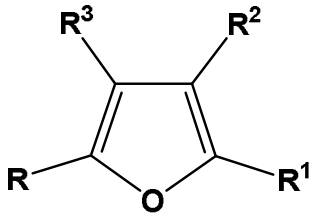
CLAIMS

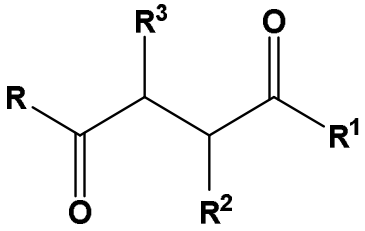
1. A process for producing a pyrrole compound, the process comprising:

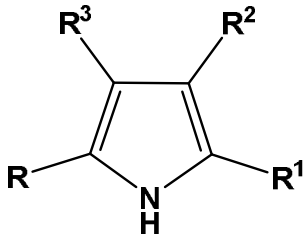
a) contacting a furan compound, a solid acid catalyst, and water to form a reaction mixture comprising a γ-dicarbonyl compound, wherein a molar ratio of water to the furan compound is in a range from 0.5:1 to 10:1; and

b) contacting the γ-dicarbonyl compound with ammonia, an ammonium salt, or a combination thereof, to form a reaction product mixture comprising the pyrrole compound.

2. The process of claim 1, wherein the furan compound (F1), the γ-dicarbonyl compound (D1), and the pyrrole compound (P1) have the following formulas:



(F1)


(D1)


(P1);

wherein R, R^1, R^2, and R^3 independently are a hydrogen atom, a C_1-C_{30} organyl group, or a C_3-C_{60} silyl group.

3. The process of claim 2, wherein R, R^1, R^2, and R^3 independently are a hydrogen atom or a C_1-C_{18} hydrocarbyl group.

4. The process of claim 2, wherein R and R^1 independently are a C_1-C_{18} hydrocarbyl group, and R^2 and R^3 are a hydrogen atom.

5. The process of claim 2, wherein R and R^1 independently are a methyl group, an ethyl group, an n-propyl group, an iso-propyl group, an n-butyl group, a t-butyl group, a phenyl group, a benzyl group, a tolyl group, or a xylyl group.

6. The process of claim 1, wherein the pyrrole compound comprises 2,5-dimethylpyrrole.

7. The process of claim 1, wherein the solid acid catalyst comprises a styrene-divinylbenzene resin, a 4-vinylpyridine divinylbenzene resin, an ionomer resin, a tetrafluoroethylene resin modified with perfluorovinyl ether groups terminated with sulfonate groups, or any combination thereof.

8. The process of claim 1, wherein the solid acid catalyst comprises a styrene-divinylbenzene resin.

9. The process of claim 1, wherein step a) is conducted at:
a temperature below the maximum operating temperature of the solid acid catalyst; and
a pressure sufficient to maintain water in the liquid phase.

10. The process of claim 1, wherein step a) is conducted at:
a temperature in a range from 80 °C to 180 °C; and
a pressure in a range from 25 to 150 psig.

11. The process of claim 1, wherein ~~step a) is conducted at a~~the molar ratio of water to the furan compound is in a range from ~~0.5~~1:1 to ~~10~~7.5:1.

12. The process of claim 1, wherein step a) is conducted in a stirred tank reactor at a weight ratio of the furan compound to the solid acid catalyst in a range from 5:1 to 50:1.

13. The process of claim 1, wherein a conversion of the furan compound is at least 90 mol %.

14. The process of claim 13, wherein a yield to the γ-dicarbonyl compound is at least 80 mol %.

15. The process of claim 1, wherein step a) is conducted in a fixed bed reactor at a furan compound WHSV in a range from 0.01 to 5.

16. The process of claim 1, further comprising:

a step of separating at least a portion of the γ-dicarbonyl compound from the reaction mixture prior to step b); and/or

a step of separating at least a portion of the solid acid catalyst from the reaction mixture prior to step b).

17. The process of claim 1, wherein step b) comprises contacting the γ-dicarbonyl compound with the ammonium salt, and wherein the ammonium salt comprises ammonium hydroxide, ammonium acetate, ammonium carbonate, ammonium bicarbonate, ammonium chloride, ammonium nitrate, ammonium phosphate, ammonium sulfate, or any combination thereof.

18. The process of claim 1, wherein:

the reaction product mixture comprises an organic phase and an aqueous phase; and

the process further comprises a step of separating at least a portion of the water from the reaction product mixture after step b).

19. The process of claim 1, wherein the pyrrole compound is produced in a yield of at least 70 mol %, based on the furan compound.

20. The process of claim 1, further comprising a step of separating at least a portion of the pyrrole compound from the reaction product mixture after step b).

21. The process of claim 1, wherein step a) is conducted at a temperature in a range from 110 °C to 170 °C.