dehydrogenation, isomerization, reductive alkylation and reductive amination. The catalyst thus prepared has an improved stability and lifetime.

Such hollow spheres can be prepared according to Andersen, Schneider and Stephanie (cf. "Neue Hochporöse Metallische Werkstoffe" [Novel highly porous metallic materials], Ingenieur-Werkstoffe, 4, 1998, p. 36-38). In this process, a mixture of the desired alloy, of an organic binder and optionally of an inorganic binder is sprayed uniformly through a fluidized bed composed of polystyrene spheres, where it coats the spheres. The coated spheres are then calcined at selected temperatures within the range of 450 to 1000°C in order to burn out the polystyrene, followed by a higher calcination temperature in order to sinter the metal together and stabilize the hollow shape. After the calcination, the catalyst is activated by a sodium hydroxide solution in order to prepare the activated base metal catalyst. An additional advantage of this catalyst system is that the thickness of the walls of the hollow shapes can be controlled easily through the coating conditions, and the porosity of the walls through the particle size and composition of the original powder mixture.

Problem

It is generally accepted that the type of chemical composition of the mixed oxide (phase formation and formation of reaction sites) and the type of physical structure (for example porosity, surface size, shape of the catalyst) and the type of heat removal can greatly influence the ability to form products (selectivity) and the productivity (space-time yield). The present disclosure~~invention~~ has for its object to provide a catalyst with an elevated catalytic activity compared to the prior art.

In a first aspect, there is provided mixed oxide catalysts which consist of gas permeable hollow shapes consisting of a plurality of layers and are of the general formula

$(Mo_{12}\ Bi_a\ C_b(Co+Ni)_c\ D_d\ E_e\ F_f\ G_g\ H_h)O_x$ (I)

in which

C: iron,
D: at least one of the elements selected from the group consisting of W, P,
E: at least one of the elements selected from the group consisting of Li, K, Na, Rb, Cs, Mg, Ca, Ba, Sr,
F: at least one of the elements selected from the group consisting of Ce, Mn, Cr, V,
G: at least one of the elements selected from the group consisting of Nb, Se, Te, Sm, Gd, La, Y, Pd, Pt, Ru, Ag, Au,
H: at least one of the elements selected from the group consisting of Si, Al, Ti, Zr,

and

a = 0.5 - 5.0
b = 0.5 - 5.0
c = 2 - 15
d = 0.01 - 5.0
e = 0.001 - 2
f = 0.001 - 5
g = 0 - 1.5
h = 0 - 800,

and

x = number which is determined by the valency and frequency of the elements other than oxygen,

comprising hollow spheres having a diameter of 0.5 to 5 mm.

In a second aspect, there is provided a process for preparing mixed oxide catalysts consisting of gas permeable hollow shapes consisting of a plurality of layers, which comprise hollow spheres with a diameter of 0.5 to 5 mm as defined above, comprising mixing solutions of compounds of the elements present in the mixed oxide catalysts of the formula I, preparing coprecipitates, isolating the resulting solid, optionally drying and calcining it, and applying the resulting finely divided solid, optionally together with a binder, in the form of a suspension as a layer to a support which consists of organic material, and removing this organic material during or after the solidification of the layer applied to it.

The disclosure~~invention~~ is based on the further object of providing

an improved process for preparing aldehydes and acids, in which acrolein and acrylic acid are prepared from propene by oxidation with air or oxygen in the presence of inert gases, including steam or offgases from the reaction, at elevated temperatures and in the presence of a heterogeneous mixed oxide catalyst. In a third aspect, there is provided a process for preparing aldehydes and acids by oxidizing olefins or methylated aromatics with air or oxygen in the presence of inert gases, steam or offgases from the reaction at elevated temperatures, characterized in that a catalyst which consists of gas permeable hollow shapes consisting of a plurality of layers and which comprises hollow spheres having a diameter of 0.5 to 5 mm and is of the general formula

$$(Mo_{12}\ Bi_a\ C_b(Co+Ni)_c\ D_d\ E_e\ F_f\ G_G\ H_h)O_x \quad (I)$$

is used, in which

C: iron,

D: at least one of the elements selected from the group consisting of W, P,

E: at least one of the elements selected from the group consisting of Li, K, Na, Rb, Cs, Mg, Ca, Ba, Sr,

F: at least one of the elements selected from the group consisting of Ce, Mn, Cr, V,

G: at least one of the elements selected from the group consisting of Nb, Se, Te, Sm, Gd, La, Y, Pd, Pt, Ru, Ag, Au,

H: at least one of the elements selected from the group consisting of Si, Al, Ti, Zr,

and

a = 0.5 - 5.0

b = 0.5 - 5.0

c = 2 - 15

d = 0.01 - 5.0

e = 0.001 - 2

f = 0.001 - 5
g = 0 - 1.5
h = 0 - 800,

and

x = number which is determined by the valency and frequency of the elements other than oxygen.

A mixed oxide catalyst shall be provided, with which not only propene conversions greater than 95% but also a high product selectivity of greater than or equal to 88% are achieved, such that the economic viability of the process is improved.

Description of the invention

The invention provides catalysts, consisting of hollow shapes, for oxidizing olefins, for example mixed oxide catalysts of the general formula

$$(Mo_{12}\ Bi_a\ C_b(Co+Ni)_c\ D_d\ E_e\ F_f\ G_g\ H_h)O_x \qquad (I),$$

in which

C: iron,
D: at least one of the elements selected from W, P,
E: at least one of the elements selected from Li, K, Na, Rb, Cs, Mg, Ca, Ba, Sr,
F: at least one of the elements selected from Ce, Mn, Cr, V,
G: at least one of the elements selected from Nb, Se, Te, Sm, Gd, La, Y, Pd, Pt, Ru, Ag, Au,
H: at least one of the elements selected from Si, Al, Ti, Zr,
and

a = 0.5 - 5.0
b = 0.5 - 5.0
c = 2 - 15
d = 0.01 - 5.0
e = 0.001 - 2
f = 0.001 - 5