

SHORT TERM SCIENTIFIC MISSION (STSM) SCIENTIFIC REPORT

This report is submitted for approval by the STSM applicant to the STSM coordinator

Action number: CM1404

STSM title: PAH, tar and soot formation during the gasification of biomass in a drop tube furnace

STSM start and end date: 03/01/2019 to 03/03/2019

Grantee name: ECOST-STSM-Request-CM1404-42605

PURPOSE OF THE STSM:

The aim of this STSM is to increase the knowledge about the catalytic effects of inorganic matter on the formation of EPA-PAH, soot and tars, during the gasification of pig manure biomass. The gasification tests will take place in a drop tube reactor (DTR). The experimental data will include gasification yields, concentration of gaseous species released, and char and ash physical and chemical characterization. Since higher heating rates can be achieved in the DTR, when compared to the TGA and the laboratory reactors, transport effects (mass and heat transfer) may be significant. The DTR can be operated under a specific experimental matrix where operating conditions (gasification temperature and atmosphere composition) are varied independently. The operating conditions are close to practical applications, but still fundamental studies can be performed. The obtained data will allow enhancing the existing knowledge of the chemical and physical processes associated biomass thermal conversion. In this context, the utilization of the unique infrastructure at Instituto Superior Tecnico in Lisboa (IST), together with the application of the experience in PAH and soot from the home group at the University of Zaragoza, will enable to obtain new fruitful results in the term of the present short-term training mission.

DESCRIPTION OF WORK CARRIED OUT DURING THE STSMS

During the STSM period has been designed a new system to capture together PAH and Tars, produced during the pig manure gasification in the DTR. The system consists of two gas washing bottles refrigerated at 0°C to favor the steam condensation, the first bottle is empty and the second one is filled with isopropanol (50 mL). Subsequently, 2 gas washing bottles refrigerated at -20 °C recover the aromatic compounds of the gasification exit stream. The first one is filled with 100 mL of isopropanol and the last one is empty in order to protect the system of pressure shock. From the analysis of the isopropanol samples will allow detecting and quantifying tars and EPA-PAH formed in the gasification experiment. In addition, an experimental planning was designed to improve the knowledge of the gasification of pig manure at different temperatures and gasification atmospheres. Once the experimental system was designed, it was necessary to buy new equipment to accomplished the requirement to capture together the PAH and Tars. While arrived the new equipment necessary, it was prepared the experimental system to analyze the formation of soot and char during gasification of pig manure at different temperatures and gasification atmospheres. The experiments were carried out in the DTR where the char particles with particles sized higher than 10 µm were recovered in a double cyclone system and soot and char particles of particles sized lower than 10 µm were recovered in a 13-stage impactor. The composition of the gas stream was also analyzed.

The effect of the gasification temperature between 900 to 1200 °C was analyzed in three different gasification atmospheres: N_2/O_2 , $N_2/O_2/CO_2$ and $N_2/O_2/H_2O$. In all cases, the oxygen feed was a 40% of the stoichiometric oxygen for the complete combustion of the pig manure and for the CO_2 and steam, the same concentration of both was used. During the experiments, the reactor was heat up until the gasification temperature, and the same time, a flow of pure N_2 was used to observe the presence of leaks in the system. Once the temperature was reached the reactant gases were fed to the reactor (O_2 and CO_2 or steam). Once the system was stable, the pig manure was fed to the reactor by a double screw feeders system. During the first 5 min of reaction, the gas flow did not pass through the impactor in order to reach the steady state without saturate the filters of the impactor, around 5 min. Once the steady state was reached, the exit gas stream from the DTR pass through the impactor to recover the soot and char from the gasification, until the saturation of the filter, that occur after 10 min of gasification. The total time of the experiment is 15 min. During all the experiments the composition of the gas exit was analyzed. In this experiments was analyzed the total amount of char and soot formed during the gasification and their distribution. In addition, the composition of the soot and char was analyzed by SEM-EDX.

DESCRIPTION OF THE MAIN RESULTS OBTAINED

In the study carried out in the drop tube reactor in the gasification of pig manure, it can be observed that the gasification temperature is key factor in the formation of soot/char. In the experiments carried out in gasification atmosphere of N_2/O_2 the minimum soot/char generation was obtained at 900°C, increasing the soot/char formation with the temperature, decreasing at the same time the CO/CO_2 ratio in the gas products.

In the other hand, in the experiments carried out in atmosphere of the mixture $N_2/O_2/CO_2$ the behavior was the opposite, found that the maximum of soot/char formation was obtained at 900°C decreasing with the increase of the gasification temperature. It also found that the ratio CO/CO_2 increases with the temperature. Therefore, it can be seen that the presence of CO_2 in the gasification agent does not benefits the reactions of soot formation during the pig manure gasification.

In the experiments carried out in atmosphere of $N_2/O_2/H_2O$ it can be seen that a maximum in soot/Char formation at 1000 °C. Respect on the CO/CO_2 ratio, it decrease with the temperature due to the increase of the CO_2 and the decrease of the CO .

Respect to the soot and char composition, the analysis SEM-EDX will allows us to know the exact composition of the samples obtained in the experiments.

Finally, remark that it is necessary study the presence of PAH in the gas exit due PAH are the precursors of the soot formation so to confirm the that the presence of CO_2 and H_2O in the gasification agent reduce the production of soot it is necessary to know the PAH presence in the gas exit. The PAH and tars composition of the exit gas stream during the gasification of pig manure will be study in the following STSM period (04/03/19-03/04/19): ECOST-STSM-Request-CM1404-43695.

FUTURE COLLABORATIONS (if applicable)

From the present work is expected the publication of two journal papers about the char, soot, tar and PAH formation during the pig manure gasification. Moreover, the present STSM has allowed to know the strong points and the connection between groups and people in order to collaborate in future research works and research project, not only national ones even in EU projects. The more feasible future collaboration is to increase the knowledge about the biomass (woody, non-woody and residues) gasification.