

Specific surface area of fire emitted particles: impact of primary particle diameter and organic content

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Specific surface area has been identified as a relevant metric for describing many physico-chemical processes involving nanostructured particles. Previous authors have introduced an alternative method to BET analysis, based on TEM image processing for measuring this property (Bau et al., 2010). This method has been validated on manufactured nanoparticles and more recently on soot particles denoting low organic content (Bourrous et al., 2018). However, in case of fire, particles produced denote huge variety of properties, in terms of size, structure and composition (especially organic and elementary carbon content). This makes a general expression of a specific surface, only based on geometrical consideration, difficult to develop. Then, there is a need for correlations taking into account the organic content of such carbonaceous particles emitted in case of fire.

The aim of the present contribution is to propose experimental values of specific surface area of realistic fire particles, linked to their organic carbon content. Based on those experimental results, a modeling approach will be introduced for extending the TEM analysis method developed in previous works.

Fire emitted particles were produced from solid and liquid fuels, representatives of nuclear industry (polymers composing gloves-boxes, waste treatment solvents, electrical cables or elements) under realistic fire conditions. Additionally, commercial black carbon samples were considered as surrogates of soot particles. Size distribution, morphology, density and organic carbon ratio (OC/TC) have been analyzed using ex-situ techniques (respectively transmission electron microscopy, volume displacement method and thermooptical analysis). Meantime, conventional BET specific surface areas of samples have been determined at 77°K with nitrogen and using ASAP 2020 from Micromeritics.

Specific surface area of black carbon and fire emitted particles are reported in figure 1 as a function of primary particle diameter. Values associated to black carbon are ranging from 10 to 1000 m²/g, highlighting the large variety of samples commercially available. For soot particles S_{BET} is ranging from 10 to 100 m²/g, values close to those reported in literature. Finally, particles emitted during realistic fire scenario are characterized with significantly lower specific surface area (from 1 to 30 m²/g) associated to a complex composition.

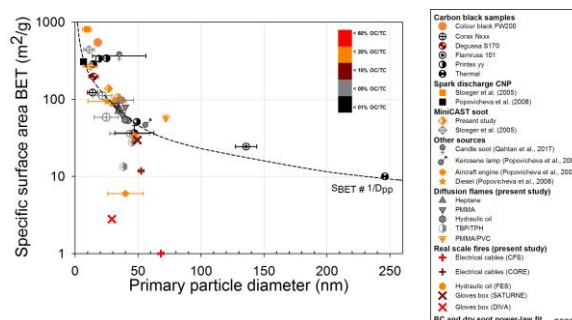


Figure 1: Evolution of BET specific surface area as a function of primary particle diameter

A significant dependence of BET specific surface area with primary particle diameter is reported for samples denoting a low OC content. Such dependence is in good agreement with the purely geometrical description of the specific surface area (Bau et al., 2010). Nevertheless, for higher OC content, significant discrepancies can be noticed. This can be partially explained by the presence of a liquid coating on the elementary carbon skeleton. Taking this into account, according to a simple model considering the mass to surface balance involved by this organic coating, a closer agreement can be reached, as presented in figure 2.

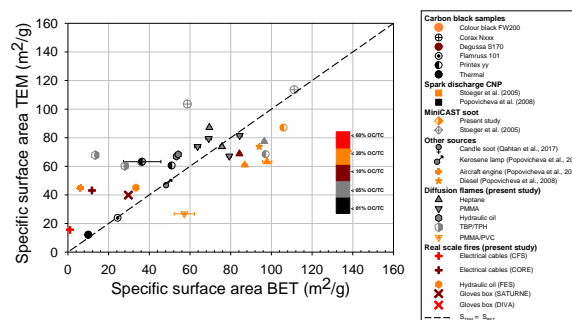


Figure 2: comparison between specific surface areas determined by TEM and BET analysis

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Bau S. et al., (2010). *Powder Tech.*, 200(3), 190–201.
Bourrous S. et al. (2018). *J. Aero. Sci.*, 126, 122–132.