14.9: Lignin

Lignin, a chemically complex biopolymer that is associated with cellulose in plants and serves to bind cellulose in the plant structure, ranks second in abundance only to cellulose as a biomass material produced by plants. Lignin is normally regarded as a troublesome waste in the processing and utilization of cellulose. The characteristic that makes lignin so difficult to handle in chemical processing is its inconsistent, widely variable molecular structure as shown by the segment of lignin polymer in Figure 14.7. This structure shows that much of the carbon is present in aromatic rings that are bonded to oxygen-containing groups, and lignin is the only major plant biopolymer that is largely aromatic. Because of this characteristic, lignin is of considerable interest as a source of aromatic compounds including phenolic compounds, which have the−OH group bonded to aromatic rings or even aromatic hydrocarbons. The abundance of hydroxyl (−OH), methoxyl ($-OCH_3$), and carbonyl (C=O) groups in lignin also suggests potential chemical uses for the substance. A significant characteristic of lignin is its resistance to biological attack. This property, combined with lignin's highly heterogeneous nature makes it a difficult substrate to use for the enzyme-catalyzed reactions favored in the practice of green chemistry to give single pure products useful as chemical feedstocks.

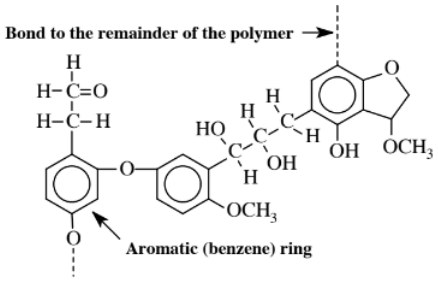

Figure 14.7. Segment of a lignin polymer molecule showing aromatic character and the disorganized, variable chemical structure that makes lignin a difficult material to use as a feedstock

Since lignin is a significant fraction of all plant biomass, significant fractions of this biopolymer must be dealt with in biorefineries. Lignin generated as a byproduct in the extraction of cellulose from wood is now largely burned for fuel, the lowest level of use for this material. By retaining much of the lignin molecule intact, use may be made of larger molecular mass segments of the molecule, such has been done for some uses for binders to hold materials together incoherent masses, fillers, resin extenders, and dispersants. There is also some potential to use lignin as a degradation-resistant structural material, such as in circuit boards. Potentially the most profitable use for lignin is to make small aromatic molecules useful for chemical synthesis. For this to be practical, special techniques will need to be developed to partially break down the lignin molecule without destroying the aromatic molecule segments in it.