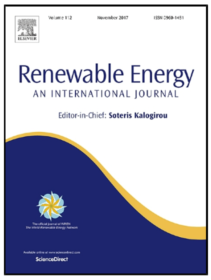
Accepted Manuscript



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PII: S0960-1481(17)30778-4

DOI: 10.1016/j.renene.2017.08.025

Reference: RENE 9123

To appear in: *Renewable Energy*

Received Date: 20 March 2017

Revised Date: 09 July 2017

Accepted Date: 11 August 2017

Please cite this article as: Hongyou Yuan, Shubin Wu, Xiuli Yin, Yanqin Huang, Daliang Guo, Chuangzhi Wu, Adjustment of biomass product gas to raise H_2/CO ratio and remove tar over sodium titanate catalysts, *Renewable Energy* (2017), doi: 10.1016/j.renene.2017.08.025

Adjustment of biomass product gas to raise H_2/CO ratio and remove tar over sodium titanate catalysts

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Abstract: To raise H_2/CO and remove tar for biomass product gas, sodium titanates $4Na_2O{\cdot}5TiO_2$ and $Na_2O{\cdot}3TiO_2$ were evaluated at 850 °C using wood powder pyrolysis gas produced from a 0.3 kg/h screw pyrolyzer with no extra steam, silica sand was selected as an inert material for comparison. The GHSV of the runs were around 2000 h^{-1} with tar content of about 200 g/Nm^3. The results suggest that $4Na_2O{\cdot}5TiO_2$ presents the highest activity, $Na_2O{\cdot}3TiO_2$ ranks slightly lower, and silica sand shows no activity of enhancing hydrogen yield. The hydrogen formation is promoted through tar cracking, water gas shift and/or methane reforming. The H_2/CO increases to 1.8–2.0, which is higher than that of silica sand (about 0.35) and raw gas (about 0.25). Tar conversion in the $4Na_2O{\cdot}5TiO_2$ reforming was about 99% and nearly no coke was formed within the test duration of about 8 h, whereas the silica sand was coked obviously in 1 h. Most tar components can be effectively reformed, except for parts of xylene, naphthalene, biphenylene, and anthracene. The activity of $4Na_2O{\cdot}5TiO_2$ decreases gradually in the long-term test because of the release of sodium and has a tendency to transform to $Na_2O{\cdot}3TiO_2$, the latter exhibits satisfactory stability and activity.

Keywords: biomass; pyrolysis; gasification; steam reforming; H_2/CO ratio; sodium titanate

1. Introduction

Nowadays, hydrogen can be produced from natural gas steam reforming coupled with water gas shift and PSA (pressure swing adsorption) [1,2]. Biomass, as a renewable and non-fossil fuel, is drawing much attention to produce hydrogen or hydrogen rich gas by means of advanced technologies such as pyrolysis and gasification [2-4]. To be tailored for some particular end-use applications, e.g. Fischer-Tropsch synthesis, dimethyl ether synthesis, domestic gas, the biomass-derived product gas needs to be adjusted and cleaned. Generally, the Fischer-Tropsch synthesis process requires a H_2/CO ratio of syngas as high as about 2.0 for maximum target product yield [2,3]. Catalytic gasification and/or reforming were usually preferred by researchers, involving the following catalysts: Ni-based catalysts[4-7], alkaline earth metal[5,8,9], rare earth catalysts[10], etc.

The presence of tar in product gas is a major obstacle limiting the demonstration of biomass gasification or pyrolysis processes. Tar contains very complex condensable hydrocarbons, including single or multiple ring aromatic compounds. As stated in the EU/IEA/USDOE tar protocol [11], tar is defined as hydrocarbons with molecular weights higher than that of benzene. Catalytic reforming/cracking is an attractive alternative decreasing the tar concentration in product gas, cracking tar into small-molecule permanent gases, and increasing the gasification efficiency.

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