HIGH RESOLUTION ELECTRON TRANSMISSION MICROSCOPY (HRTEM) AND RAMAN SPECTROSCOPY FOR STUDYING SOOT NANOSTRUCTURE EVOLUTION IN FLAMES

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Advanced diagnostic tools as High Resolution Electron Transmission Microscopy (HRTEM) and Raman spectroscopy require opportune data treatment procedures that are in continuous development with the aim of giving a detailed nanostructural carbon analysis.
In the present work, the lab-made image analysis approach ("Analyse Plan") was exploited for studying the evolution of soot nanostructure in premixed fuel-rich flames of aliphatic and aromatic fuels. A new HRTEM image analysis procedure, based on mathematical morphology, able to avoid the artifacts created by the layer distortions and to access to more numerous and specific structural parameters, was also applied to flame-formed soot. Three main parameters related to the geometry of the individual fringes were extracted: length, tortuosity, and local curvature radii which are correlated with the defective and disordered soot character. Their trends, along with the percentage of nearly-straight fragments, also reported in the work, clearly showed the structure improvement, i.e. a better stacking of longer and more planar aromatic layers, with aging for both the fuels. It was found that nanostructural ordering occurs faster for benzene with respect to ethylene, but reaches similar features at the end of the flame in agreement with the evolution of bulk properties as H/C ratio and optical properties of soot.
Raman evaluation of in-plane layer length, La, was also carried out showing a quite good agreement with the layer length obtained by the HRTEM image analysis.
Specific aromatic sizes were assigned to the extracted HRTEM fringes on the basis of the fringe length distribution and assuming that the aromatic fringes are in the shape of parallelograms. The structural hypotheses (condensation degree, hydrogen/carbon ratio, etc.) used for getting the aromatic size distributions were done to render these structures compatible with the measured H/C content and UV-Visible absorption properties and eventually, to give a view of the different aromatic growth occurring during soot inception and formation in aliphatic and aromatic flames.

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