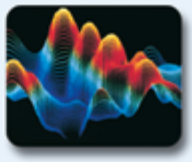
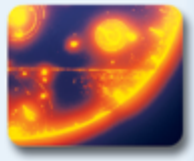
Chemistry in Action

Combustion Synthesis

What do aerospace materials, cutting tools, catalytic materials, ceramic engine parts, ball bearings, high-temperature superconductors, hydrogen storage, and fuel cells have in common? They are made of ceramics, composites, and other advanced materials.

Conventional techniques used to make these materials consist of a high-temperature furnace, with temperatures ranging from 500°C to 2000°C, to supply the energy needed for the reaction to take place. Because these furnaces may reach only 2000°C, it may take minutes to hours to convert reactants to solid-state products, and the mixtures are heated unevenly. As a result, flaws can be introduced into the structures, which can cause stress points in the materials.

A different high-temperature technique is *combustion synthesis,* which generates its own energy to keep the reaction continuing. Once the reactant mixture is ignited, a heat wave moves through the sample, producing the solid-state product. The mixture can reach temperatures up to 4000°C, twice what is possible with conventional high-temperature furnaces. Combustion synthesis also allows reactions to be completed in just seconds. Hence, this technique produces the desired material faster and requires less supplied energy than conventional techniques do. In addition, the intense and quick heating produces materials that are chemically homogeneous. More than 500 compounds, such as lightweight and heat-resistant aerospace materials, are created by combustion synthesis.

In a typical combustion synthesis procedure, the reactant powders are mixed and then pressed into a cylindrical pellet. The pellet is ignited by an intense heat source, such as an electrically heated coil or a laser. Because the combustion-synthesis reaction is very exothermic, the reaction is self-propagating, and the process does not need any further input of energy. This type of self-propagation is called a *reaction wave,* in which the reaction propagates through the starting material in a self-sustained manner. Therefore, compared with conventional high-temperature methods, this technique is an energy-saving process. In addition, the high temperatures and short reaction times can produce materials that would not be synthesized under conventional conditions. Currently, scientists are studying reaction waves, including how they move through the initial mixtures. As scientists better understand the characteristics of combustion synthesis, they can refine the technique to be more useful in advanced materials production.

Questions

1. Why is this technique called *combustion synthesis?*
2. Why might this technique result in a more chemically homogeneous material?

▼ *Once the reactant mixture is ignited, the combustion wave moves through the sample, synthesizing the solid-state product.*