Learning Objective

• Describe the gasification and liquefaction of coal and the interest in its conversion.

Oil and natural gas resources are limited. Current estimates suggest that the known reserves of petroleum will be exhausted in about 60 years, and supplies of natural gas are estimated to run out in about 120 years. Coal, on the other hand, is relatively abundant, making up more than 90% of the world’s fossil fuel reserves. As a solid, coal is much more difficult to mine and ship than petroleum (a liquid) or natural gas.

Coal Gasification and Liquefaction

A great deal of current research focuses on developing methods to convert coal to gaseous fuels (coal gasification) or liquid fuels (coal liquefaction). In the most common approach to coal gasification, coal reacts with steam to produce a mixture of CO and H$_2$ known as synthesis gas, or syngas: Because coal is 70%–90% carbon by mass, it is approximated as C in Equation \(\text{15.8.1}\).

\[
\text{C}_{(s)} + \text{H}_2\text{O}_{(g)} \rightarrow \text{CO}_{(g)} + \text{H}_2(g) \quad \Delta H = 131 \text{ kJ} \tag{15.8.1}
\]

Converting coal to syngas removes any sulfur present and produces a clean-burning mixture of gases. Syngas is also used as a reactant to produce methane and methanol. A promising approach is to convert coal directly to methane through a series of reactions:

\[
\begin{align*}
2\text{C(s)} + 2\text{H}_2\text{O(g)} \rightarrow & \text{CH}_4(g) + \text{CO}_2(g) \quad \Delta H = -206 \text{ kJ} \\
\text{Overall:} \quad 2\text{C(s)} + 2\text{H}_2\text{O(g)} \rightarrow & \text{CH}_4(g) + \text{CO}_2(g) \quad \Delta H_{\text{comb}} = 15 \text{ kJ}
\end{align*}
\]

Burning a small amount of coal or methane provides the energy consumed by these reactions. Unfortunately, methane produced by this process is currently significantly more expensive than natural gas. As supplies of natural gas become depleted, however, this coal-based process may well become competitive in cost.

Similarly, the techniques available for converting coal to liquid fuels are not yet economically competitive with the production of liquid fuels from petroleum. Current approaches to coal liquefaction use a catalyst to break the complex network structure of coal into more manageable fragments. The products are then treated with hydrogen (from syngas or other sources) under high pressure to produce a liquid more like petroleum. Subsequent distillation, cracking, and reforming can be used to create products similar to those obtained from petroleum. The total yield of liquid fuels is about 5.5 bbl of crude liquid per ton of coal (1 bbl is 42 gal or 160 L). Although the economics of coal liquefaction are currently even less attractive than for coal gasification, liquid fuels based on coal are likely to become economically competitive as supplies of petroleum are consumed.
Summary

• There is great interest in developing methods to convert coal to gaseous fuels (coal gasification) or liquid fuels (coal liquefaction) as it is more convenient to mine and transport gas and liquid fuels.
• Converting coal to syngas (synthesis gas) removes any sulfur present and produces a clean-burning mixture of gases.

Sources

• Libretex: General Chemistry (Petrucci et al.)

Contributors and Attributions

• Marisa Alviar-Agnew (Sacramento City College)