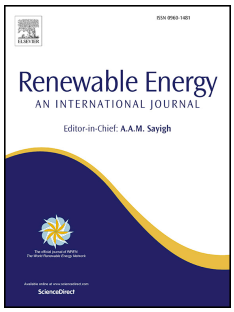
Accepted Manuscript



Methanol synthesis from biogas: A thermodynamic analysis

A. Vita, C. Italiano, D. Previtali, C. Fabiano, A. Palella, F. Freni, G. Bozzano, L. Pino, F. Manenti

PII: S0960-1481(17)31123-0

DOI: 10.1016/j.renene.2017.11.029

Reference: RENE 9431

To appear in: *Renewable Energy*

Received Date: 20 September 2017

Revised Date: 23 October 2017

Accepted Date: 11 November 2017

Please cite this article as: Vita A, Italiano C, Previtali D, Fabiano C, Palella A, Freni F, Bozzano G, Pino L, Manenti F, Methanol synthesis from biogas: A thermodynamic analysis, *Renewable Energy* (2017), doi: 10.1016/j.renene.2017.11.029.

Methanol synthesis from biogas: A thermodynamic analysis

A. Vita[1], C. Italiano[1], D. Previtali[2], C. Fabiano[1], A. Palella[1], F. Freni[3], G. Bozzano[2], L. Pino[1], F. Manenti[2]

[1]*CNR-ITAE, Institute for Advanced Energy Technologies "Nicola Giordano", Via Salita S. Lucia sopra Contesse 5, 98126 Messina, Italy*

[2]*Department of Chemistry, Materials and Chemical Engineering "Giulio Natta", Polytechnic of Milano, Piazza Leonardo da Vinci 32, 20133 Milano, Italy*

[3]*Department of Electronic Engineering, Chemistry and Industrial Engineering, University of Messina, Contrada di Dio, 98166 Messina, Italy*

Abstract

A new approach for the direct conversion of syngas into methanol has been proposed as alternative to the conventional process requiring WGS and/or PSA clean-up steps for syngas upgrading. A comparative thermodynamic equilibrium analysis of biogas reforming processes (dry reforming, steam reforming and oxy-steam reforming) has been performed using the Gibbs free energy minimization method. The calculations have been carried out under different biogas composition (CH_4/CO_2=1-2.3), reaction temperature (400-900°C), S/CH_4 (0.0-3.0) and O_2/CH_4 (0.0-0.2) molar ratios. The effects of process variables on the reforming performances as well as on the syngas quality, in term of CH_4 and CO_2 conversion, H_2/CO and H_2/CO_2 ratios, coke deposition and energetic consumption, has been examined. Subsequently, methanol synthesis has been studied using the same mathematical approach, with the aim to identify the most adequate operating conditions for the direct conversion of the syngas obtained from reforming process into methanol. The simulations suggested that steam reforming of biogas, with high methane content, is the most appropriate route to produce a syngas quality suitable for the new proposed approach.

Keywords: Methanol synthesis; Biogas; Reforming processes; Thermodynamic analysis; PRO\II process simulator; Gibbs free energy minimization.