BRIEF SUMMARY

[009] In accordance with examples described herein, a catalyst structure comprises a porous support structure comprising an aluminum oxide material (e.g., Al_2O_3), an aluminosilicate material, or a zirconium oxide material (e.g., ZrO_2), and any two or more metals loaded in the porous support structure, the two or more metals selected from the group consisting of Ga, Ag, Mo, Zn, Co and Ce. Each metal is loaded in the porous support structure is present in an amount from about 0.1 wt% to about 20 wt%.

[0009a] In an aspect, there is provided a catalyst structure comprising:

a porous support structure comprising an aluminosilicate material, and

a plurality of metals loaded in the porous support structure, the plurality of metals including at least three metals selected from the group consisting of:

Ga, Ag, Zn, Co and Ce, or

Ga, Ag, Mo, Zn and Co;

wherein each metal loaded in the porous support structure is present in an amount from about 0.1 wt% to about 20 wt%.

[0010] In other examples, a process of forming the catalyst structure is provided. Further, a method of upgrading hydrocarbons in the presence of the catalyst structure is described herein.

[0010a] In another aspect, there is provided a method of forming the catalyst structure as defined above, the method comprising:

dissolving three or more metal salts in water to form a metal precursor solution, the two or more metal salts including the three or more metals;

loading the metal precursor solution into the porous support structure;

drying the support structure loaded with metal precursor for a period of at least 2 hours at a temperature from about 80 °C to about 120 °C; and

calcining the dried support structure loaded with metal precursor at a temperature ranging from about 300 °C to about 700 °C and at a heating rate that increases in an amount ranging from about 5 °C/min to about 20 °C/min.

[0010b] In another aspect, there is provided a method of upgrading a first hydrocarbon product to form a second hydrocarbon product, the method comprising:

receiving a feedstock of the first hydrocarbon product in a reactor; and

reacting the first hydrocarbon product in the reactor in the presence of a gas and the catalyst structure as defined above to produce the second hydrocarbon product, wherein the gas comprises methane, hydrogen or nitrogen, and one or more properties of the second hydrocarbon product is changed in relation to the first hydrocarbon product.

[0011] The above and still further features and advantages of the present disclosure will become apparent upon consideration of the following detailed description of specific examples thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] FIG. 1 depicts a reaction system for upgrading heavy oil utilizing a catalyst structure and in a methane, N_2 or H_2 environment in accordance with example embodiments described herein.

[0013] Like reference numerals have been used to identify like elements throughout this disclosure.

DETAILED DESCRIPTION

[0014] In the following detailed description, while aspects of the disclosure are disclosed, alternate embodiments of the present disclosure and their equivalents may be devised without parting from the spirit or scope of the present disclosure. It should be noted that any discussion herein regarding “one embodiment”, “an embodiment”, “an exemplary embodiment”, and the like indicate that the embodiment described may include a particular feature, structure, or characteristic, and that such particular feature, structure, or characteristic may not necessarily be included in every embodiment. In addition, references to the foregoing do not necessarily comprise a reference to the same embodiment. Finally, irrespective of whether it is explicitly described, one of ordinary skill in the art would readily appreciate that each of the particular features, structures, or