Analysis of particulate emissions from combustion of peat briquettes in a domestic-scale stove

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Abstract

This poster presents preliminary work on the characterisation of particulate matter (PM) emissions from a conventional domestic-scale stove burning peat briquettes, a biomass fuel commonly used in Ireland. This work attempts to reflect real-world usage, and as such PM is gathered from ignition through until smouldering. Preliminary particulate size data are presented, along with micrographs generated using the scanning electron microscope (SEM) technique.

Introduction

In Ireland, combustion of solid biomass, including peat, is increasing [1]. Government policies target substantial further growth, to help meet 2020 RES targets [2]. However, there is growing concern over the air-quality impacts of the associated PM emissions – particularly in the residential sector. Several studies have identified PM as having an adverse effect on human health (e.g. review by Kim et al. [3]); in particular it is viewed as harmful to the cardiovascular and respiratory systems.

Particle size has an important correlation with toxicity [3], since it determines the depth of penetration of PM into these systems. Nonetheless, data on PM emissions from residential stoves, in terms of size distributions and chemical composition, are sparse. This project addresses that gap. Thus, this work examines preliminary PM size distributions for peat briquettes, along with scanning electron microscope (SEM) micrographs of filtered PM.

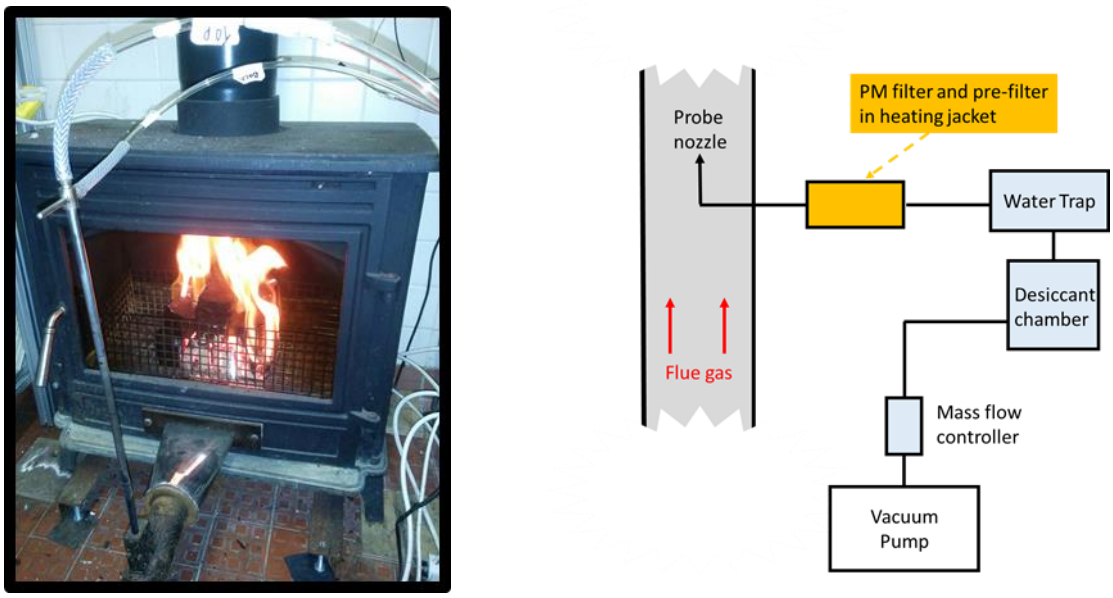
Materials and Methods

Particle size measurements have been obtained using a Palas/Welas Promo 2000 H aerosol spectrometer, which analyses the dispersion of white light from PM (Mie Theory). Measurements are averaged at 10-second intervals for the duration of a burn.

PM samples are also collected on two heated (120 °C) filters placed in series: a quartz wool pre-filter, and a high-efficiency Emfab™ borosilicate glass microfibre filter. All PM measurements are obtained directly from the flue gas without dilution.

An important aspect of this work is that it attempts to reflect real-world usage in order to obtain a more representative picture of emissions from household stoves.

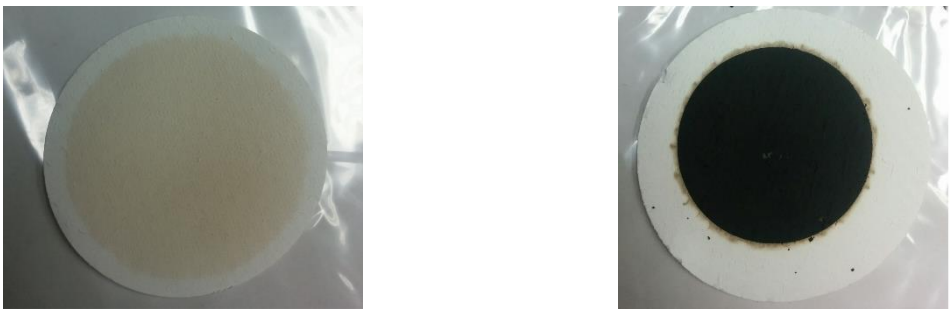
Thus, each test begins from a cold start, and includes the ignition, full-burn, and smouldering phases. A 12 Pa pressure drop is maintained across the stove.



(a) (b)

Figure 1. (a) Domestic stove used in testing and (b) schematic of the PM sampling train

Results



(a) (b)

Figure 2. PM filters (a) Emfab filter and (b) pre-filter

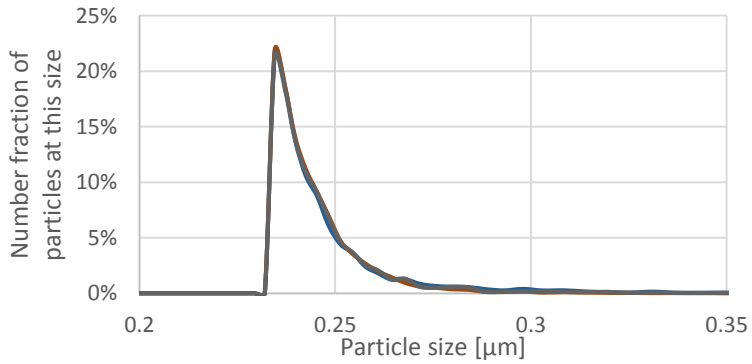
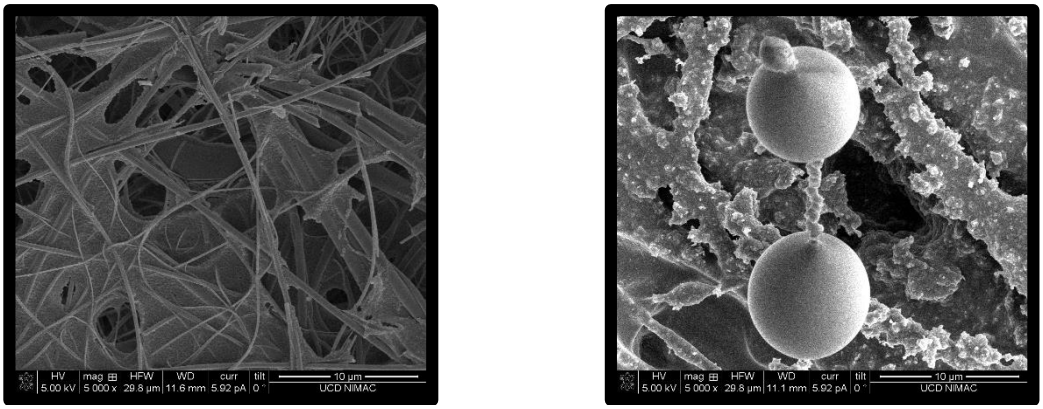


Figure 3. Particle size data for peat briquettes



(a) (b)

Figure 4. SEM of (a) a blank Emfab™ filter and (b) an Emfab™ filter with PM

Conclusions and Future Work

Significant PM emissions from peat briquettes burned in a conventional domestic stove were observed, as seen in figure 2. The preliminary particle size data in figure 3 indicate that the PM is less than 0.5 µm in diameter. However, comparison of figures 4 (a) and (b) shows the presence of larger spherical particles, of the order of approximately 8 µm. Also evident in figure 4 (b) is the build-up of smaller particulate matter on the fibres of the filter that is not present on the blank filter.

Refinement of the particle size measurement technique is required to reconcile the finding of these larger spherical particles with the size data. Elemental analysis using energy-dispersive X-ray spectroscopy (EDX) of the samples is also planned in an attempt to determine the chemical composition of the PM emissions.

Acknowledgements

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References

[1] SEAI, Energy in the Residential Sector, 2013 Report
[2] DCENR, National Renewable Energy Action Plan, 2nd Progress Report, February 2014
[3] Kim et al. A review on the human health impact of airborne particulate matter, Environment International, 2015