COAL COMBUSTION IN A DOMESTIC DEVICE: SPECTROMETRIC CHARACTERIZATION OF FLY ASHES

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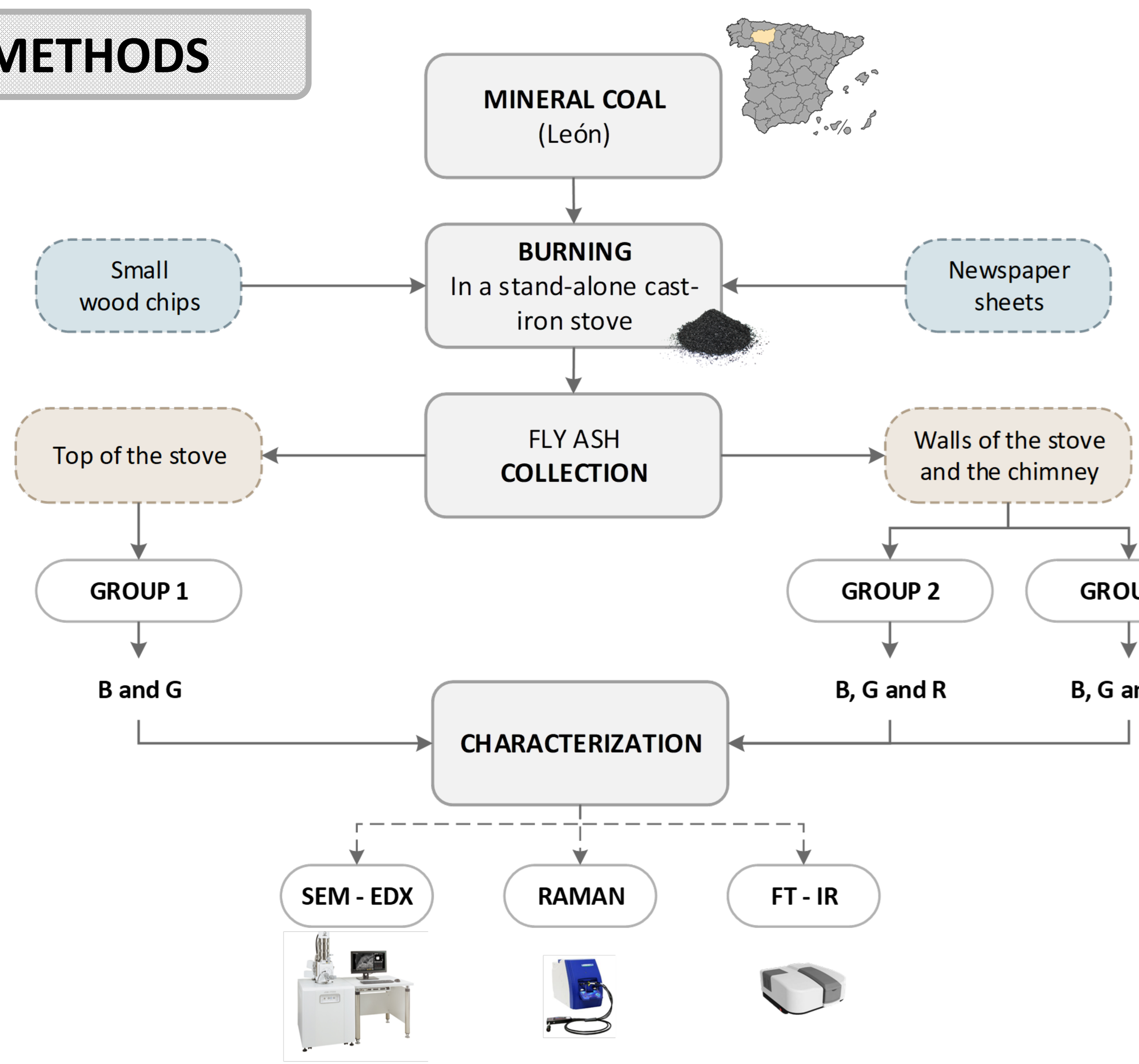
INTRODUCTION

Nowadays coal continues to be one of the main sources of energy worldwide, consuming around 2.5 billion T per year. Despite the energy benefit that is obtained and is expected to be obtained from its exploitations, coal consumption is responsible for 30-40 % of global CO_2 emissions from fossil fuels and it's also an important source of environmental pollution by particulate matter (PM) (Balat, 2007; Gasparotto and Da Boit Martinello, 2021).

Derived from its combustion, the coal fly ash particles produced tend to escape from the emission control devices, remaining suspended in the air and consequently assuming an important source of pollution. Hence, the importance of understanding their physical and chemical properties in order to develop control policies and environmental remediation arises (Yao *et al.*, 2015).

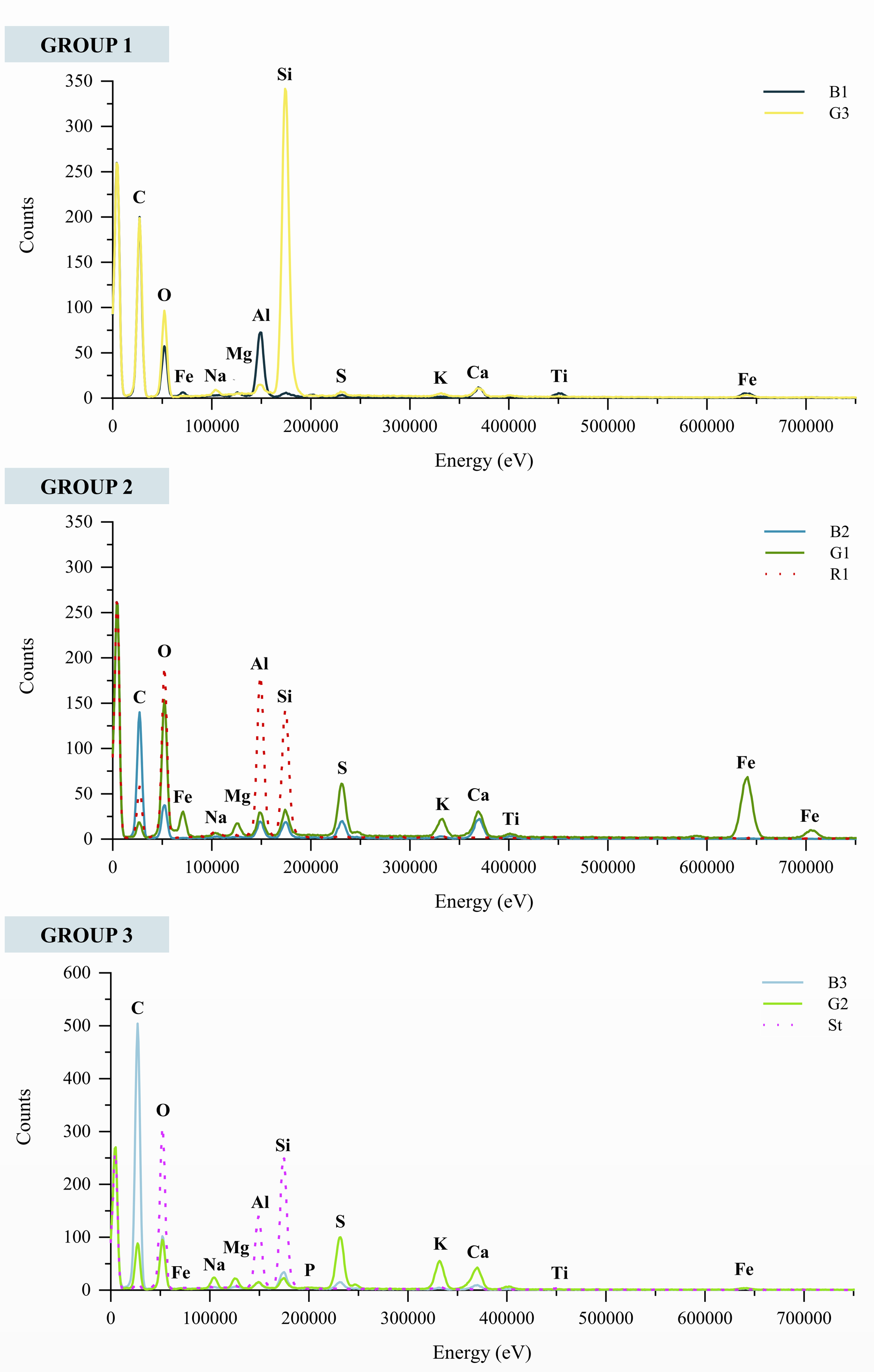
Specifically, coal fly ash from León (NW of Spain) is analyzed as it continues to be one of the Spanish provinces with the highest consumption of mineral coal in its domestic installations (Blanco-Alegre *et al.*, 2022). To do this, the samples are characterized spectroscopically using the FT-IR and Raman techniques, as well as morphologically and structurally using the SEM microscope associated with energy dispersive X-ray spectrometry (SEM-EDX).

METHODS



RESULTS

SEM – EDX

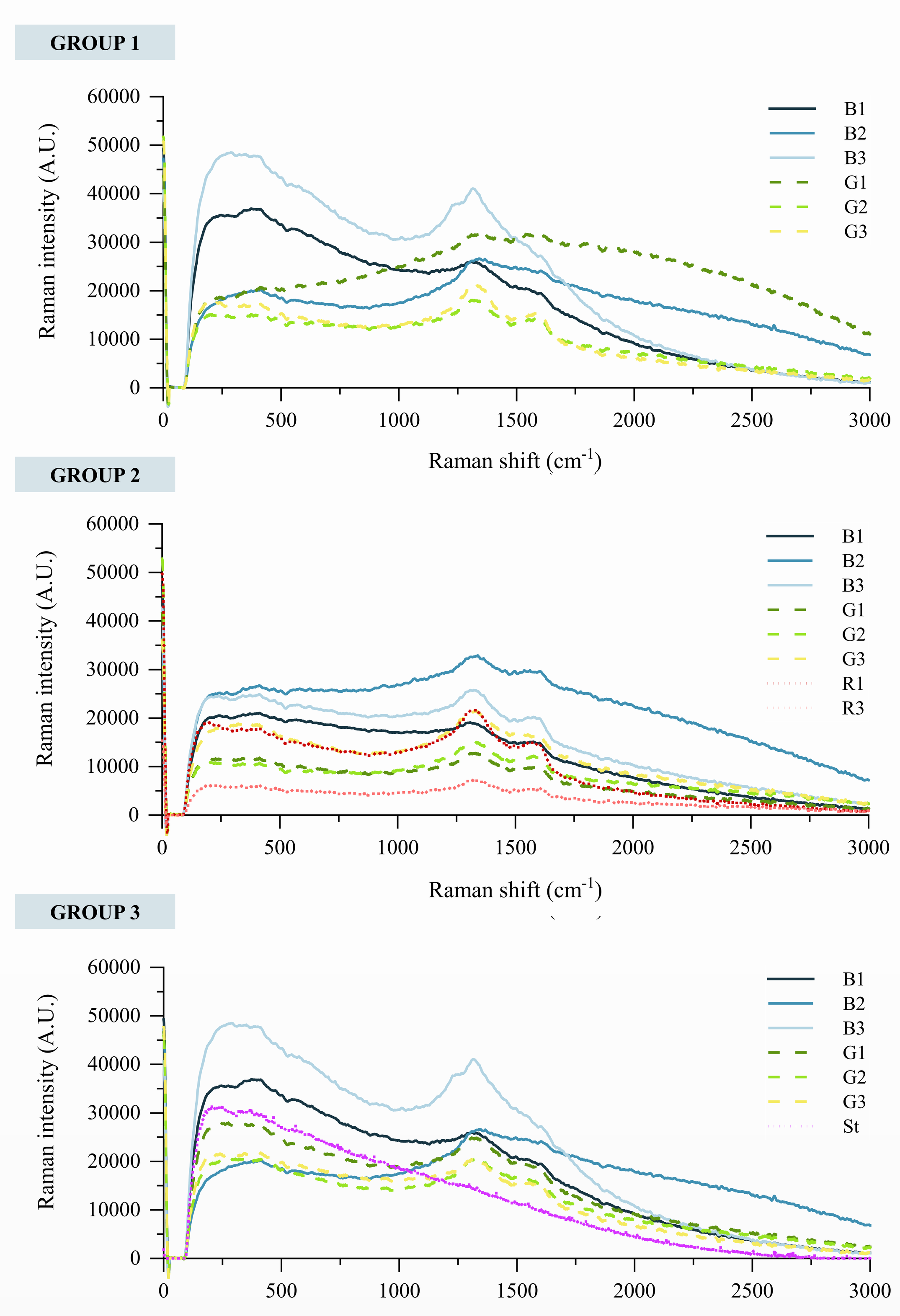


In the EDX analysis of the most representative samples of the coal fly ashes studied, similarities are observed regarding their elemental composition for the three study groups (group 1, 2 and 3).

Numerous carbon-based particles have been found, possibly due to unburned or deficiently burned coal. However, the most abundant type of particle for the three groups are those made up of aluminium (Al) and silicon (Si), combined with oxygen (O) derived from which the presence of aluminosilicates can be deduced. Also, the presence of other minor elements, such as iron (Fe) or magnesium (Mg), among others, is variable.

Finally, the presence of phosphorus (P) stands out only for the ashes with a darker coloration (***B***) belonging to group 3 and the presence of titanium (Ti) for the ashes with a darker coloration (***B***) of group 1, of coloration more reddish (***R***) of group 2, as well as in the stone (***St***) analyzed in group 3.

RAMAN

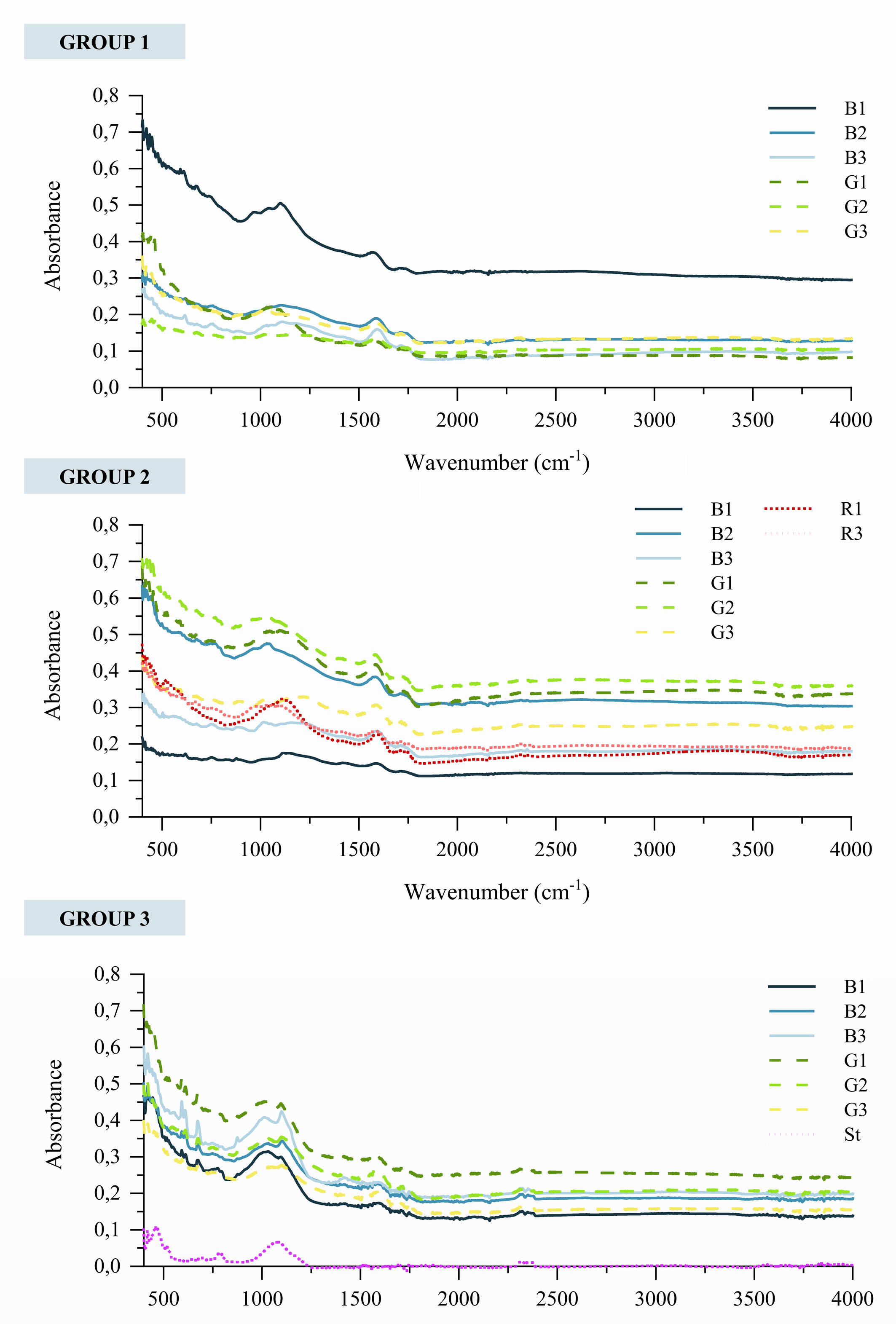


The main Raman signals recorded are two broad peaks at 1360 and 1570 cm^{-1}, presented in all samples except ***St***. This doublet is related to amorphous carbon, which is very sensitive to this technique.

Others less intense signals are also present. Particularly for group 1, the presence of iron oxides (410 cm^{-1}), SiO_2 (475 cm^{-1}) and $CaCO_3$ (aragonite, 860 cm^{-1}, and calcite, 1075 cm^{-1}) is denoted. However, the presence of $CaMg(CO_3)_2$ (340 and 780 cm^{-1}) stands out only for the samples with a darker colour (***B***).

Regarding group 2, both the ***B*** and the ***G*** samples have similar composition except for $CaMg(CO_3)_2$ (344 cm^{-1}), present only in ***G*** samples. For the reddest particles, only SiO_2 (475 cm^{-1}) was identified. In the other hand, for group 3, it turns also out that the ***B*** and ***G*** samples have a similar composition. The greatest differences occur for ***St*** sample, in which TiO_2 (199 cm^{-1}), Fe_2O_3 (242 cm^{-1}), SiO_2 (470 cm^{-1}) and C (graphite, 1600 cm^{-1}) were identified (Edwards et al., 2005; Yin et al., 2018, 2019; Xu et al., 2020).

FT – IR



FT-IR complements the previous results by revealing the presence of aluminium (Al), not previously identified with Raman spectrometry, but it was with EDX.

For the ashes of group 1, in addition to the compounds already described, the presence of aluminosilicates stands out: feldspar (425 cm^{-1}) in the case of the ***G*** samples and kaolinite (1030 cm^{-1}) for both types of particles (***B*** and ***G***).

Subsequently, for the ashes of group 2, both for the ***G*** and reddish (***R***) particles, the presence of aluminosilicates was again identified: albite (420 cm^{-1}), feldspar (425 cm^{-1}) and kaolinite (1030 cm^{-1}) and also the presence of SiO_2 (750 cm^{-1}).

Finally, for group 3, for the samples with black (***B***) and grey (***G***) coloration, the previous aluminosilicates were observed and exclusively for the ***B*** samples, the presence of $Ca_5(PO_4)_3$ (1100 cm^{-1}), as stated by EDX results (Yin et al., 2018, 2019; Davis et al., 2020).

CONCLUSIONS

1) Three complementary analytical techniques have been used to adequately characterize coal fly ash.
2) Derived from EDX, it has been seen that, for the three groups (1, 2 and 3), the elemental composition is similar. However, the presence of numerous carbon-based particles stands out, as well as those made of aluminium and silicon, which predominates the entire samples.
3) Using Raman, the presence of amorphous carbon (doublet at 1360 and 1570 cm^{-1}) is observed in all the samples analyzed except for the stone (St) in which the biggest differences occurred. Deconvolution is needed to reveal more information.
4) Finally, by means of FTIR, the previous results are complemented, verifying the presence of aluminium (Al) in the different aluminosilicates identified.

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