Low-temperature energy conversion of CO2 and waste heat into syngas using a doped ceria nanoparticle catalyst

Technology #cu12075

This technology is a ceria-based nanoparticle catalyst designed for a waste-to-energy conversion system. The catalyst facilitates the reduction of CO2 and H2O to CO and H2, a mixture known as syngas, which can be combusted for electricity production or used as a chemical feedstock to synthesize a wide range of organic chemicals and fuels. This process capitalizes on free and abundant waste heat, and even solar heat, to supply reaction energy. Waste CO2 is used as a CO precursor with non-potable water as a hydrogen precursor. The nanoparticles are heated to release oxygen, then cooled and mixed with CO2 or H2O, facilitating fuel preparation in the form of CO and H2. The oxygen generated from the production of syngas re-oxidizes the ceria catalyst for additional reduction cycles. The catalyst bed can sit within a gas solid solar reactor for onsite energy production from power plant flue gas. In this way, wasted CO2 can be transformed into a new energy stream.

Energy production from CO2 can be achieved at lower temperatures with waste heat and solar energy

The catalyst formulation differs from previous technology in its structure and composition; it can be doped with transition metals including Cu, Zr, and Pd. These dopants can create vacancy centers within the material that allow for a lower catalyst activation temperature. The ceria nanoparticle catalyst has unusual redox properties including 6% Ce3+ content (measured by X-ray spectroscopy techniques) at room temperature in air, a property indicative of its low temperature catalytic activity. The temperature reduction allows for more activation of the ceria catalyst and drastically enhances material durability and process economics. The activation energy for the reduction of CO2 and H2O by this doped ceria catalyst was measured to be 50 kJ/mol.

Beyond its enhanced operational temperature range, the catalytic conversion can use several different sources of heat to facilitate renewable fuel creation. The heater can be a passive heater or exchanger, and the heat source can be waste heat from an industrial process (e.g. in the form of flue gas). Alternatively, the heater can also utilize coal, electric or other forms of energy including a solar concentration device or other heat generation devices.
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Applications:

- Catalyst for a low temperature, potentially solar-powered process to convert CO2 and non-potable water into a range of fuel-based products
- Low temperature catalyst material for other processes including low temperature water-gas shift reaction, fuel cells, and automotive catalytic converters

Advantages:

- Low temperature operation enhances the reactor and catalyst material durability
- Low temperature conditions are less expensive than high temperature conditions
- Low material costs allow for a low temperature reactor
- Creates energy from waste streams
- Removes CO2 emissions from the atmosphere
- Can expand the use of solar energy beyond electric production to fuel and chemical synthesis
- Ceria catalyst can be easily implemented within current reactors

Patent information:


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Related Publications:


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