vessel until the metal is melted and is at a temperature desirable for foaming. The metal is poured into a heated vessel in which foaming is to take place. A material adapted to effect foaming is then fed into the molten metal until sufficient material has been added to produce a low density foam. The material is immediately exposed to additional heat to cause additional expansion of the cells within the metal alloy foam. The foam thus formed may be cooled by quenching with water and the metal alloy foam may then be treated by using a warm caustic soda solution to cause removal of the easily removable metal to provide a catalytic metal foam or the metal alloy foam may be heated to a temperature at which the metal adapted to be easily removed from the metal alloy foam is vaporized and may then be removed by subjecting to a predetermined amount of vacuum or may be treated by any suitable means which produces the desired catalytic metal foam.

If a continuous process is to be employed, after the cooling of the metal alloy foam, the foam may be continuously treated.

The invention also relates to a method for adding to an organic reaction, a catalytic metal foam formed by the aforescribed method to catalyze said reaction. For example a 28% nickel-72% aluminum alloy foam may be used to prepare a metal alloy foam by melting and adding a material adapted to effect foaming. The metal alloy foam thus produced may then be leached with a 25% warm caustic soda solution. A portion of the resultant material may then be added in the form of a block to an organic solution such as benzene to cause hydrogenation of said solution. Another organic reaction which may be catalyzed by the product of my method is benzoylmethionine which is converted to benzoylamino-butyric acid.

A catalytic metal foam may be formed from a nickel-zinc alloy foam. The alloy foam is prepared by melting the alloy, adding a foaming agent, heating and then cooling. The resultant foam is then heated to a temperature below the melting temperature of the alloy and above the vaporization point of zinc so that upon subjection to a small amount of vacuum, the zinc vapors can

be easily removed thus providing a nickel catalytic foam. The resultant catalytic foam may then be used for the hydrogenation of vegetable oils.

The invention is further illustrated by the following examples which illustrate certain embodiments but are not to be taken as limiting the invention only to those particular embodiments illustrated, it being understood that other embodiments and equivalents will be apparent to those skilled in the art.

Example 1

784 g. aluminum is heated to 900° C. in a steel crucible, and at that temperature 305 g. nickel are added and allowed to dissolve. The alloy is stirred and allowed to cool to 854° C. at which time a foaming agent (20% zirconium hydride) is stirred into the mixture with an iron rod. The resultant body is cooled by quenching with water. The cooled metal alloy foam is then leached with a 25% caustic soda solution causing removal of aluminum. A ½ g. sample of the aforementioned foam is then added to a container containing 4 liters of hexene and is subjected to 1500 lbs./sq. in. pressure provided by hydrogen. The system is allowed to run in this manner for 8 hours at which time 3.9 liters of hexane are obtained.

Example 2

800 g. zinc are placed in a pressed steel crucible and heated to 950° C. 200 g. of nickel are then added and allowed to dissolve. The alloy is stirred well and then 3.38 g. of zirconium hydride suspended in zinc powder are added and stirred therein using an iron rod. The foam is formed immediately and is cooled. The foam is then put in a pressure chamber and the foam subjected to a temperature of 900° C. and the pressure reduced from 760 mm. pressure to .1 mm. pressure of mercury to remove the zinc from the alloy. After two hours, the foam is removed and provides a catalytic nickel foam. A ½ g. sample of the aforementioned foam is then added to a container containing 4 liters of octene and is subjected to 1500 lbs./sq. in. pressure provided by hydrogen. The system is allowed to run in this manner for 8 hours at which time 3.9 liters of octane are obtained.

It may thus be seen that my invention is broad in scope and is not to be limited except by the appended claims.

Having thus disclosed my invention, I claim:

1. A method for preparing a catalytic metal foam comprising providing a molten pool of metal alloy consisting of a catalytic metal and at least one metal adapted to be easily removed from said metal alloy after foaming; introducing into the interior of the pool, a material adapted to effect foaming of the alloy to form a body of molten metal alloy containing discrete cellular bubbles distributed therethrough cooling said body, treating said body to remove said metal adapted to be easily removed

from the metal alloy foam to provide catalytic metal foam.

2. A method for preparing a catalytic metal foam comprising providing a molten pool of metal alloy consisting of a catalytic metal and at least one metal adapted to be easily removed from said metal alloy after foaming; introducing into the interior of the pool, a material adapted to effect foaming of the alloy to form a body of molten metal alloy containing discrete cellular bubbles distributed therethrough cooling said body, leaching said body to remove said metal adapted to be easily removed from the metal alloy foam to provide catalytic metal foam.

3. A method for preparing a catalytic metal foam comprising providing a molten pool of nickel-aluminum alloy; introducing into the interior of the pool, a material adapted to effect foaming of the alloy to form a body of molten metal alloy containing discrete cellular bubbles distributed therethrough cooling said body, leaching said body to remove the aluminum from the nickel-aluminum foam to provide catalytic nickel foam.

4. A method for preparing a catalytic metal foam comprising providing a molten pool of metal alloy consisting of a catalytic metal and at least one metal adapted to be easily removed from said metal alloy after foaming, introducing into the interior of the pool, a material adapted to effect foaming of the alloy to form a body of molten metal alloy containing discrete cellular bubbles distributed therethrough cooling said body, heating said body to a temperature sufficiently high to vaporize said metal adapted to be easily removed, subjecting said body to sufficient vacuum to remove said metal adapted to be easily removed thus providing a catalytic metal foam.

5. A method for preparing a catalytic metal foam comprising providing a molten pool of a nickel-zinc alloy, introducing into the interior of the pool, a material adapted to effect foaming of the alloy to form a body of molten metal alloy containing discrete cellular bubbles distributed therethrough cooling said body, heating said body to a temperature sufficiently high to vaporize the zinc contained in the alloy, subjecting said body to sufficient vacuum to remove said zinc thus providing a catalytic nickel foam.

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