What is claimed is:

1. A method comprising:

(a) Subjecting ethylbenzene and oxygen to a propylene oxide (PO) production process or a propylene oxide and styrene monomer (POSM) co-production process to produce an effluent;

(b) Separating ethylbenzene and styrene from the effluent and recovering an organic stream comprising at least one oxygenate;

(c) Subjecting the organic stream to a hydrotreatment in the presence of a hydrotreatment catalyst comprising molybdenum to produce a hydrotreatment product comprising ethylbenzene; and

(d) Separating an ethylbenzene product stream from the hydrotreatment product, to yield a residual stream.

2. The method of claim 1, wherein the hydrotreatment catalyst further comprises nickel, cobalt, or a combination thereof.

3. The method of claim 2, wherein the hydrotreatment catalyst is a sulfided catalyst.

4. The method of claim 1, further comprising recycling the ethylbenzene product stream to the PO/POSM process.

5. The method of claim 1, wherein the hydrotreatment is carried out in the presence of a diluent, wherein the diluent comprises ethylbenzene, recycled ethylbenzene, or a portion of a bottoms from a distillation tower.

6. The method of claim 1, wherein the ethylbenzene recovery, defined as the weight percent of the organic stream before hydrotreatment that is converted to ethylbenzene, is greater than 20 wt%.

7. The method of claim 1, wherein the organic stream comprises a contaminant selected from sodium, potassium, or both, and wherein the method further comprises removing at least a portion of the contaminant to provide a pretreated organic stream, prior to subjecting the pretreated organic stream to hydrotreatment.

8. The method of claim 7, wherein removing at least a portion of the contaminant prior to hydrotreatment comprises:

(e) contacting the organic stream with water and carbon dioxide, whereby sodium is extracted from the organic stream, and separating an aqueous sodium-containing slurry phase from an organic phase comprising a reduced sodium content relative to the organic stream; passing the organic stream over a catalyst guard bed prior to hydrotreatment; or both contacting the organic stream with water and carbon dioxide, whereby sodium is extracted from the organic stream, and separating an aqueous sodium-containing slurry phase from an organic phase comprising a reduced sodium content relative to the organic stream; and passing the organic stream over a catalyst guard bed prior to hydrotreatment; or

(f) subjecting the organic stream to an acid wash and subsequent neutralization to provide the pretreated organic stream; passing the organic stream over a catalyst guard bed prior to hydrotreatment; or both subjecting the organic stream to an acid wash and subsequent neutralization to provide the pretreated organic stream and passing the organic stream over a catalyst guard bed prior to hydrotreatment.

9. The method of claim 8, wherein the contacting in (e) comprises combining the carbon dioxide with the water to form a CO_2-saturated water stream, and contacting the CO_2-saturated water stream with the organic stream; combining the organic stream and the water to form a mixture, and injecting the carbon dioxide as a gas thereinto; or both.

10. The method of claim 1 further comprising subjecting at least a portion of the hydrotreatment product to further hydrotreatment.

11. The method of claim 1, wherein (d) separating the ethylbenzene product stream from the hydrotreatment product comprises distillation.

12. The method of claim 1 further comprising recycling at least a portion of the ethylbenzene product stream, at least a portion of the residual stream, or both, to the hydrotreatment in (c).

13. The method of claim 1, wherein the residual stream comprises diphenylbutane isomers.

14. The method of claim 1, wherein the at least one oxygenate is selected from methylbenzyl alcohol (MBA), 2-phenyl ethanol (PEA), ethers, acetophenone (ACP), ethers of MBA and PEA, propylene oxide ring opening compounds, or a combination thereof.

15. A method comprising:

(a) Subjecting ethylbenzene and oxygen to a propylene oxide (PO) production process or a propylene oxide and styrene monomer (POSM) co-production process to produce an effluent;

(b) Separating ethylbenzene and styrene from the effluent and recovering an organic stream comprising at least one oxygenate and sodium contamination;

(c) Reducing the level of sodium in the contaminated organic stream, to provide a pretreated organic stream;

(d) Subjecting the pretreated organic stream to a hydrotreatment in the presence of a hydrotreatment catalyst comprising molybdenum to produce a hydrotreatment product comprising ethylbenzene;

(e) Separating an ethylbenzene product stream from the hydrotreatment product, to provide a residual stream.

16. The method of claim 15, wherein reducing the level of sodium in the contaminated organic stream to provide the pretreated organic stream comprises:

(f) contacting the contaminated organic stream with water and carbon dioxide, whereby sodium is extracted from the contaminated organic stream, and separating an aqueous sodium-containing phase from an organic phase comprising a reduced sodium content relative to the contaminated organic stream; passing the contaminated organic stream over a catalyst guard bed prior to hydrotreatment; or both contacting the contaminated organic stream with water and carbon dioxide, whereby sodium is extracted from the contaminated organic stream, and separating an aqueous sodium-containing phase from an organic phase comprising a reduced sodium content relative to the contaminated organic stream; and passing the contaminated organic stream over a catalyst guard bed prior to hydrotreatment; or

(g) subjecting the contaminated organic stream to an acid wash and subsequent neutralization to provide the pretreated organic stream; passing the contaminated organic stream over a catalyst guard bed prior to hydrotreatment; or both subjecting the contaminated organic stream to an acid wash and subsequent neutralization to provide the pretreated organic stream; and passing the contaminated organic stream over a catalyst guard bed prior to hydrotreatment.

17. A method comprising:

(a) Subjecting ethylbenzene and oxygen to a propylene oxide (PO) production process or a propylene oxide and styrene monomer (POSM) co-production process to produce an effluent;'

(b) Separating ethylbenzene and styrene from the effluent and recovering an organic stream comprising at least one oxygenate;

(c) Subjecting the organic stream to a hydrotreatment in the presence of a hydrotreatment catalyst comprising molybdenum to produce a hydrotreatment product comprising ethylbenzene;

(d) Separating an ethylbenzene product stream from the hydrotreatment product, to yield a residual stream; and

(e) Reusing the separated ethylbenzene product as a feed in the propylene oxide (PO) production process or the propylene oxide and styrene monomer (POSM) co-production process.

18. The method of claim 17, wherein the organic stream comprises a contaminant selected from sodium, potassium, or both, and wherein the method further comprises removing at least a portion of the contaminant to provide a pretreated organic stream, prior to subjecting the pretreated organic stream to hydrotreatment.

19. The method of claim 15, further comprising the step of recycling the ethylbenzene product stream to the PO/POSM process.