What is claimed is:

1. A fixed-bed reactor cell for transforming one or more reactant gases, the fixed-bed reactor cell comprising:

an optically transparent cylindrical enclosure;

a first fitting attaching the reactor cell at a first end of the enclosure to at least one delivery channel and receiving at least one reactant input gas;

a second fitting attaching the reactor cell at a second end of the enclosure to at least one delivery channel and outputting at least one output gas;

an optically transparent catalyst support packed as a fixed bed substantially filling the enclosure;

a first plasmonic photocatalyst supported by the catalyst support, wherein the first plasmonic photocatalyst comprises a catalyst coupled to a plasmonic material having a plasmon resonant frequency to catalyze a desired chemical reaction, and

a light source applied to substantially an entirety of at least an interior of the enclosure while the at least one reactant input gas is passed through the enclosure, the reactor cell transforming the at least one reactant input gas into at least one output gas via the at least one reactant input gas reacting with at least the first plasmonic photocatalyst.

2. The reactor cell of claim 1, wherein the optically transparent enclosure has at least 50% transmittance for at least one predetermined light wavelength.

3. The reactor cell of claim 1, wherein the optically transparent enclosure comprises glass, borosilicate glass, quartz, fused quartz, aluminosilicate glass, lithium-aluminosilicate glass, sapphire, or combinations thereof.

4. The reactor cell of claim 1, wherein the catalyst support is selected to have an absorbance sufficiently low to catalyze the transformation of the at least one reactant input gas into the at least one output gas for at least one predetermined light wavelength.

5. The reactor cell of claim 1, wherein the catalyst support comprises silica, quartz, fused quartz, glass, borosilicate glass, sapphire, diamond, or combination thereof.

6. The reactor cell of claim 1, wherein the catalyst support is an aerogel comprising silicon dioxide, aluminum oxide, titanium dioxide, zirconium dioxide, holmium oxide, samarium oxide, erbium oxide, neodymium(III) oxide, or a combination thereof.

7. The reactor cell of claim 1, wherein the catalyst support is an aluminum oxide.

8. The reactor cell of claim 1, configured for a second plasmonic photocatalyst to be supported by the catalyst support, wherein the second plasmonic photocatalyst differs from the first plasmonic photocatalyst.

9. The reactor cell of claim 1, wherein the enclosure has an inner diameter ranging from 0.2 cm to 30 cm, or 0.5 cm to 10 cm, and a length ranging from 10 cm to 2 m, or 50 cm to 1 m.

10. The reactor cell of claim 1, wherein the light source comprises at least one LED, metal halide bulb, high pressure sodium bulb, xenon lamp, incandescent bulb, fluorescent bulb, halogen bulb, HID, laser or combination thereof.

11. The reactor cell of claim 1, wherein the optically transparent enclosure further comprises an outer cavity and a central cavity arranged coaxially with the outer cavity, wherein the outer cavity contains at least the first plasmonic photocatalyst on the catalyst support and substantially surrounds the central cavity, and wherein the central cavity comprises at least one of the light source and a thermal management feature.

12. The reactor cell of claim 11, wherein the outer cavity of the optically transparent enclosure comprises a reflective surface facing the central cavity.

13. The reactor cell of claim 11, wherein the thermal management feature includes a fluid input coupled to a first end of the central cavity and a fluid output coupled to a second end of the central cavity such that fluid may flow through the reactor cell to add or remove heat from the reactor cell.

14. The reactor cell of claim 11, wherein the thermal management feature comprises at least one metal rod or a plurality of metal wires.

15. A method for transforming at least one reactant gas using a fixed-bed reactor cell, the method comprising:

supporting a first plasmonic photocatalyst on a fixed bed, the fixed bed substantially filling the enclosure, wherein the first plasmonic photocatalyst comprises a catalyst coupled to a plasmonic material having a plasmon resonant frequency to catalyze a desired chemical reaction;

supplying at least one reactant input gas via at least one delivery channel to a first fitting connected to a first end of an optically transparent cylindrical enclosure;

illuminating, via at least one light source, at least an interior of the reactor cell;

outputting at least one output gas via at least one delivery channel from a second fitting connected to a second end of the enclosure, and

transforming the at least one reactant input gas into the at least one output gas via the at least one reactant input gas reacting with at least the first plasmonic photocatalyst.

16. The method of claim 15, further comprising heating the reactor cell via a thermal management feature disposed at least partially within the enclosure.

17. The method of claim 15, further comprising heating the at least one cell via only the at least one reactant reacting with the plasmonic photocatalyst, without applying any additional dedicated heating source.

18. A reactor cell comprising:

an enclosure comprising at least one input, at least one output, and a central cavity;

a light source disposed in the central cavity; and

at least one plasmonic photocatalyst on a catalyst support disposed within the enclosure and substantially surrounding the central cavity, wherein the plasmonic photocatalyst comprises a catalyst coupled to a plasmonic material.

19. The reactor cell of claim 18, wherein the outer cavity of the transparent enclosure comprises a reflective surface facing the central cavity.

20. The reactor cell of claim 1, wherein the enclosure has a length ranging from 50 cm to 1 m.

21. The reactor cell of claim 8, wherein the second plasmonic photocatalyst has a different plasmon resonant frequency from that of the first plasmonic photocatalyst.

22. The reactor cell of claim 8, wherein the second plasmonic photocatalyst has a different diameter from that of the first plasmonic photocatalyst.

23. The reactor cell of claim 8, wherein the first plasmonic photocatalyst and second plasmonic photocatalyst are arranged in different layers from one another.

24. The reactor cell of claim 8, wherein the first plasmonic photocatalyst absorbs a first wavelength range relative to other wavelengths, while the second plasmonic photocatalyst absorbs a second wavelength range relative to other wavelengths, and wherein the first wavelength range differs from the second wavelength range.

25. A fixed-bed reactor cell configured to transform one or more reactant gases, the fixed-bed reactor cell comprising:

an optically transparent cylindrical enclosure;

a first end of the enclosure configured to receive at least one reactant input gas;

a second end of the enclosure configured to output at least one output gas;

an optically transparent catalyst support configured to be a fixed bed substantially filling the enclosure; and

a first plasmonic photocatalyst configured to be supported by the catalyst support, wherein the first plasmonic photocatalyst comprises a catalyst coupled to a plasmonic material having a plasmon resonant frequency to catalyze a desired chemical reaction,

wherein the reactor cell is configured to transform the at least one reactant input gas into at least one output gas via the at least one reactant input gas reacting with at least the first plasmonic photocatalyst upon application of a light source to substantially an entirety of at least an interior of the enclosure.

26. The reactor cell of claim 25, further comprising a second plasmonic photocatalyst configured to be supported by the catalyst support, wherein the second plasmonic photocatalyst differs from the first plasmonic photocatalyst.

27. The reactor cell of claim 25, wherein the optically transparent enclosure further comprises an outer cavity and a central cavity arranged coaxially with the outer cavity, wherein the outer cavity is configured to contain at least the first plasmonic photocatalyst on the catalyst support and substantially surrounds the central cavity, and wherein the central cavity is configured to receive at least one of the light source and a thermal management feature.

28. The reactor cell of claim 25, wherein the thermal management feature includes a fluid input configured to couple to a first end of the central cavity and a fluid output configured to couple to a second end of the central cavity such that fluid may flow through the reactor cell to add or remove heat from the reactor cell.