CLAIMS

1. A method for upgrading pyrolysis oil, the method comprising:

contacting the pyrolysis oil with hydrogen in the presence of a mixed metal oxide catalyst at reaction conditions to produce a reaction effluent comprising light aromatic compounds, where:

the pyrolysis oil comprises multi-ring aromatic compounds;

the mixed metal oxide catalyst comprises:

from 60 wt.% to 95 wt.% iron oxide;

from 1 wt.% to 20 wt.% zirconium oxide;

from 0.1 wt.% to 10 wt.% cerium oxide; and

from 1 wt.% to 20 wt.% aluminum oxide,

where the weight percentages are based on the total weight of the mixed metal oxide catalyst; and

contacting the pyrolysis oil with hydrogen in the presence of the mixed metal oxide catalyst at the reaction conditions converts at least a portion of the multi-ring aromatic compounds in the pyrolysis oil to the light aromatic compounds.

2. The method of claim 1, in which the pyrolysis oil comprises greater than or equal to 30 weight percent (wt.%) multi-ring aromatic compounds having greater than or equal to sixteen carbon atoms based on the total weight of the pyrolysis oil.

3. The method of either one of claims 1 or 2, comprising contacting the pyrolysis oil with hydrogen in the presence of the mixed metal oxide catalyst at a temperature of from 300 degrees Celsius (°C) to 500 °C, at a pressure of from 1 megapascal (MPa) (10 bar) to 20 MPa (200 bar), or both.

4. The method of any one of claims 1-3, where the light aromatic compounds comprise aromatic hydrocarbons having six to thirteen carbon atoms, or where the light aromatic compounds comprise benzene, toluene, ethylbenzene, xylene, or combinations of these.

5. The method of any one of claims 1-4, further comprising mixing the pyrolysis oil with toluene prior to contacting the pyrolysis oil with hydrogen in the presence of the mixed metal oxide catalyst.

6. The method of claim 5, comprising mixing the pyrolysis oil and toluene at a weight ratio of pyrolysis oil to toluene of from 95/5 to 65/35.

7. The method of any one of claims 1-6, further comprising separating a gaseous constituent from the reaction effluent after contacting the pyrolysis oil with hydrogen in the presence of the mixed metal oxide to yield a liquid portion of the reaction effluent.

8. The method of any one of claims 1-7, further comprising separating the reaction effluent to produce a used mixed metal oxide catalyst and a reaction product comprising light aromatic compounds.

9. The method of claim 8, comprising separating the reaction effluent in a separation unit to produce the used mixed metal oxide catalyst and the reaction product, where the separation unit comprises a centrifuge.

10. The method of claim 9, where contacting the pyrolysis oil with hydrogen in the presence of the mixed metal oxide catalyst at the reaction conditions produces a condensate that is deposited on the mixed metal oxide catalyst to produce the used mixed metal oxide catalyst, and the method further comprises washing the used mixed metal oxide catalyst with toluene to remove at least a portion of the condensate from the used mixed metal oxide catalyst.

11. The method of either one of claims 9 or 10, comprising vacuum drying the used mixed metal oxide catalyst first at a temperature of from 20 °C to 30 °C and second at a temperature greater than 80 °C.

12. The method of any one of claims 1-11, where contacting the pyrolysis oil with hydrogen in the presence of the mixed metal oxide catalyst at the reaction conditions converts the portion of the multi-ring aromatic compounds in the pyrolysis oil to the light aromatic compounds in a single step, without conducting a subsequent chemical reaction step.

13. The method of any one of claims 1-12, further comprising separating a gaseous constituent from the reaction effluent after contacting the pyrolysis oil with hydrogen in the presence of the mixed metal oxide to yield a liquid portion of the reaction effluent.

14. A system for upgrading pyrolysis oil, the system comprising:

a pyrolysis upgrading unit comprising a mixed metal oxide catalyst, where:

the mixed metal oxide catalyst comprises:

from 60 wt.% to 95 wt.% iron oxide;

from 1 wt.% to 20 wt.% zirconium oxide;

from 0.1 wt.% to 10 wt.% cerium oxide; and

from 1 wt.% to 20 wt.% aluminum oxide,

where the weight percentages are based on the total weight of the mixed metal oxide catalyst; and

the pyrolysis upgrading unit is operable to contact the pyrolysis oil with hydrogen in the presence of the mixed metal oxide catalyst to produce a reaction effluent; and

a separation unit disposed downstream of the pyrolysis upgrading unit and operable to separate used mixed metal oxide catalyst from the reaction effluent to produce a reaction product comprising light aromatic compounds.

15. The system of claim 14, where the separation unit is directly downstream of the pyrolysis upgrading unit, where the separation unit comprises a centrifuge.