Comparison of syngases produced under different biomass gasification conditions by principal component analysis

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Gasification is one of the most promising technology for utilizing renewable resources to produce fossil fuel alternatives. It is an important thermochemical method for conversion of biomass into combustible gaseous mixture of syngas consisting mainly of hydrogen (H_2), carbon monoxide (CO), methane (CH_4) and carbon dioxide (CO_2) by partial oxidation of the biomass at high temperatures generally in the range 800-1000ºC. There is a great amount of biomass resources, including forestry and agricultural waste, with later being cheaper, adding a high economic potential compared to the expensive woody biomass fuels (Gai and Dong,2012). Additionaly, over the past few years some studies considered also the combined exploitation of crude glycerol -the only by-product of the biodiesel production by vegetable oil transesterification, with locally produced agro-residues by thermochemical treatments in order to explore a viability of crude glycerol as the abundant source to produce high added value fuels like renewable H_2 production (Skoulou, et al., 2012; Skoulou and Zabanioutou, 2013; Delgado et al., 2013; Wei et al., 2011;Sricharoenchaikul and Atong, 2012; Chen et al., 2012). The combined thermochemical conversion of crude glycerol from the biodiesel production with the locally available biomass might be also considered as an important step contributing to the sustainability and economical production of biodiesel particulary in small and medium-scale plants, which are nowmanaging the glycerol excess as a waste because of its impurities, with final impact on the increasing storage and management costs (Đurišić-Mladenović et al., 204; Skoulou et al., 2012; Skoulou and Zabaniotou, 2013).

The goal of this study was to compare the syngas quality produced by co-gasification of crude glycerol and olive kernel with syngases produced by gasification of other types of biomass in order to comparatively characterize the produced syngases and to assess general information common for different gasification systems. The literature-based data on the composition of the produced gases were assessed by principal component analysis (PCA)- a commonly used chemometric technique for data reduction and simplification of large sets of intercorrelated variables, which are treated equally. The principal of PCA is to characterize each case (named also as object,sample or observation) not by analyzing every variable, but projecting the data in a much smaller sub set of new variables called principal components (PCs).The parameters included in the input data set were volumetric percentages of hydrogen, carbon monoxide, carbon dioxide and methane, the gas lower heating values amd two derived indicators: H_2/CO ratio and (H_2+CO) content. In total, the data setgathered 84 syngases taken from 11 studies comparable in 7 variables.

The PCA reflected similarity among majority of syngases produced by different gasification systems taking into account the considered variables; the seen outlying syngases had specific (unusual to others) composition primarily characterized by lower quantities of H_2 (less than 16% (v/v)) and significantly higher or lower quantities of CO_2 if compared to the whole H_2- and CO_2-range inthe input data set, respectively. Clear separation among the gases from different gasification systems could not be seen, but there was a slight gradual separation of syngases seen along PC1, indicated that different gasification systems influenced differences in syngas H_2/CO ratio and CH_4 (and CO) content. On the other hand, dispersion of the syngases from different studies was more pronounced along PC2 or PC3than along PC1, suggesting that varying conditions within particular study (e.g. T, λ, feedstock composition) influenced more the differences in H_2 and CO_2 contents (variables correlated significantly with PC2 and PC3, respectively) than the CH_4 (and CO) contents and H_2/CO ratio. Concerning the gases produced by co-gasification of crude glycerol with olive kernel it was apparent that they compared favorably with published data. They were closely positioned to the gases with intermediateto the highest H_2 contents, having intermediate to low CO_2 contents, and intermediate H_2/CO ratios compared to other syngases in the data set.Additionally, it might be concluded that olive-based waste gasification may result in wide range of the gas composition, suggesting that the choice of operating conditions carries the important and decisive role for syngas quality and quantity.

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