World Academy of Science, Engineering and Technology
International Journal of Bioengineering and Life Sciences
Vol:10, No:01, 2016

Experimental and Simulation Results for the Removal of H2S from Biogas by Means of Sodium Hydroxide in Structured Packed Columns

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Abstract : Biogas is a promising technology which can be used as a vehicle fuel, for heat and electricity production, or injected in the national gas grid. It is storable, transportable, not intermittent and substitutable for fossil fuels. This gas produced from the wastewater treatment by degradation of organic matter under anaerobic conditions is mainly composed of methane and carbon dioxide. To be used as a renewable fuel, biogas, whose energy comes only from methane, must be purified from carbon dioxide and other impurities such as water vapor, siloxanes and hydrogen sulfide. Purification of biogas for this application particularly requires the removal of hydrogen sulfide, which negatively affects the operation and viability of equipment especially pumps, heat exchangers and pipes, causing their corrosion. Several methods are available to eliminate hydrogen sulfide from biogas. Herein, reactive absorption in structured packed column by means of chemical absorption in aqueous sodium hydroxide solutions is considered. This study is based on simulations using Aspen Plus™ V8.0, and comparisons are done with data from an industrial pilot plant treating 85 Nm3/h of biogas which contains about 30 ppm of hydrogen sulfide. The rate-based model approach has been used for simulations in order to determine the efficiencies of separation for different operating conditions. To describe vapor-liquid equilibrium, a γ/ϕ approach has been considered: the Electrolyte NRTL model has been adopted to represent non-idealities in the liquid phase, while the Redlich-Kwong equation of state has been used for the vapor phase. In order to validate the thermodynamic model, Henry's law constants of each compound in water have been verified against experimental data. Default values available in Aspen Plus™ V8.0 for the properties of pure components properties as heat capacity, density, viscosity and surface tension have also been verified. The obtained results for physical and chemical properties are in a good agreement with experimental data. Reactions involved in the process have been studied rigorously. Equilibrium constants for equilibrium reactions and the reaction rate constant for the kinetically controlled reaction between carbon dioxide and the hydroxide ion have been checked. Results of simulations of the pilot plant purification section show the influence of low temperatures, concentration of sodium hydroxide and hydrodynamic parameters on the selective absorption of hydrogen sulfide. These results show an acceptable degree of accuracy when compared with the experimental data obtained from the pilot plant. Results show also the great efficiency of sodium hydroxide for the removal of hydrogen sulfide. The content of this compound in the gas leaving the column is under 1 ppm.

Keywords : biogas, hydrogen sulfide, reactive absorption, sodium hydroxide, structured packed column
Conference Title : ICBST 2016 : International Conference on Biogas Science and Technology
Conference Location : Paris, France
Conference Dates : January 21-22, 2016