Production of Hydrogen Through a Sulfur-Iodine Cycle Based on the Electrochemical Bunsen Reaction

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Background & Description:

The production of hydrogen through the sodium iodine cycle based on the electrochemical Bunsen reaction involves a series of chemical reactions that use water as the feedstock to produce hydrogen. This process is a promising and sustainable method for large-scale hydrogen production as it relies on renewable sources of energy and has minimal environmental impact. By using this process, hydrogen can be produced efficiently, which can be used in various applications such as fuel cells and as a feedstock to produce chemicals.

The production of hydrogen through sodium iodine cycle based on electrochemical Bunsen reaction involves three main reactions: Bunsen reaction, hydrogen iodide decomposition, and hydrogen sulfide decomposition.

1. Electrochemical Bunsen Reaction:

   $2H_2O + SO_2 + I_2 \rightarrow 2HI + H_2SO_4$, Conversion Rate: 100%

2. H_2SO_4 Decomposition section:

   a. H_2SO_4 Decomposer:

      $H_2SO_4 \rightarrow H_2O + SO_3$, Conversion Rate: 100%

   b. SO3 Decomposer

      $SO_3 \rightarrow SO_2 + 0.5O_2$, Conversion Rate: 78%

3. HI Decomposition section:

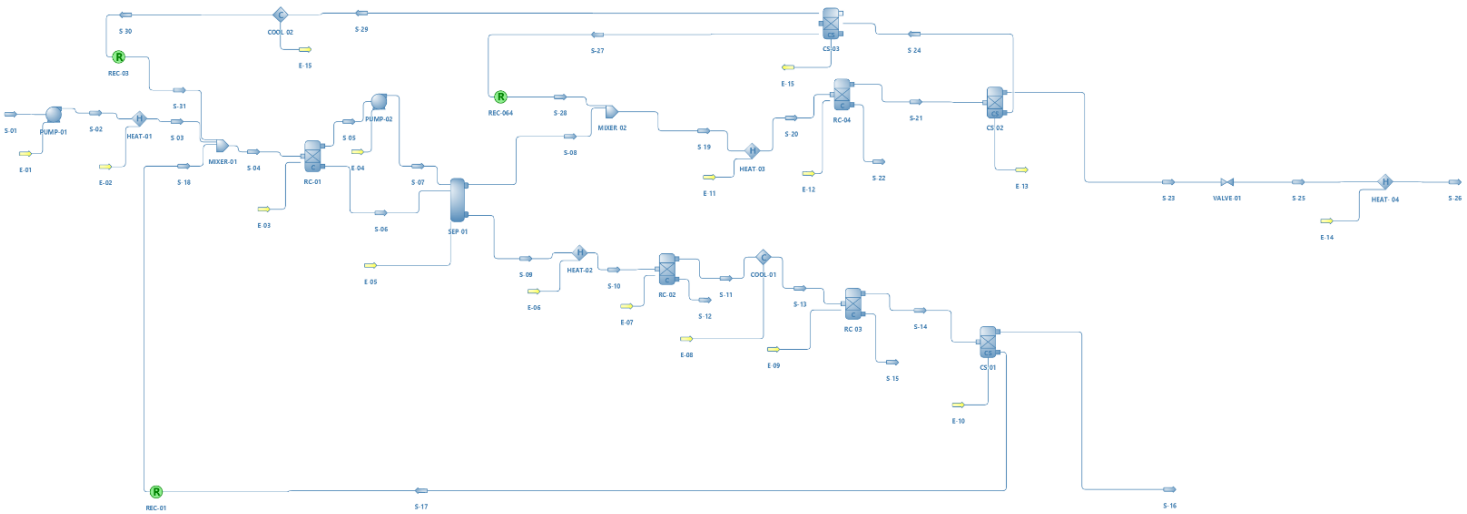
   $2HI \rightarrow H_2 + I_2$, Conversion Rate: 40%

In this flowsheet, S-01 is the main feed of water, S-18 and S-31 are recycled HI and H_2SO_4 feeds respectively whereas S-26 and S-16 are the H_2 and O_2 product stream respectively.

Software & Flowsheet specifications:

1. DWSIM Version: 5.8.3
2. Thermodynamics: NRTL
3. Temperature: Kelvin
4. Pressure: MPa
5. Molar flow rate: mol/s
6. Mass flow rate: g/s
7. Volumetric flow rate: m^3/s

Flowsheet:



Results:

BUNSEN REACTOR									
Object	**S-01**	**S-02**	**S-03**	**S-04**	**S-05**	**S-06**	**S-18**	**S-31**	
Temperature	298.15	298.19	313	313.274	313	313	313	313	**K**
Pressure	0.1	0.5	0.5	0.101325	0.101325	0.101325	0.101325	0.101325	**MPa**
Mass Flow	18.0153	18.0153	18.0153	1919.25	206.491	1712.76	0	1901.24	**g/s**
Molar Flow	1	1	1	36.53	1.68951	34.8405	0	35.53	**mol/s**
Molar Flow (Mixture) / Water	1	1	1	24.989	0.0874991	24.9015	0	23.989	**mol/s**
Molar Flow (Mixture) / Hydrogen	0	0	0	0	0	0	0	0	**mol/s**
Molar Flow (Mixture) / Oxygen	0	0	0	0	0	0	0	0	**mol/s**
Molar Flow (Mixture) / Hydrogen iodide	0	0	0	4.431	1.60044	2.83056	0	4.431	**mol/s**
Molar Flow (Mixture) / Iodine	0	0	0	7.11	0.00156544	7.10843	0	7.11	**mol/s**
Molar Flow (Mixture) / Sulfur dioxide	0	0	0	0	0	0	0	0	**mol/s**
Molar Flow (Mixture) / Hydrogen Sulfide	0	0	0	0	0	0	0	0	**mol/s**
Molar Flow (Mixture) / Sulfur trioxide	0	0	0	0	0	0	0	0	**mol/s**

H2SO4 DECOMPOSITION												
Object	**S-06**	**S-09**	**S-10**	**S-11**	**S-12**	**S-13**	**S-14**	**S-15**	**S-16**	**S-17**	**S-18**	
Temperature	313	329.304	1123	1123	1123	1123	313	313	313	313	313	**K**
Pressure	0.101325	0.101325	0.101325	0.101325	0.101325	0.101325	0.101325	0.101325	0.101325	0.101325	0.101325	**MPa**
Mass Flow	1712.76	1564.46	1564.46	1564.46	0	1564.46	0	1564.46	15.9994	0	0	**g/s**
Molar Flow	34.8405	33.4337	33.4337	33.4337	0	33.4337	0	33.4337	0.5	0	0	**mol/s**
Molar Flow (Mixture) / Water	24.9015	24.6136	24.6136	24.6136	0	24.6136	0	24.6136	0	0	0	**mol/s**
Molar Flow (Mixture) / Hydrogen	0	0	0	0	0	0	0	0	0	0	0	**mol/s**
Molar Flow (Mixture) / Oxygen	0	0	0	0	0	0	0	0	0.5	0	0	**mol/s**
Molar Flow (Mixture) / Hydrogen iodide	2.83056	1.7172	1.7172	1.7172	0	1.7172	0	1.7172	0	0	0	**mol/s**
Molar Flow (Mixture) / Iodine	7.10843	7.10287	7.10287	7.10287	0	7.10287	0	7.10287	0	0	0	**mol/s**
Molar Flow (Mixture) / Sulfur dioxide	0	0	0	0	0	0	0	0	0	0	0	**mol/s**
Molar Flow (Mixture) / Hydrogen Sulfide	0	0	0	0	0	0	0	0	0	0	0	**mol/s**
Molar Flow (Mixture) / Sulfur trioxide	0	0	0	0	0	0	0	0	0	0	0	**mol/s**

HI DECOMPOSITION														
Object	**S-07**	**S-08**	**S-19**	**S-20**	**S-21**	**S-22**	**S-23**	**S-24**	**S-25**	**S-26**	**S-27**	**S-28**	**S-29**	**S-30**	
Temperature	1435.69	329.304	713.123	723	723	723	723	723	723	313	723	723	723	313	**K**
Pressure	1.17	0.101325	0.101325	0.101325	0.101325	0.101325	0.101325	0.101325	0.1	0.1	0.101325	0.101325	0.101325	0.101325	**MPa**
Mass Flow	206.491	354.796	4728.36	4728.36	4728.36	0	2.01588	4727.27	2.01588	2.01588	4373.56	4373.56	1901.24	1901.24	**g/s**
Molar Flow	1.68951	3.0963	69.2857	69.2857	69.8285	0	1	69.2857	1	1	66.1894	66.1894	35.53	35.53	**mol/s**
Molar Flow (Mixture) / Water	0.0874991	0.375368	0.375368	0.375368	0.375368	0	0	0.375368	0	0	0	0	23.989	23.989	**mol/s**
Molar Flow (Mixture) / Hydrogen	0	0	0	0	0.542761	0	1	0	1	1	0	0	0	0	**mol/s**
Molar Flow (Mixture) / Oxygen	0	0	1.82135	1.82135	1.82135	0	0	1.82135	0	0	1.82135	1.82135	0	0	**mol/s**
Molar Flow (Mixture) / Hydrogen iodide	1.60044	2.7138	2.7138	2.7138	1.62828	0	0	1.62828	0	0	0	0	4.431	4.431	**mol/s**
Molar Fraction (Mixture) / Iodine	0.000926564	0.00230267	0.000102904	0.000102904	0.0156477	0	0	0.0157702	0	0	0	0	0.200113	0.200113	
Molar Flow (Mixture) / Sulfur dioxide	0	0	57.4833	57.4833	57.4833	0	0	57.4833	0	0	57.4833	57.4833	0	0	**mol/s**
Molar Flow (Mixture) / Hydrogen Sulfide	0	0	4.52426	4.52426	4.52426	0	0	4.52426	0	0	4.52426	4.52426	0	0	**mol/s**
Molar Flow (Mixture) / Sulfur trioxide	0	0	2.3605	2.3605	2.3605	0	0	2.3605	0	0	2.3605	2.3605	0	0	**mol/s**

Conclusion:

Thus, the flowsheet for the production of hydrogen through the sodium-iodine cycle based on the electrochemical Bunsen reaction resulted in the formation of 1 mol/s of H_2 and 0.5 mol/s of O_2 from an initial input of 1 mol/s of H_2O. This was achieved through the use of a sodium-iodine cycle, which involved various unit operations such as chemical conversion, and separation.

Reference:

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