CLAIMS

1. A catalytic distillation structure, comprising:

a rigid framework having at least two grids;

a plurality of horizontal fluid permeable tubes mounted to said grids to form a plurality of fluid pathways among the plurality of horizontal fluid permeable tubes, wherein each horizontal fluid permeable tubes have a profile of a six-sided polygon; and

a plurality of vertical plates or wires connecting vertically aligned tubes of the plurality of horizontal fluid permeable tubes, wherein the plurality of vertical plates or wires connects from a corner of one vertically aligned tubes to a corner of an adjacent vertically aligned tube.

2. The catalytic distillation structure of claim 1, further comprising a first series of vertically aligned tubes and a second series of vertically aligned tubes, wherein the first series comprises the plurality of horizontal fluid permeable tubes arrayed in a parallel, adjacent and vertically aligned columns within the first series, and the second series comprises the plurality of horizontal fluid permeable tubes arrayed in a parallel, adjacent and vertically aligned columns within the second series.

3. The catalytic distillation structure of claim 2, wherein the first series of vertically aligned tubes are offset from the second series of vertically aligned tubes thereby the horizontal fluid permeable tubes of the first series overlap the horizontal fluid permeable tubes of the second series without contacting the horizontal fluid permeable tubes of the second series of plates to thereby form a tortuous fluid pathway.

4. The catalytic distillation structure of claim 3, wherein a height of the plurality of vertical plates or wires evenly space apart the horizontal fluid permeable tubes in the first series and the second series, and wherein the first series and the second series are stacked side-by-side a distance apart.

5. The catalytic distillation structure of claim 3, further comprising:

a geometry of the six-sided polygon forming a first angle in four corners of the six-sided polygon, a second angle in two corners of the six-sided polygon, wherein the first angle is greater than the second angle,

wherein the second angle is in the corners of vertically aligned tubes that are connected by the plurality of vertically plates or wires,

wherein the six-sided polygon comprises two sides of a first length and four sides of a second length,

wherein the first angle is at a corner of a connection of a side of the first length and a side of the second length and the second angle is at a corner of a connection of two sides of the second length, and

wherein the second length is greater than or shorter than the first length.

6. The catalytic distillation structure of claim 1, wherein the plurality of horizontal fluid permeable tubes and plurality of vertical plates or wires are made of a same material, wire mesh.

7. The catalytic distillation structure of claim 1, further comprising at least one support rod to rigidly hold the at least two grids at distance apart from each grid.

8. The catalytic distillation structure of claim 1, wherein each of the plurality of horizontal fluid permeable tubes have an opening at a first end and second end of said tubes.

9. The catalytic distillation structure of claim 1, wherein the grids comprises a plurality of openings, wherein the plurality of openings of the grids have a profile equal to the profile of the plurality of horizontal fluid permeable, and wherein the plurality of horizontal fluid permeable tubes are positioned in the plurality of openings of the grids.

10. The catalytic distillation structure of claim 1, wherein the six-sided polygon is a hexagon, and the plurality of vertically plates or wires connect the vertically aligned tubes from a top corner of the hexagon of one vertically aligned tube to a bottom corner of the hexagon of the adjacent vertically aligned tube.

11. A distillation column reactor for concurrently carrying out reactions and separating the products from the reactants, comprising:

a vertically disposed vessel;

one or more catalytic distillation structures disposed in the vertically disposed vessel, comprising:

a rigid framework having at least two grids;

a plurality of horizontal fluid permeable tubes mounted to said grids to form a plurality of fluid pathways among the plurality of horizontal fluid permeable tubes, wherein each horizontal fluid permeable tubes have a profile of a six-sided polygon; and

a plurality of vertical plates or wires connecting vertically aligned tubes of the plurality of horizontal fluid permeable tubes, wherein the plurality of vertical plates or wires connects from a corner of one vertically aligned tubes to a corner of an adjacent vertically aligned tube.

12. The distillation column reactor of claim 11, further comprising one or more re-boilers, condensers, feeding tanks, or separators connected to the vertically disposed vessel via flow lines, and wherein the flow line from the feeding tanks connects to the vertically disposed vessel at, above, or below the one or more catalytic distillation structures.

13. The distillation column reactor of claim 11, wherein the rigid framework is removably attached to the vertically disposed vessel by welding, crimping, adhesives, or mechanical fasteners.

14. A catalytic distillation structure, comprising:

a rigid framework having at least two grids spaced apart;

a plurality of horizontal fluid permeable tubes mounted to said grids to form a plurality of fluid pathways among the plurality of fluid permeable tubes, wherein each fluid permeable tubes have a profile of a six-sided polygon, wherein each of the fluid permeable tubes extend from a first to a second of the at least two grids;

a plurality of vertical plates or wires connecting and aligning tubes of the plurality of fluid permeable tubes, wherein the plurality of plates or wires connects from a lowermost corner of one aligned tubes to an uppermost corner of an adjacent aligned tube.

15. The catalytic distillation structure of claim 14, further comprising a first series of vertically aligned tubes and a second series of vertically aligned tubes, wherein the first series comprises the plurality of fluid permeable tubes arrayed in a parallel, adjacent and aligned columns within the first series, and the second series comprises the plurality of fluid permeable tubes arrayed in a parallel, adjacent and aligned columns within the second series.

16. The catalytic distillation structure of claim 15, wherein the first series of aligned tubes are offset from the second series of aligned tubes and the fluid permeable tubes of the first series overlap the fluid permeable tubes of the second series without contacting the fluid permeable tubes of the second series of plates to thereby form a tortuous fluid pathway.

17. The catalytic distillation structure of claim 16, wherein a height of the plurality of plates or wires evenly space apart the fluid permeable tubes in the first series and the second series, wherein the first series and the second series are stacked side-by-side a distance apart.

18. The catalytic distillation structure of claim 16, further comprising:

a geometry of the six-sided polygon forming a first angle in four corners of the six-sided polygon, a second angle in two corners of the six-sided polygon, wherein the first angle is greater than the second angle,

wherein the second angle is in the corners of vertically aligned tubes that are connected by the plurality of plates or wires,

wherein the six-sided polygon comprises two sides of a first length and four sides of a second length,

wherein the first angle is at a corner of a connection of a side of the first length and a side of the second length and the second angle is at a corner of a connection of two sides of the second length, and

wherein the second length is greater than or shorter than the first length.

19. The catalytic distillation structure of claim 14, wherein the plurality of fluid permeable tubes and plurality of plates or wires are made of a same material.

20. The catalytic distillation structure of claim 14, further comprising at least one support rod to rigidly hold the at least two grids a distance apart from each other.

21. The catalytic distillation structure of claim 14, wherein each of the plurality of fluid permeable tubes have an opening at a first end and second end of said tubes.

22. The catalytic distillation structure of claim 14, wherein the grids comprises a plurality of openings, wherein the plurality of openings of the grids have a profile equal to the profile of the plurality of fluid permeable tubes.

23. The catalytic distillation structure of claim 14, wherein a series of aligned tubes connected via the plates or wires do not comprise welds, and wherein the plurality of fluid permeable tubes are positioned in the plurality of openings of the grids.

24. The catalytic distillation structure of claim 14, wherein the tubes are horizontal and are aligned vertically.

25. A distillation column reactor for concurrently carrying out reactions and separating the products from the reactants, comprising:

a vertically disposed vessel; and

one or more catalytic distillation structures as recited in claim 14 disposed in the vertically disposed vessel.

26. The distillation column reactor of claim 25, wherein the rigid framework is removably attached to the vertically disposed vessel by welding, crimping, adhesives, or mechanical fasteners.