# Microstructure of Carbon Fibers Derived from Softwood Lignin Precursors

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The microstructure of carbon fibers derived from dry-spun lignin is reported. High-purity lignin samples encompassing different molecular weights were obtained by fractionation of Kraft lignin using a process developed Thies and co-workers [Klett et al. ACS Sus Chem Eng 2016]. These fractions were dry-spun into thin lignin fibers and converted to carbon fibers with the highest reported tensile strength of 1.4 GPa, as reported in an earlier study [Jin et al. ACS Sus Chem Eng 2018]. The microstructure of fibers carbonized at temperatures ranging from 1000 to 2100°C is reported here. Raman spectroscopy, conducted on carbon fibers derived from a lignin sample with a number-average molecular weight ($M_n$) of about 7 kDa, indicated an area ratio of G-to-D peak ($I_G/I_D$) of 0.18, which indicates a low level of graphitic development. However, the ratio increased to 0.23 for carbon fibers made from lignin with a larger $M_n$ of about 14 kDa, and further to 0.28 for carbon fibers derived from lignin with the highest $M_n$ of about 28 kDa. Although these lignin-derived carbon fibers possess a low degree of graphitic crystallinity, larger molecular weight of lignin led to better carbon-layer formation in carbon fibers, which helps in the attainment of superior mechanical properties.