

CLAIMS

I/We Claim:

1. A method for desorbing ammonia from an adsorbent material comprising:
5 providing an adsorbent material having ammonia adsorbed therein; and
exposing the adsorbent material to microwave radiation to thereby desorb
ammonia from the adsorbent material.
2. The method of claim 1 further comprising:
10 passing a sweep gas through the adsorbent material to thereby remove desorbed
ammonia from the adsorbent material.
3. The method of claim 1 further comprising:
removing a pure stream of desorbed ammonia from the adsorbent material by
15 subjecting the adsorbent material to a vacuum pump.
4. The method of claim 1, wherein the adsorbent material is one or more of
4A, 5A, or 13X zeolites.
- 20 5. The method of claim 1, wherein exposing the adsorbent material to
microwave radiation to thereby desorb ammonia from the adsorbent material comprises:
exposing the adsorbent material to microwave radiation having a first photon
energy; and
exposing the adsorbent material to microwave radiation having a second photon
25 energy, the second photon energy being greater than the first photon energy.
6. The method of claim 1, wherein providing an adsorbent material having
ammonia adsorbed therein comprises:
passing a gas mixture through the adsorbent material, the gas mixture comprising
30 H₂, N₂ and ammonia, wherein the adsorbent material selectively adsorbs the ammonia
while allowing a mixture of H₂ and N₂ to pass through the adsorbent material.

7. The method of claim 6, further comprising:

directing the mixture of H₂ and N₂ that passes through the adsorbent material to an electrochemical purifier to thereby produce high purity H₂ at the outlet of the electrochemical purifier, and

5 directing the high purity H₂ to an electrochemical compressor to thereby produce high pressure, high purity H₂ at the outlet of the electrochemical purifier outlet.

8. The method of claim 7 wherein the electrochemical purifier and the electrochemical compressor are proton exchange membrane devices.

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9. The method of claim 6, further comprising:

cracking ammonia to form the gas mixture comprising H₂, N₂ and ammonia.

10. The method of claim 1, further comprising:

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removing desorbed ammonia from the adsorbent material; and

directing, via a pump, the removed ammonia to an ammonia cracker.

11. The method of claim 10, wherein providing an adsorbent material having ammonia adsorbed therein comprises:

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passing an output stream from an ammonia cracker through the adsorbent material, the output stream comprising a residual amount of uncracked ammonia.

12. The method of claim 11, wherein exposing the adsorbent material to microwave radiation to thereby desorb ammonia from the adsorbent material comprises:

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periodically exposing the adsorbent material to microwave radiation.

13. An apparatus for removing ammonia from an adsorbent material, comprising:

an adsorbent vessel;

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an adsorbent material disposed within the adsorbent vessel, the adsorbent material having ammonia adsorbed therein; and

a microwave emitter configured to direct microwave radiation at the adsorbent material disposed in the adsorbent vessel.

14. The apparatus of claim 13, wherein the microwave emitter is located outside of the adsorbent vessel.

5 15. The apparatus of claim 14, wherein the adsorbent vessel further comprises:
a microwave transparent window, wherein the microwave emitter is configured to direct microwave radiation into the adsorbent vessel through the microwave transparent window.

10 16. The apparatus of claim 14, wherein the apparatus further comprises:
one or more angled pipe sections extending from the adsorbent vessel;
wherein a microwave emitter is positioned proximate a terminal end of each of the one or more angled pipe sections; and
wherein each of the one or more angled pipe sections is configured to direct
15 microwave radiation into the adsorbent vessel such that the microwave radiation propagates down the length of the adsorbent vessel.

17. The apparatus of claim 13, wherein the microwave emitter is disposed inside the adsorbent vessel.
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18. The apparatus of claim 17, wherein the adsorbent vessel is partitioned into an upper portion and a lower portion, and the microwave emitter is disposed in the upper portion such that the microwave is isolated from the lower portion.

25 19. The apparatus of claim 17, wherein the microwave emitter comprises a plurality of microwave emitters, and the plurality of microwave emitters are positioned along a central axis of the adsorbent vessel.

20. The apparatus of claim 19, further comprising:
a launcher associated with each of the plurality of microwave emitters, the
30 launchers being configured to direct microwave radiation emitted by the microwave emitters in a rotational, axial, or combination of rotational and axial directions.