Emissions of polycyclic aromatic hydrocarbons from combustion and thermal decompositionof the poplar wood pellets and sawdust

B. D. Škrbić[1*], V. B. Marinković[1,2], S. B. Spaić[2], V.J. Milanko[2], S. Lj. Branovački[3]

[1] University of Novi Sad, Faculty of Technology, Bulevar Cara Lazara 1, 21000 Novi Sad, Serbia
[2]Higher Education Technical School of Professional Studies Novi Sad, Školska 1, 21000 Novi Sad, Serbia
[3]Institute for Occupational Safety Novi Sad, Školska 3, 21000 Novi Sad, Serbia
* Presenting author e-mail: biljana@tf.uns.ac.rs

Abstract

The present study was undertaken to investigate, for the first time, the level of 16 US-EPA polycyclic aromatic hydrocarbons (PAHs) in smoke from combustion and thermal decomposition of the poplar wood pellets and sawdust of poplar clone I-214 (P. *x euramericana* cl. I-214) mostly cultivated in Serbia. Level of total PAHs formed during combustion of wood pellets was 4.7 mg kg^{-1}, whereas during combustion of sawdust it was 3.8 mg kg^{-1}, while the resulting total PAHs concentration during thermal degradation under atmospheric conditions of pellets and sawdust was 3.4 mg kg^{-1} and 3.7 mg kg^{-1}, respectively. Concentration of PAHs found in this study will also serve as a baseline for further monitoring campaingns.

Keywords: **poplar wood sawdust, pellets, combustion products, thermal decomposition under atmospheric conditions products, PAHs**

1. Introduction

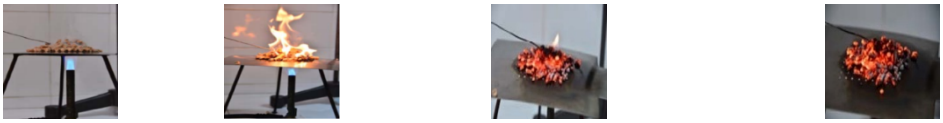
Wood pellet industry is an important part of bioenergy industry with annual production of 14 million tons in 2010 according Biswas et.al. (2014). In the light of the increasing production of waste, like as sawdust, during manufacturing of wood, demands for wood pellets as chip alternative raw materials for direct combustion in pellet burning appliances is also increasing. However, due to adequately protect the enviroment and the human health the level of emitted PAHs is of great concern.

2. Material and methods

Samples of sawdust and pellets, about 5 g, were burned on a panels of inox (20×20×0.1 cm). The thermal decomposition process, under atmospheric conditions, is carried out on the compact plate and the gas burner remained turned on till the sample changed to ash. The combustion process is carried out on the plate of the same dimensions, which in its central part (dimensions 10×10 cm), has 81 openings with diameter 2.5 mm, evenly arranged and the gas burner was put out at the moment of ignition the sample. Air samples with PAHs were collected using a fine-particle glass filter followed by polyurethane foam disks placed in a glass sampling cartridge. Temperatures of the samples were measured using digital thermometer, by thermocouple NiCr-Ni, with accuracy of measurement 1°C. PAHs were extracted from samples by Soxhlet extractor using 10% volume fraction of diethyl ether in *n*-hexane. Analysis of PAHs was performed by GC MS. Analyzed PAHs were (naphthalene (Nap), acenaphthylene (AcPy), acenaphthene (Acp), fluorene (Flu), phenanthrene (PhA), anthracene (AnT), fluoranthene (FluA), pyrene (Pyr), benzo[*a*]anthracene (BaA), chrysene (Chr), benzo[*b*]fluoranthene (BbF), benzo[*k*]fluoranthene (BkF), benzo[*a*]pyrene (BaP), indeno[*1,2,3-cd*]pyrene (InP), dibenzo[*a,h*]anthracene (DbA), benzo[*g,h,i*]perylene (BghiP). Limit of detection for individual PAHs ranged from 0.009 to 0.019 ngm^{-3}, while limit of quantification ranged from 0.028 to 0.056 ngm^{-3}.The accuracy measured as the efficiencies of the fortified samples ranged from 80% to 106% for PAHs. The calculated "recovery" values for all investigated PAHs were in accordance with the recommended (75-125%) by SRPS ISO 12884 (2010). Measurement uncertainty was from ± 25% to ± 50%.

3. Results and discussion

Combustion of a small amount of pellets or sawdust can be divided into four sequential stages: pre-combustion or pre-heating, flaming combustion, smoldering combustion and glowing or embering combustion in accordance with our experimental set up (Fig. 1).



Pre-combustion *Flaming combustion* *Smoldering combustion* *Glowing or embering combustion*

Fig. 1 Phases of pellets combustion

Figure 2 shows the relative time scales for the different combustion and thermal decomposition stages of wood pellets and sawdusts, together with approximate temperatures for the flaming stages. The Fig 2.1 revealed that the final glowing stage was the longest stage of wood pellet combustion, while Fig 2.2 showed that sawdust enter the glowing stage earlier. Time burning for the same mass of pellets and sawdust, was approximately same, which is in accordance with the previously obtained results by Biswas et.al. (2014). They concluded that combustion time of single pellet was affected by biomass composition while the role of particle size distribution in pellets was insignificant. Fig 2.1 and Fig 2.2 showed that smoldering stage of pellets was lasted longer then with sawdust. Additionally, time burning for the same mass of pellets and sawdust, was longer for sawdust.

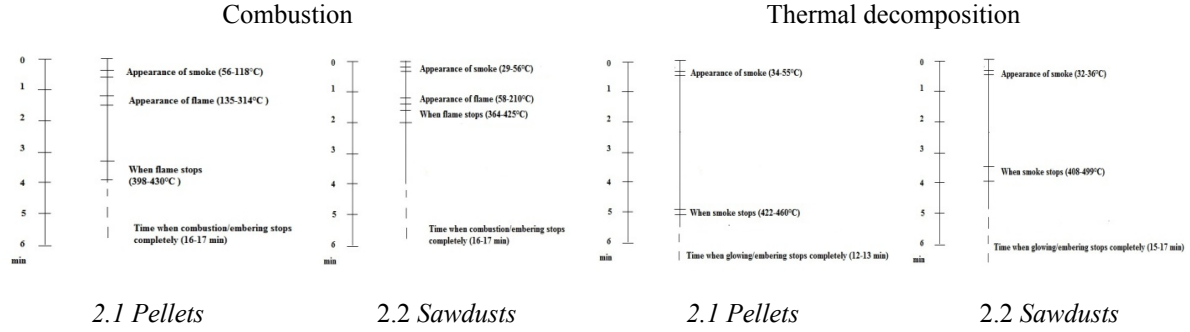


Fig 2. Approximate time scale for the different combustion and thermal decomposition stages of pellets and sawdusts

The results obtained during combustion and thermal decomposition of the pellets and sawdust are presented in the Fig. 3. The most common PAHs for pellets in both processes are PhA, Flu and Nap, while for sawdust are PhA, Flu, Nap, AcPy and Flu (descending order of concentrations). The PAHs BkF, InP, DbA, Bg,h,iP were not detected either in the combustion process nor in the thermal decomposition process of pellets and sawdust, respectively. The levels of the analyzed PAHs obtained during thermal combustion and thermal decomposition of sawdust were almost the same which can be attributed to the shape of the material. Since wood sawdust is in a loose form and within the mass of sawdust, a larger amount of air will be present in real conditions, thus the process is proceeding similarly as when airflow is enabled.

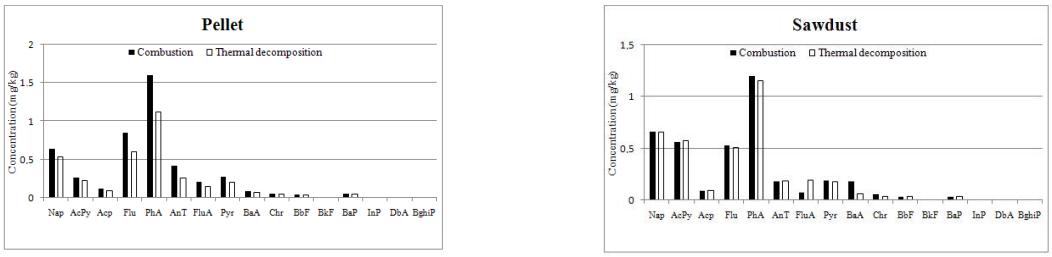


Fig. 3 Released PAHs masses per mass unit of the pellets and sawdust – combustion and thermal decomposition

3. Conclusion

The total level of PAHs was more pronounced in smoke from pellets then from sawdust during combustion being in relation with higher temperatures, within the pellet itself, sufficient for pyrolitic reactions. During the thermal decomposition process level of PAHs obtained is approximately the same for pellet and sawdust for most PAHs. The results from the laboratory study indicate increased concentrations of Nap and AcPy in the process of thermal degradation of sawdust compared to pellet, while the levels of PhA and Flu were enhanced in smoke from pellets during combustion.

4. References

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