CLAIMS

1. A process for the purification of a hydrogen feed stream comprising hydrogen and one or more impurities selected from the group consisting of nitrogen, argon, methane, carbon monoxide, carbon dioxide, and water, the process comprising:

separating a crude hydrogen stream by an adsorption process using a plurality of adsorbent beds to produce the hydrogen feed stream and an impurites-enriched tail gas stream;

cooling the hydrogen feed stream to produce a cooled hydrogen stream; and

contacting the cooled hydrogen stream with a liquid hydrogen wash stream counter-currently to produce a pure hydrogen stream depleted in the one or more impurities and a liquid hydrogen effluent stream enriched in the one or more impurities;

wherein the adsorption process comprises a counter-current purge step during which a purge gas is introduced to remove one or more crude impurities selected from nitrogen, argon, methane, carbon monoxide, carbon dioxide, and water from the plurality of adsorbent beds; and

wherein the purge gas comprises a stream derived from the liquid hydrogen effluent stream.

2. The process of claim 1, wherein the adsorption process comprises a depressurization step during which a hydrogen-rich tail gas fraction is removed from the plurality of beds; and further comprising

combining the hydrogen-rich tail gas fraction with the crude hydrogen stream.

3. The process of claim 2, wherein the hydrogen content of the hydrogen-rich tail gas fraction is greater than 20% by volume.

4. The process of claim 1, further comprising separating the impurities-enriched tail gas stream to produce a hydrogen-enriched tail gas fraction and a hydrogen-depleted tail gas fraction; and

combining the hydrogen-enriched tail gas fraction with one or more of the crude hydrogen stream and the hydrogen feed stream.

5. The process of claim 1, further comprising cooling the hydrogen feed stream by indirect heat exchange with the liquid hydrogen effluent stream.

6. The process of claim 1, further comprising cooling the hydrogen feed stream by indirect heat exchange with the pure hydrogen stream.

7. The process of claim 1, further comprising passing the pure hydrogen stream through an online adsorber at a cryogenic temperature to adsorb the one or more impurities and produce an ultra-pure hydrogen stream and a loaded adsorber; and

passing a regeneration gas stream through the loaded adsorber at ambient temperature and pressure to regenerate the loaded adsorber and produce a spent regeneration gas stream comprising the one or more impurities.

8. The process of claim 7, wherein the regeneration gas comprises at least a portion of the pure hydrogen stream.

9. The process of claim 7, wherein the regeneration gas comprises at least a portion of the ultra-pure hydrogen stream.