Claims

1. Method for producing high value chemicals from feedstock, wherein the feedstock is waste material or comprises waste material, the method comprising:
   (a) providing a fluidised reactor system comprising a pyrolysis chamber (2) and combustion chamber (12), and
   (b) inputting the feedstock into the pyrolysis chamber (2) and executing a pyrolysis process at a temperature in the range of from 650 to 850°C to obtain a product gas comprising high value chemicals.

2. The method according to claim 1, wherein the pyrolysis process is executed at a temperature in the range of from 700 to 800°C, preferably 730 to 770°C.

3. The method according to claim 1 or 2, further comprising transferring the product gas from the pyrolysis chamber to a tar removal system to remove one or more tar fractions from the product gas.

4. The method according to claim 3, wherein one or more of the following applies:
   - the product gas transferred to the tar removal system comprises class 3-5 heavy tar fractions, the content of class 3-4 being greater than the content of class 5 by weight of the total class 3-5 heavy tar fractions;
   - the product gas transferred to the tar removal system comprises by weight of the total class 3-5 heavy tar fractions: (i) from 50 to 80% class 3 heavy tars, (ii) from 10 to 40% class 4 heavy tars and (iii) 10% or less class 5 heavy tars;
   - the product gas transferred to the tar removal system comprises from 20 to 30 g/Nm^3 of class 3-5 heavy tars;
   - the product gas transferred to the tar removal system comprises a ratio of dust to class 3-5 heavy tars from 1:99 to 10:90;
   - the product gas transferred to the tar removal system comprises from 0 to 2 g/Nm^3 of dust.

5. The method according to any preceding claim, wherein one or more of the following applies:
   - the waste material is municipal solid waste;
   - the waste material is biomass, biomass rich refuse-derived fuel, plastic rich refuse-derived fuel and plastics or combinations thereof;
   - the waste material comprises plastic;
   - the waste material comprises 30 to 100% of plastic by weight of the waste material, preferably from 50 to 80%;
   - the feedstock comprises 5 to 30% water originating from the waste material and/or separately added to the feedstock;

- the anthropogenic carbon present in the waste material is from 40 to 100% of the carbon in the waste material, preferably from 60 to 90%.

6. The method according to any preceding claim, wherein the high value chemicals in the product gas are olefins and/or monocyclic aromatic compounds, preferably wherein the olefins are ethylene, propylene, C_4 olefins, C_5 olefins, or combinations thereof and/or the monocyclic aromatic compounds are benzene, toluene, xylene, styrene or combinations thereof.

7. The method according to any preceding claim, further comprising (c) transferring the product gas into a product recovery unit and isolating the high value chemicals, optionally wherein the product gas is transferred from the pyrolysis chamber (2) to a tar removal system (52) prior to being subjected to step (c) to remove one or more tar fractions from the product gas.

8. The method according to claim 7, wherein:
   - the tar removal system (52) comprises an absorption unit (56) to remove light tar fractions from the product gas, such as light tar fractions, preferably to remove light tar fractions from the product gas, such as light tar fractions, and dust, optionally wherein a portion of the light tar fractions is transferred to the combustion chamber (12);

   and/or
   - the tar removal system (52) comprises a quench unit (54) to remove heavy tar fractions from the product gas, optionally wherein the product gas is quenched via a quenching medium, typically oil, at a temperature in the range of from 50 to 95°C, preferably 60 to 90°C, more preferably 60 to 85°C, and preferably wherein the spent quenching medium obtained after the quenching has a viscosity in the range of from 40 to 200 cP, preferably from 80 to 160 cP, optionally wherein a portion of the heavy tar fraction is transferred to the combustion chamber (12).

9. The method according to any preceding claim, wherein in the combustion chamber a combustion process is executed at a temperature in the range of from 30 to 130°C higher than the pyrolysis process, preferably 50 to 110°C.

10. The method according to any preceding claim, further comprising circulating bed material from the combustion chamber (12) to the pyrolysis chamber (2) via a transport zone (42), wherein the pyrolysis process and the combustion process are executed in the bed material, optionally wherein one or more of the following applies:
    - upon circulating the bed material sufficient heat is transferred from the combustion chamber (12) to the pyrolysis chamber (2) to execute the pyrolysis process;
    - the temperature difference between the combustion chamber (12) and the pyrolysis chamber (2) is increased by decreasing the circulation rate of the bed material, and wherein

the temperature difference between the combustion chamber (12) and the pyrolysis chamber (2) is decreased by increasing the circulation rate of the bed material;

- the circulation rate of the bed material is from 10 to 100 kg bed material circulated per kg of feedstock, more preferably 20 to 60 kg per kg;
- fluidisation gas is transferred into the transport zone (42) to control the circulation rate of the bed material, optionally at more than one region, preferably wherein the temperature difference between the combustion chamber (12) and the pyrolysis chamber (2) is increased or decreased by changing the ratio of fluidisation gas transferred into a first region of the transport zone relative to a second region of the transport zone;
- the transport zone comprises a first region (44) to allow the downflow of bed material from the combustion chamber (12) and a second region (46) to allow the upflow of bed material to the pyrolysis chamber (2) , preferably wherein the fluidisation gas is transferred into an upstream portion (48) of the second region (46) and into a downstream portion (47) of the second region (46);
- fluidisation gas is transferred into the transport zone (42) with a velocity from 0.5 to 3 m/s, preferably from 1 to 2.5 m/s, even more preferably 2 m/s, preferably wherein the velocity of the fluidisation gas in the upstream portion (48) and/or downstream portion (47) is from 0.5 to 3 m/s, preferably from 1 to 2.5 m/s, even more preferably 2 m/s.

11. The method according to any preceding claim, wherein fluidisation gas is transferred into the pyrolysis chamber (2), typically from a product recovery unit (40) of the fluidised reactor system, to control the circulation rate of the bed material, preferably wherein the velocity of the fluidisation gas in the pyrolysis chamber (2) is from 5 to 8.5 m/s, preferably from 5.5 to 7.5 m/s.

12. The method according to any preceding claim, further comprising isolating tail gas or off gas from the product gas, preferably wherein at least a portion of the tail gas or off gas is transferred to the combustion chamber (12), and/or wherein at least a portion of the tail gas or off gas is used for the production of chemicals, preferably hydrogen, CO and/or olefins are used for the production of chemicals.

13. The method according to any preceding claim, further comprising transferring the product gas from the pyrolysis chamber to a particulate removal unit, such as a cyclone, prior to being transferred to a tar removal system to remove dust from the product gas.

14. The method for producing high value chemicals from feedstock, wherein the feedstock is waste material or comprises waste material, the method comprising:
    (a) providing a fluidised reactor system comprising a pyrolysis chamber (2) and combustion chamber (12),

(b) inputting the feedstock into the pyrolysis chamber (2) and executing a pyrolysis process at a temperature in the range of from 650 to 850°C to obtain a product gas comprising high value chemicals;

(c) transferring the product gas from the pyrolysis chamber to a particulate removal unit to remove dust from the product gas;

(d) transferring the product gas from the particulate removal unit to a tar removal system (52), comprising a quench unit (54), to remove heavy tar fractions from the product gas,

wherein the product gas transferred to the tar removal system comprises from 0 to 2 g/Nm^3 of dust and from 20 to 30 g/Nm^3 of class 3-5 heavy tars, including (i) from 50 to 80% class 3 heavy tars and (ii) from 10 to 40% class 4 heavy tars and (iii) 10% or less class 5 heavy tars, based on total weight of the class 3-5 heavy tars.