Hydrogen production by steam reforming of glycerol

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Background and description:

Glycerol is a byproduct of biodiesel production, it contains many impurities such as methanol, fatty acids, and, soaps. Purifying it is not cost-effective, so researchers are exploring ways to convert crude glycerol into valuable products, as it has applications in various industries, including food and beverages, personal care, and more. Steam reforming of glycerol is one of the ways to convert it into hydrogen fuel.

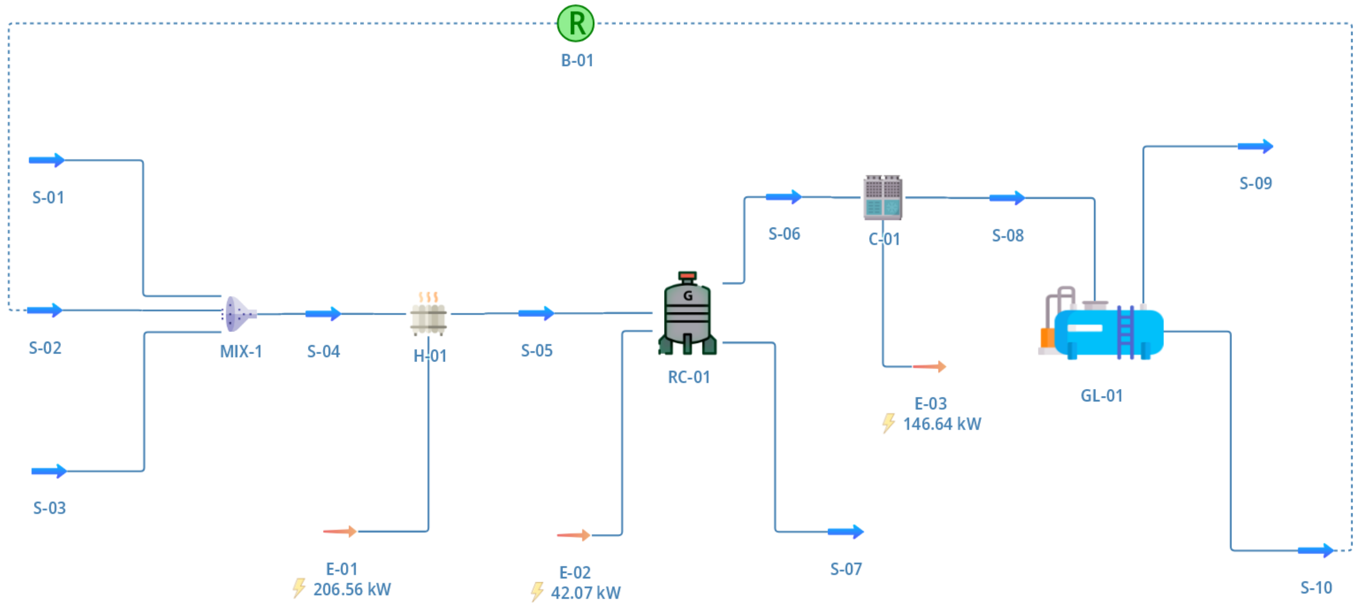
Pure glycerol and water (Both at 1 atm and 25 °C) enter to mixer. This feed is heated through a heater up to 600 °C and passed to the reformer. The reformer used in this simulation is a Gibbs reactor which calculates the equilibrium composition of the product at specified temperature and pressure. The product from the reformer is cooled back to 25 °C by using a cooler. The cooled product is finally separated through a gas-liquid separator. Hydrogen in the product gas is the desired component of the process. While liquid mainly containing water is a byproduct of the process. This water has been recycled.

$$C_3H_8O_3 + 3H_2O \rightleftharpoons 7H_2 + 3CO_2 \; (\Delta Hr^{298K} = 127.7 \text{ KJmol}^{-1})$$

Stoichiometric moles of components are taken in the feed stream. It can be observed from the master property table that 62.68 % (mol/mol) of hydrogen can be produced by steam reforming of glycerol at T=600 °C and P=1atm. Also, complete conversion of glycerol has been observed. Moreover, complete coke reduction is attained at these operating conditions. Results also show that 5.42 moles of hydrogen can be produced per mole of glycerol fed.

Thermodynamic package: Peng-Robinson Equation of State.

Flowsheet:



Results:

Master Property Table						
Object	Glycerol	Water IN	Recycled water	Product gas	Water OUT	Units
Temperature	25	25	25	25	25	C
Pressure	1	1	1	1	1	atm
Molar Flow	1	3	5.37724	8.65894	5.37724	kmol/h
Molar Fraction (Mixture) / Glycerol	1	0	0	0	0	
Molar Fraction (Mixture) / Water	0	1	1.00E+00	2.67E-02	1.00E+00	
Molar Fraction (Mixture) / Hydrogen	0	0	1.89E-07	0.626848	1.89E-07	
Molar Fraction (Mixture) / Carbon dioxide	0	0	1.25E-04	0.236505	1.25E-04	
Molar Fraction (Mixture) / Carbon monoxide	0	0	1.00E-08	0.08607	1.00E-08	
Molar Fraction (Mixture) / Methane	0	0	9.86E-11	0.02385	9.86E-11	
Molar Fraction (Mixture) / Carbon	0	0	0.00E+00	0	0.00E+00	

Reference:

Haider, M. A., & Chaturvedi, N. D. (2023). An energy-efficient and cleaner production of hydrogen by steam reforming of glycerol using Aspen Plus. *International Journal of Hydrogen Energy*. https://doi.org/10.1016/j.ijhydene.2023.09.089