PROVISIONAL APPLICATION
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TITLE OF INVENTION:

COMPOSITIONS AND METHODS FOR SUBSURFACE GEOTHERMAL OLEFIN PRODUCTION

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COMPOSITIONS AND METHODS FOR SUBSURFACE GEOTHERMAL OLEFIN PRODUCTION

FIELD

[0001] The present disclosure relates to compositions and methods for subsurface geothermal olefin production, and more particularly, relates to compositions and methods for producing olefins within the Earth's subsurface by harnessing naturally occurring geothermal heat and pressure to drive chemical transformations.

GENERAL DESCRIPTION

[0002] The present disclosure, and the claims provided below, is directed to compositions and methods for producing olefins—such as ethylene, propylene, and higher alkenes—within the Earth's subsurface by harnessing naturally occurring geothermal heat and pressure to drive chemical transformations. For example, aqueous fluids containing carbon dioxide and/or bicarbonate species can be injected into geologic formations where they undergo subsurface reactions facilitated by water–rock interaction under elevated temperature and pressure conditions. In some embodiments, the aqueous fluid can include buffering agents, pH regulators, or alkali salts to improve catalytic activity. Some examples of elevated temperature and pressure conditions of the present embodiments can be approximately in a range of about 50 degrees Celsius to about 500 degrees Celsius, and approximately a range of about 1 atmosphere to about 100 atmospheres, respectively.

[0003] The reactions of the present disclosure can be two-step reactions. For example, these subsurface reactions can produce reactive intermediates that, in the presence of catalysts, can undergo catalytic polymerization to form C_2+ olefins. An example reaction mechanism is presented below:

[0004] [INVENTORS, PLEASE COMPLETE WITH EXAMPLES OF TWO-STEP REACTIONS OF THE PRESENT EMBODIMENTS THAT WE DISCUSSED]

Step 1: Syn gas generation.

$$H_2O + Fe^{2+} \rightarrow \frac{1}{2}H_2 + Fe^{3+} + OH^-$$

$$H_2 + CO_2 \rightarrow H_2O + CO$$

Step 2: Fisher-Tropsch type reaction.

$$H_2 + CO \rightarrow olefin$$

[0005] The methods of the present embodiments can increase reaction yield by engineering reaction kinetics and varying precursors and/or condition of the reactions. It will be appreciated that in some embodiments, the reactions of the present disclosure can occur in a subsurface reactor having a sealed and pressurizable space configured to maintain elevated geothermal temperature and pressure. As discussed by the reactions above, aqueous fluids containing carbon dioxide and/or bicarbonate species can react with the in-situly generated hydrogen gas to produce a carbon monoxide (CO) intermediate. Catalysis of the intermediate can be enabled by surfaces containing iron and/or other transition metals either naturally present in the rock matrix or delivered externally in the form of catalysts. Some non-limiting examples of catalysts that react with these intermediates can include engineered Fischer–Tropsch catalysts composed of iron-, cobalt-, nickel-based materials or their combinations, or with noble metal dopants such as rhenium, platinum, pladium, rhodium, and ruthenium **[INVENTORS, PLEASE LIST OTHER EXAMPLES TO THE EXTENT APPLICABLE].** Use of these catalysts can convert the carbon monoxide to an olefin.

[0006] It will be appreciated that the iron in the rock matrix can work bifunctionally as both a heterogeneous catalyst and a reductant. **[INVENTORS, DURING OUR DISCUSSION YOU INDICATED THAT CO2 IS REDUCED TO CO AND THE CATALYST CONVERTS THE CO TO THE OLEFIN. HOW DOES THAT JIVE WITH THIS SENTENCE? THOSE SEEM TO BE AT ODDS WITH ONE ANOTHER AS THAT SUGGESTION INDICATES THAT IT DOES ACT AS A REDUCTANT].** The catalysts can be introduced into the subsurface, or into a reactor in the subsurface, as particles, nanoparticles, supported catalysts, or dispersed materials. Some non-limiting examples of olefins can include one or more of ethylene, propylene, butenes, heavy-olefins or their mixtures, which are essential in producing synthetic rubber, lubricants, and plasticizers. **[INVENTORS, PLEASE COMPLETE WITH ADDITIONAL EXAMPLES].**

[0007] In some embodiments, the catalytic process may be enhanced by supplementing the system with synthetic catalysts introduced into the reaction zone. In contrast to conventional Fischer–Tropsch synthesis, which uses externally sourced hydrogen and synthesis gas along with energy-intensive surface reactors, the present methods achieve olefin synthesis entirely in-situ by leveraging geothermal energy and geochemical environments. A person skilled in the art will recognize that the reaction mechanism of the present embodiments can undergo different reaction pathways than conventional Fischer–Tropsch synthesis. For example, unlike conventional Fischer–Tropsch synthesis, the present methods do not require externally supplied H_2 or CO. Instead, the necessary reactants are generated in-situ within the subsurface environment. Additionally, no external heat or pressure is applied; rather, the process leverages naturally occurring high-temperature and high-pressure geothermal conditions. The reaction mechanism also differs from conventional Fischer–Tropsch synthesis by involving solid–liquid–gas interfacial catalysis, which enables alternative reaction pathways and potentially different product distributions.. **[INVENTORS, PLEASE PROVIDE OTHER DISTINGUISHING FEATURES OF THE PRESENT METHODS OVER FISCHER-TROPSCH, IF APPLICABLE, SUCH AS DIFFERENT REACTION PATHWAYS OF THE PRESENT INVENTION].** This approach can provide a low-carbon, decentralized, and scalable pathway for the generation of high-value petrochemical feedstocks under naturally sustained conditions.

[0008] One skilled in the art will appreciate further features and advantages of the disclosures based on the provided for descriptions and embodiments. Accordingly, the inventions are not to be limited by what has been particularly shown and described. All publications and references cited herein are expressly incorporated herein by reference in their entirety.

[0009] Some non-limiting claims are provided below.

What is claimed is:

1. A method for producing olefins in a subsurface reactor, the method comprising:

introducing an aqueous fluid containing carbon dioxide or a bicarbonate species into a reactor, the reactor having a sealed and pressurizable space configured to maintain an elevated geothermal temperature and pressure; and

adding one or more catalysts into the reactor to undergo a catalytic reaction to form an olefin, the one or more catalysts comprising iron-, cobalt-, nickel-based materials, or combinations thereof.

2. The method of claim 1, wherein the olefin comprises a C_2+ olefin.

3. The method of claim 2, wherein the one or more catalysts react with the aqueous fluid to form a reactive intermediate generated from water–rock or fluid–mineral interaction that are converted to C_2+ olefins via catalytic polymerization.

4. The method of claim 3, wherein the reactive intermediate includes carbon-containing species formed at mineral surfaces during the reaction.

5. The method of claim 3 or claim 4, wherein the C_2+ olefins include one or more of ethylene, propylene, butenes, or their mixtures.

6. The method of any of claims 1 to 5, wherein the catalytic reaction favors the production of olefins over paraffins.

7. The method of any of claims 1 to 6, wherein the reactor is configured to provide a controlled catalytic environment under geothermal conditions.

8. The method of any of claims 1 to 7, wherein the pressure inside the reactor is in approximately a range of about 1 atmosphere to about 100 atmospheres and the temperature is in approximately a range of about 50 degrees Celsius to about 500 degrees Celsius.

9. The method of any of claims 1 to 8, wherein the aqueous fluid further includes buffering agents, pH regulators, or alkali salts to improve catalytic activity.

10. The method of any of claims 1 to 9, wherein the one or more catalysts are introduced into the reactor as particles, nanoparticles, supported catalysts, or dispersed materials.

11. The method of any of claims 1 to 10, wherein at least a portion of the one or more catalysts are naturally present in the surrounding rock and comprises iron-bearing minerals selected from olivine, serpentine, pyroxene, or magnetite.

12. The method of any of claims 1 to 11, wherein the one or more catalysts include mixed-phase materials such as transition metal oxides, carbides, or sulfides.

13. The method of any of claims 1 to 12, wherein the olefin is recovered in gas, liquid, or mixed phases.

14. The method of any of claims 1 to 13, wherein the olefin is recovered through a flow system including pipes, extraction wells, or return conduits.

15. The method of any of claims 1 to 14, wherein the reactor further includes temperature sensors, flow controllers, or inlets for gas flow.

16. The method of any of claims 1 to 15, further comprising refreshing the one or more catalysts by injecting new catalyst material or chemical activators into the reactor.

17. The method of any of claims 1 to 16, wherein the aqueous fluid is introduced in batches or continuously to control reaction time and product output.

18. The method of any of claims 1 to 17, wherein introducing the aqueous fluid further comprises injecting the aqueous fluid.

19. The method of any of claims 1 to 18, wherein the reactor is monitored with sensors measuring temperature, pressure, fluid composition, or olefin concentration.

20. The method of any of claims 1 to 19, wherein the aqueous fluid contains dissolved carbon species including carbonate, bicarbonate, or dissolved CO_2.

21. The method of any of claims 1 to 20, wherein catalytic polymerization mainly occurs on solid surfaces inside the reactor and is enhanced by natural fluid movement or mixing.

22. The method of any of claims 1 to 21, wherein the olefin makes up at least 20% of the total hydrocarbons produced by molar percentage.

23. The method of any of claims 1 to 22, further comprising recovering the olefin from the reactor through a fluid or gas extraction pathway.