CLAIMS

1. A method for optimizing the flow of gas to parallel fermentation processes, the method comprising:

   a. separating a gas stream derived from at least one industrial source into a hydrogen rich stream, having a H_2:CO ratio of at least 2:1 and a hydrogen depleted stream, having a H_2:CO ratio of less than 2:1 using at least one hydrogen separation module;

   ~~a.~~b. passing the hydrogen rich stream and hydrogen depleted stream in parallel to a first and second fermentation process respectively said first, and second fermentation processes being run in parallel;

   ~~b.~~c. fermenting at least a portion of the hydrogen rich stream in a first fermentation process using at least one reactor comprising a liquid nutrient medium containing a culture of one or more C1-fixing microorganism to produce a first fermentation product; and

   ~~c.~~d. fermenting at least a portion of the hydrogen depleted stream in a second fermentation process comprising at least one reactor comprising a liquid nutrient medium containing a culture of one or more C1-fixing microorganism to produce a second fermentation product,

   wherein the first fermentation product and second fermentation product are different products.

2. The method of claim 1, wherein the first fermentation product is ethanol and the second fermentation product is 2,3-butanediol.

3. The method of claim 1, wherein the liquid nutrient medium is flowed to the first fermentation process and the second fermentation process in parallel.

4. The method of claim 1, wherein the hydrogen separation module is a pressure swing adsorption process.

5. The method of claim 1, wherein the industrial source is selected from the group consisting of carbohydrate fermentation, gas fermentation, cement making, pulp and paper making, steel making, oil refining and associated processes, petrochemical production, coke production, anaerobic or aerobic digestion, gasification, natural gas extraction, methane reformation, oil extraction, metallurgical processes, for production

and/or refinement of aluminium, copper, and/or ferroalloys, geological reservoirs, and catalytic processes.

6. The method of claim 1, wherein at least a portion of the gas stream is comprised of a blast furnace top gas from a metallurgical process.

7. The method of claim 1, ~~wherein~~ further characterized in that at least a portion of a vent gas produced in the first fermentation process is recycled to the hydrogen rich stream.

8. The method of claim 7, further characterized in that~~wherein~~ at least a portion of the vent gas produced in the first fermentation process is passed through a pressure swing adsorption process prior to being recycled to the hydrogen rich stream.

9. The method of claim 1, further characterized in that ~~wherein~~ at least a portion of a vent gas produced in the second fermentation process is recycled to the hydrogen depleted stream.

10. The method of claim 9, ~~wherein~~ further characterized in that at least a portion of the vent gas produced in the second fermentation process is passed through a pressure swing adsorption process prior to being recycled to the hydrogen depleted stream.

11. The method of claim 1, wherein the C1-fixing microorganism is selected from the group consisting of *Moorella*, *Clostridium*, *Ruminococcus*, *Acetobacterium*, *Eubacterium*, *Butyribacterium*, *Oxobacter*, *Methanosarcina*, and *Desulfotomaculum*.

12. The method of claim 1, wherein the C1-fixing microorganism is *Clostridium autoethanogenum*.

~~13. A method for optimizing the flow of gas to fermentation processes in series, the method comprising:~~

~~a. separating a gas stream derived from at least one industrial source into a hydrogen rich stream and a hydrogen depleted stream using at least one hydrogen separation module;~~

~~b. fermenting at least a portion of the hydrogen rich stream in a first fermentation process using at least one reactor comprising a liquid nutrient medium containing a culture of one or more C1-fixing microorganism to produce a first fermentation product; and~~

~~c. fermenting at least a portion of the hydrogen depleted stream in a second fermentation process comprising at least one reactor comprising a liquid nutrient~~

medium containing a culture of one or more C1-fixing microorganism to produce a second fermentation product,

wherein at least a portion of the first fermentation product is passed to the second fermentation process.

14. The method of claim 13, wherein the first fermentation product is acetic acid.

15. The method of claim 14, wherein at least a portion of the acetic acid from the first fermentation process is converted to ethanol in the second fermentation process.

16. The method of claim 13, wherein the hydrogen separation module is a pressure swing adsorption process.

17. The method of claim 13, wherein the industrial source is selected from the group consisting of carbohydrate fermentation, gas fermentation, cement making, pulp and paper making, steel making, oil refining and associated processes, petrochemical production, coke production, anaerobic or aerobic digestion, gasification, natural gas extraction, methane reformation, oil extraction, metallurgical processes, for production and/or refinement of aluminium, copper, and/or ferroalloys, geological reservoirs, and catalytic processes.

18. The method of claim 13, wherein at least a portion of the gas stream is comprised of a blast furnace top gas from a metallurgical process.

19. The method of claim 13, wherein at least a portion of a vent gas produced in the first fermentation process is recycled to the hydrogen rich stream.

20. The method of claim 19, wherein at least a portion of the vent gas produced in the first fermentation process is passed through a pressure swing adsorption process prior to being recycled to the hydrogen rich stream.

21. The method of claim 13, wherein at least a portion of a vent gas produced in the second fermentation process is recycled to the hydrogen depleted stream.

22. The method of claim 21, wherein at least a portion of the vent gas produced in the second fermentation process is passed through a pressure swing adsorption process prior to being recycled to the hydrogen depleted stream.

23. The method of claim 13, wherein the C1-fixing microorganism is selected from the group consisting of *Moorella*, *Clostridium*, *Ruminococcus*, *Acetobacterium*, *Eubacterium*, *Butyribacterium*, *Oxobacter*, *Methanosarcina*, and *Desulfotomaculum*.

24. The method of claim 13, wherein the C1-fixing microorganism is *Clostridium autoethanogenum*.

25.13. The method of claims 1 and 13, wherein at least a portion of the gas stream is derived from a methane reformation process.

14. The method of claim 2513, wherein the methane reformation process converts at least a portion of a methane-containing gas into a gas stream comprising at least a portion of carbon monoxide and hydrogen.

15. The method of claim 1, wherein the hydrogen rich stream has a H_2:CO ratio between 2:1 and 5:1.

26.16. The method of claim 1, wherein the hydrogen depleted stream has a H_2:CO ratio between 0.1:1 and less than 2:1.

27. A method for optimizing gas flow to a fermentation process, the method comprising:

a. fermenting at least a portion of a gas stream from an industrial source using at least one reactor comprising a liquid nutrient medium containing a culture of one or more C1-fixing microorganism to produce a fermentation product and a vent gas stream; and

b. recycling at least a portion of the vent gas stream to the bioreactor,

wherein the recycling of at least a portion of the vent gas stream to the bioreactor reduces and/or mitigates the potential inhibition of the culture.

28. The method of claim 27, wherein at least a portion of the vent gas is passed through a pressure swing adsorption process prior to being recycled to the bioreactor.

29. The method of claim 28, wherein the pressure swing adsorption process removes at least a portion of at least one component selected from the group consisting of carbon dioxide, inorganic hydrocarbons, tars, organic nitrogen, and organic and inorganic sulfur from the vent gas stream.

30. The method of claim 28, wherein the pressure swing adsorption process simultaneously removes at least a portion of at least two components selected from the group consisting of carbon dioxide, inorganic hydrocarbons, tars, organic nitrogen, and organic and inorganic sulfur from the vent gas stream.

31. A method for optimizing gas flow to a fermentation process, the method comprising:

a. fermenting at least a portion of a gas stream from an industrial source using at least one reactor comprising a liquid nutrient medium containing a culture of one or more C1-fixing microorganism to produce a fermentation product and a vent gas stream;

b. removing at least a portion of at least one component selected from the group consisting of carbon dioxide, inorganic hydrocarbons, tars, organic nitrogen, and organic and inorganic sulfur from the vent gas using a pressure swing adsorption process to produce a clarified vent gas; and

c. recycling at least a portion of the clarified vent gas to the bioreactor.

32. The method of claim 31, wherein at least a portion of the gas stream is comprised of a blast furnace top gas from a metallurgical process.

33. The method of claim 31, wherein a total gas stream to the fermentation process is comprised of a combination of the gas stream from the industrial source and at least a portion of the clarified vent gas.

34. The method of claim 33, wherein the recycling of at least a portion of the clarified vent gas to the bioreactor increases an overall composition of methane and nitrogen in the total gas stream by at least 15 percent.

35. The method of claim 33, wherein the recycling of at least a portion of the clarified vent gas to the bioreactor increases an overall composition of methane and nitrogen in the total gas stream by at least 50 percent.