CLAIMS

What is claimed is:

1. A trickle bed reactor, comprising:

a plurality of catalyst beds connected in series and progressively increasing in catalyst mass in a direction from upstream to downstream; and

a plurality of heat exchangers, wherein each of the heat exchangers is located between two of the plurality of catalyst beds, and wherein each of the heat exchangers does not exchange heat with an outer surface of a vessel that contains any of the catalyst beds.

2. The trickle bed reactor claim 1, wherein the plurality of catalyst beds are not in a shell and tube heat exchange configuration.

3. The trickle bed reactor of claim 1, further comprising:

a gas additive line in fluid communication with at least one of the plurality of catalyst beds; or

a liquid additive line in fluid communication with at least one of the plurality of catalyst beds.

4. The trickle bed reactor of claim 1, wherein productivity of the plurality of catalyst beds progressively decreases in a direction from upstream to downstream, and wherein a first productivity of the first catalyst bed is in a range of 5 to 10 times greater than a last productivity of the last catalyst bed.

5. The trickle bed reactor of claim 1, further comprising:

a first reactor vessel containing a first set of the plurality of catalyst beds; and

a second reactor vessel containing a second set of the plurality of catalyst beds, wherein an inlet of the second reactor vessel is fluidly coupled to a product outlet of the first reactor vessel.

6. The trickle bed reactor of claim 5, wherein the product outlet of the first reactor vessel comprises a gas outlet line and a liquid outlet line, and wherein the trickle bed reactor further comprises:

a compressor disposed along the gas outlet line and configured to compress the gas product received from the first reactor vessel; and

a pump disposed along the liquid outlet line and configured to pump the liquid product received from the first reactor vessel to the second reactor vessel,

wherein the compressed gas product is configured to combine with the liquid product prior to introduction of both the liquid product and the gas product into the second reactor vessel.

7. The trickle bed reactor claim 1, further comprising:

a feed line containing reactant and fluidly connected to the first catalyst bed of the plurality of catalyst beds, wherein the plurality of catalyst beds are configured to convert the reactants to one or more products;

an effluent line containing the one or more product, wherein the effluent line is fluidly connected to the last catalyst bed of the plurality of catalyst beds.

8. A method for operating a trickle bed reactor, the method comprising:

passing one or more reactants over a plurality of catalyst beds connected in series and progressively increasing in catalyst mass in a direction from upstream to downstream;

wherein the trickle bed reactor comprises a plurality of heat exchangers, wherein each of the heat exchangers is located between two of the plurality of catalyst beds, and wherein each of the heat exchangers does not exchange heat with an outer surface of a vessel that contains any of the catalyst beds.

9. The method of claim 8, wherein the trickle bed reactor further comprises:

a gas additive line in fluid communication with at least one of the plurality of catalyst beds; or

a liquid additive line in fluid communication with at least one of the plurality of catalyst beds.

10. The method of claim 8, wherein the reactants comprise sodium gluconate and the catalyst beds comprise an oxidation catalyst.

11. The method of claim 10, wherein at least a portion of the reactants form an oxidized product.

12. The method of claim 11, wherein the oxidized products comprise sodium glucarate.

13. The method of claim 8, further comprising introducing additional sodium gluconate to the trickle bed reactor via the liquid additive line.

14. The method of claim 8, wherein the trickle bed reactor lacks a core-shell configuration.

15. The method of claim 8, wherein the catalyst mass increases by from 100 kg to 1,000,000 kg.

16. The method of claim 8, wherein the operating pressures for the trickle bed reactor ranges from 50 PSI to 100,000 PSI.

17. The method of claim 8, wherein the operating temperatures for the trickle bed reactor ranges from 60°C to 120°C.