Multi-wavelength absorption and morphological characteristics of aerosol particles from different biofuel types in India

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The present study characterises aerosol emissions from ten different biofuels used in rural households, examining multi-wavelength light absorption properties and morphological characteristics during flaming and smoldering combustion phases. Strong linear correlations (R^2 = 0.95–0.99) were observed between absorption Ångström exponent (AAE) values across all biofuels. Higher absorption coefficients at 880 nm corresponded to lower AAE values, indicating black carbon (BC) dominance during flaming, while brown carbon (BrC) dominated during smoldering. SEM-EDX analysis revealed flaming combustion produced chain-like aggregates of spherical particles (50–300 nm), while smoldering generated irregular, web-like structures. Carbon dominated both phases (50.8–60.3% flaming, 52.4–62.7% smoldering), with higher potassium during flaming. These findings establish frameworks for source apportionment and understanding climate impacts.

Keywords: Biofuels, black carbon, flaming, morphology, smoldering.

during winter months[4,5]. In rural continental environments, the complex interplay between anthropogenic and natural BC and BrC sources creates challenges for understanding regional climate and local air quality impacts. Biomass burning, including agricultural residue combustion and household biofuel use, constitutes a significant BC and BrC source. Optical properties and relative contributions vary considerably depending on fuel type, combustion conditions, and atmospheric processing.

The absorption Ångström exponent (AAE) serves as a critical parameter for characterising wavelength-dependent aerosol absorption, helping distinguish between different light-absorbing aerosol types. BC typically exhibits AAE values near 1, while BrC shows higher values (2–7), depending on composition and source[6]. This wavelength-dependent behaviour makes AAE valuable for carbonaceous aerosol source apportionment. Combustion conditions, particularly flaming versus smoldering combustion, significantly influence the optical and physical properties of emitted aerosols. Flaming combustion typically produces more BC, while smoldering generates higher BrC and organic carbon amounts[7]. These distinct phases produce particles with different morphological characteristics, affecting light-absorbing properties and atmospheric behaviour.