What is claimed is:

1. A reactor system for producing beta-mercaptoethanol, comprising:

a reactor containing a fixed bed of a solid catalyst comprising a heterogeneous ion exchange resin;

an ethylene oxide stream comprising ethylene oxide connected directly or indirectly to the reactor;

a hydrogen sulfide stream comprising liquid hydrogen sulfide connected directly or indirectly to the reactor; and

an effluent stream connected to the reactor, wherein the effluent stream comprises a reaction product comprising beta-mercaptoethanol and less than 0.5 wt. % thiodiglycol on a hydrogen sulfide-free basis,

wherein the fixed bed of the solid catalyst comprises a top zone, a middle zone, and a bottom zone; and wherein the top zone includes about 66% of a chemically inert solid diluent and about 33% solid catalyst by volume, the middle zone in includes about 50% of the chemically inert solid diluent and about 50% solid catalyst by volume, and the bottom zone includes 100% solid catalyst by volume,

wherein hydrogen sulfide is present in the reactor as a liquid phase and as a gas phase, and

wherein the reactor is an adiabatic reactor.

2. The reactor system of claim 1, which includes no internal and/or external source for cooling the reactor.

3. The reactor system of claim 1, wherein the reaction product consists essentially of the beta-mercaptoethanol and the thiodiglycol.

4. The reactor system of claim 1, wherein no detectable amount of ethanedithiol is present in the reaction product when analyzing a sample of the effluent stream via gas chromatography to two decimal places for weight percent or to three decimal places for mole percent.

5. The reactor system of claim 1, wherein after a single pass through the reactor a conversion of ethylene oxide to the reaction product in the reactor is greater than about 99 wt. % based on a weight of the ethylene oxide that converts to the reaction product divided by a weight of the ethylene oxide fed to the reactor.

6. The reactor system of claim 1, wherein the solid catalyst has weakly basic active groups to allow a conversion of ethylene oxide by hydrogen sulfide with a selectivity to beta-mercaptoethanol greater than about 99 wt. % based on a total weight of the ethylene oxide that converts to beta-mercaptoethanol divided by a total weight of the ethylene oxide that converts into the reaction product.

7. The reactor system of claim 1, wherein the ethylene oxide stream and the hydrogen sulfide stream each connect directly to the reactor without mixing ethylene oxide and hydrogen sulfide prior to introduction to the reactor.

8. The reactor system of claim 7, wherein a thermocouple is placed in an end of the ethylene oxide stream which is connected to the reactor, wherein the thermocouple is linked to a controller configured to stop a flow of the ethylene oxide stream upon detecting a temperature in the ethylene oxide stream which is above a threshold temperature.

9. The reactor system of claim 1, further comprising a mixing stream that is connected to the ethylene oxide stream, the hydrogen sulfide stream, and the reactor, wherein the mixing stream is configured to mix the ethylene oxide and hydrogen sulfide prior to introduction of the ethylene oxide and hydrogen sulfide to the reactor.

10. The reactor system of claim 9, wherein a thermocouple is placed in an end of the mixing stream which is connected to the reactor, wherein the thermocouple is linked to a controller configured to stop a flow of the ethylene oxide stream upon detecting a temperature in the mixing stream which is above a threshold temperature.

11. The reactor system of claim 1, wherein the hydrogen sulfide stream and the ethylene oxide stream are connected to a top of the reactor.

12. The reactor system of claim 1, wherein the reactor is a plug flow reactor.

13. The reactor system of claim 1, wherein the ethylene oxide stream comprises liquid ethylene oxide.

14. The reactor system of claim 1, wherein after a single pass through the reactor a conversion of ethylene oxide to the reaction product in the reactor is greater than about 99 wt. % based on a weight of the ethylene oxide that converts to the reaction product divided by a weight of the ethylene oxide fed to the reactor.