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**Title:** Coal Derivatives by Destructive Distillation

**Level:** Secondary

**Day/Time:** One class period

**KERA Goals:** 2.1

**Objective:**

This is a "hands-on" activity demonstrating the production of coke, one of the most widely used raw materials derived from coal. This activity may also serve to stimulate student research into the differences in coal types and coal products.

**Background Information:**

Coal is a fossil fuel formed by the anaerobic (without the presence of oxygen) decay of plants that lived millions of years ago. The energy found in coal is solar energy stored by the plants. It remains in the hydrocarbons left behind during the decay process. We can burn these hydrocarbons and release the stored energy.

During the formation of coal, it goes through several stages which differ in the amount of moisture and nitrogen impurities remaining in the organic material. The first three stages of coal are sedimentary rock formed by layers of silt covering the decaying plants. The moisture and nitrogen impurities are squeezed out of the material by the weight of the silt deposits. Peat and lignite are early stages that are found on or near the surface of the earth. Although these materials will burn, the flame is smoky because of the moisture content. Bituminous, or soft coal, is the third stage and the most abundant type of coal. It has lost most of its moisture and nitrogen impurities and is an efficient heating material. The final stage of coal, anthracite, is a metamorphic rock. It is found only in areas where tremendous pressure and heat from mountain building processes can change the bituminous coal into a hard substance which is mostly carbon. Anthracite is the cleanest of all coal, since it has the least impurities.

Although coal accounts for 20 percent of total US energy use and is the major source of fuel used in the production of electricity, its derivatives serve as raw materials in manufacturing. Many coal derivatives are produced indirectly by the destructive distillation of bituminous coal. This process takes place in the absence of oxygen (within an airtight oven) and prevents the coal from burning. The remaining material, coke, is nearly pure carbon. It is the most widely used coal derivative and is burned by mills to change ore into pure iron that is needed to make steel. Some of the gases produced during the distillation process can be refined to form ammonia, coal tar and light oil. Manufacturers can use these products to make a variety of products.

This lab activity will use bituminous coal to produce three derivative mixtures during a destructive distillation process.

**Materials:**

Soft coal sample

## Coal Derivatives by Destructive Distillation-Sec.

Flame source  
Crushed ice  
Ring stand  
Pyrex or Kimax test tube  
Gas bottle or flask  
2-hole stopper  
Test tube holder  
Bent glass tubing  
Large beaker  
Wooden splints

### Activity:

1. Place some small lumps of bituminous coal in a Pyrex or Kimax test tube and clamp the test tube to a ring stand.
2. Use a bent glass tube to attach the test tube to a gas bottle. Be sure the glass tube does NOT touch the bottom of the bottle. (See diagram).
3. Insert a bent tube into the two-hole stopper in the gas bottle. The other end of the tube should be drawn to a narrow opening at one end.
4. Place the bottle in a beaker of crushed ice.
5. Heat the coal slowly by moving a flame back and forth along the test tube.
6. After several minutes, bring a lighted wooden splint to the tip of the narrow tube. Does the coal gas produced burn?
7. When no more gas is produced, turn off the flame. Remove the beaker from the ice.
8. The bituminous coal in the test tube has been changed to coke.
9. The liquid in the bottom of the beaker is coal tar.

### Results:

Below are sample questions for your students to answer.

1. Record your observations as you placed a lighted splint to the narrow tube opening in step 6 in the procedure.
2. Describe the mixture that remains in the test tube at the conclusion of the experiment.
3. Describe the mixture that forms in the gas bottle that was submerged in crushed ice.

### Evaluation and Investigations:

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Answers to some of these questions can be found in the discussion section of this activity and other questions involve outside research.

1. Define the following terms used during the discussion:

Anaerobic

Coke

Hydrocarbons

Organic

2. Describe the characteristics of the following stages of coal (include common name, physical characteristics, chemical composition, burning attributes)

Anthracite

Bituminous

Lignite

Peat

3. a) How is the decay process that forms coal similar to the distillation process from which coal is derived?

b) How is combustion (burning) different than destructive distillation?

c) Why is the difference important?

4. a) What coal is used to produce coke?

b) What regions of the U.S. mine this type of coal?

c) What restrictions are placed on the type of coal used for carbonization (coke-making)?

d) How does this affect the coal mined in this area?

5. a) Ammonia (NH<sub>4</sub>) is derived from the gases produced during the destructive distillation. What substance in coal produced this compound?

b) Could ammonia be derived from anthracite distillation?

6. What are some possible uses for coal tar and coal gas?

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