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A non-destructive technique for assessing fossil wood decay using ATR-FTIR spectroscopy

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The stable carbon isotope composition ($\delta^{13}C$) of fossil wood is widely used as a paleoclimate indicator; however, diagenetic alteration of $\delta^{13}C$ values can substantially bias proxy results. Previous work hypothesized that diagenesis preferentially removes cellulose rather than lignin, suggesting that a method for rapidly quantifying cellulose and lignin contents may help to screen wood fossils for alteration. In this study, we tested two hypotheses: H1) that our current cellulose extraction technique produces pure α-cellulose, and H2) that the relative abundance of cellulose to lignin can be accurately assessed using attenuated total reflectance-Fourier transform infrared (ATR-FTIR) spectroscopy. To test these hypotheses, we analyzed an analytical-grade cellulose standard and pairs of bulk wood and extracted cellulose from modern oak (n = 2 pairs) and a suite of late Oligocene wood fossils (n = 8 pairs). ATR-FTIR spectra were collected on a Thermo-Nicolet iS50 ATR accessory by averaging 32 scans in the mid-infrared (400 cm^{-1} - 4000 cm^{-1}) at a resolution of 4 cm^{-1}. In our testing of H1, we found that the extracted cellulose for all modern and fossil samples closely matched the standard, confirming that our extraction approach is precise and accurate. In our testing of H2, we found that most wood fossils had smaller peaks than modern wood in a characteristic cellulose domain between 1033 cm^{-1} to 1059 cm^{-1}. Similarly, these specimens had relatively larger peaks in a characteristic lignin domain between 1606 cm^{-1} to 1425 cm^{-1}. Two fossil specimens (NNW141 and NNW035) have ATR-FTIR spectra more similar to modern wood than the other fossils, suggesting better preservation. Inferences of fossil wood preservation from the FTIR analyses matched cellulose yields that were independently quantified using chemical extraction: although most wood fossils yielded cellulose content <10%, specimens NNW141 and NNW035 ranged from 26% to 39%, similar to modern wood. Calculated $\delta^{13}C$ enrichment between cellulose and whole wood were consistent with recent work that showed a trend of higher cellulose yields with lower enrichment values. Collectively, our analyses suggest that the ATR-FTIR approach is a valid predictor for cellulose to lignin abundance in wood.