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The Nexus of Polycyclic Aromatic Compounds, Black Carbon, Light Absorption, and Genotoxicity in Urban PM2.5

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Approximately 7.8 million deaths worldwide were attributable to $PM_{2.5}$ pollution (GBD, 2021). Polycyclic aromatic compounds (PACs) in $PM_{2.5}$ are key contributors to both the health effects and light absorption properties of these fine particles. A robust association has also been reported between black carbon (BC) concentrations and mortality from cardiovascular and respiratory diseases. Therefore, the interplay among PACs, BC, toxicity, and light absorption in PM2.5 warrants further investigation. In this study, we examined these relationships using both combustion source samples and urban ambient aerosol samples. For combustion-derived particles, PACs—including priority polycyclic aromatic hydrocarbons (PAHs) and those characterized by the benzene polycarboxylic acid (BPCA) method—appear to be the intrinsic link connecting light absorption, fluorescence properties (Abs_{365nm}, Fmax), and toxicity (ROS, IL-8, γ-H2AX) of the extractable organic matter (EOM). In ambient PM2.5 samples collected from eight Chinese cities, similar significant inter-correlations were observed, including BC, but only in winter samples with higher pollution levels. Fourier transform ion cyclotron resonance mass spectrometry (FT-ICR-MS) analysis revealed that, in addition to PACs, a range of combustion-derived molecules with low molecular weight, high aromaticity, and high degree of unsaturation are involved in this integrated physicochemical nexus. We conclude that combustion emissions are likely the primary driver of both light absorption and lung cancer risk associated with urban $PM_{2.5}$. Consequently, lung cancer risk (via γ-H2AX) can be effectively predicted by either PACs (via BPCA), or optical properties (via Abs_{365nm} and Fmax).