Refined paleo-fire interpretations from the distribution patterns and $\delta^{13}C$ of fire-derived molecules

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Fire is a critical component of the Earth system, and molecular tools are increasingly used to study it in deep time. Polycyclic aromatic hydrocarbons (PAHs), produced *via* incomplete combustion of organics, are signatures of vegetation burned in the geologic past. Relative concentrations of methylated to parent PAHs can indicate if they were sourced primarily from burned vegetation (pyrogenic) or from weathered fossil carbon (petrogenic) sources. However, distributions of pyrogenic PAHs are potentially sensitive to burn conditions and plant type. This study aims to examine how fire-derived PAHs reflect their vegetation sources and burn environment. We examined PAH distributions from modern controlled burn experiments, including both new measurements and those available in the published literature, to determine the effects of vegetation type, burn phase (i.e., ash, smoke), and temperature control on the production of specific molecules. Additionally, we measured the carbon isotope values of plant tissue and fire-derived individual PAHs to examine fractionation during combustion for different plant types and burn conditions. Results indicate burn phase has the strongest control on PAH distributions, with vegetation type exerting a secondary control. Photosynthetic pathway of the burned material has the strongest control on isotopic values of PAHs, which show a ~10‰ offset between C_3 and C_4. These results provide a basis for differentiating between combusted plant communities in the geologic record, which will improve interpretations of paleo-fire ecology.