

SORPTION INCINERATION OF CHLORINATED HYDROCARBONS, ACID, HEAVY METALS,
AND EXCESS NUTRIENTS IN WATER USING COAL-DERIVED SOLIDS

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3. Introduction and Objectives

The basic objective of the research was the development of systems for the sorption and incineration of water pollutants based upon solid phases derived from coal. The research was designed within the context of an overall system that should provide a net gain of energy and that should be cost-effective because of the sale of energy and byproducts. The byproducts are obtained from the pyrolysis or gasification of coal. Some of the major objectives of the research were the following: (1) Production of char from coal in a manner maximizing valuable byproduct recovery, (2) development of the most effective and energy-conserving modes of char activation, (3) evaluation of coal chars for the absorption of contaminants from water, (4) determination of the effectiveness of ash from char incineration as a water purification additive, (5) evaluation of the incineration of the spent char for energy production and destruction or immobilization of sorbed water contaminants.

4. Statement of Problem

The economical treatment of polluted water for the removal of sewage, industrial chemicals, heavy metals, and other contaminants is a problem wherever impaired water is encountered. This is especially true when energy costs rise, along with the cost of chemicals conventionally used to treat water. There is a need to look to inexpensive, readily available materials for water treatment. Coal has the potential to produce such materials.

5. Method of Investigation

The two general methods that can be used to produce char from coal are pyrolysis (heating to decomposition in the absence of air) and gasification. The latter may be designed to produce an activated char directly, or to produce a non-activated char that can be activated in a separate step. Pyrolysis produces a non-activated char that must be activated in a separate step. The method used in this study consisted of heating the char (coke or carbon) to 850°C in a stream of nitrogen gas saturated with water vapor until an approximately 10% weight loss has been incurred.

The coal used in this study was Rosebud subbituminous coal from Hanna, Wyoming. Coal was taken from a freshly cut seam in pieces at least 20 cm across and stored under water until used. Prior to use the coal was sieved and a 20-60 mesh size was collected. Char was prepared from this coal by the use of the apparatus shown in Figure 1. The coal was subjected to pyrolytic gas-

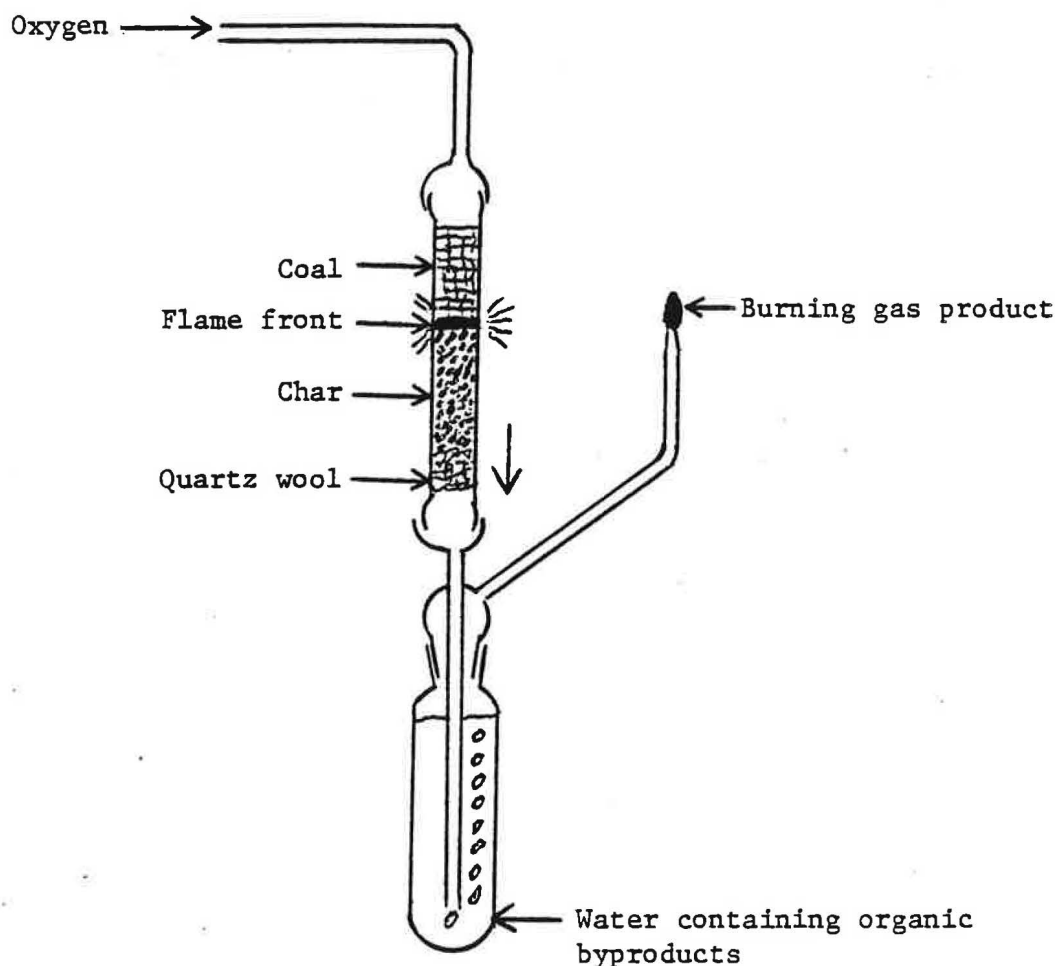


Figure 1. Apparatus for the pyrolytic gasification of coal.

ification in the apparatus shown in Figure 1. The 20-60 mesh coal was contained in a 15-mm i.d., 30-cm long quartz tube and was held in place by quartz wool packed loosely into the bottom of the tube. Prior to packing into the tube, the coal particles were contained under water, which was drained from the coal in a glass filter funnel to the extent that the moist coal particles

were still adherent to each other. A flow of oxygen gas was maintained downward through the tube. Char was prepared from the coal by initiating a combustion flame front at the bottom of the coal column. Once initiated, the flame front moved steadily in a direction counter to the oxygen flow. A column of non-activated char was left below the flame front. A combustible gas and organic byproducts flowed from the bottom of the tube during pyrolysis of the coal. The organic byproducts were collected in a trap containing water; the water was saved for studies of organic compound removal by coal char and ash.

Coal ash was prepared by an apparatus similar to that shown in Figure 1, except that the quartz tube was held in a horizontal configuration. A flame front was initiated at the downstream end of the gas flow through the tube. The flame front first moved the length of the coal column counter to the flow of oxygen, then reversed itself and consumed the char, leaving coal ash. The apparatus in this same configuration was used for the preparation of activated coal char. The char was activated in a stream of water-saturated nitrogen flowing through the char bed maintained at 850°C for a period of 1 hour. As the char was heated, large quantities of tar were evolved from it, showing that the char retains a large quantity of tar byproduct from the gasification. An approximately 10 percent weight loss was incurred by the char during activation.

6. Results

The activated char product produced as described in the previous section was found to be effective in removing a number of important water pollutants. Among these were organic byproducts produced from coal gasification and heavy metals. The organic byproducts of coal gasification served as model organic water pollutant compounds, and include hydrocarbons, phenols, and nitrogen compounds. Heavy metals were also effectively removed by the activated coal char. The char found most effective for this purpose was that produced from "re-burning" char twice with a reverse burn in the apparatus shown in Figure 1. Subbituminous coal ash was likewise found effective in removing organic compounds and heavy metals from water.

7. Conclusions and Applications

The results of this research show the usefulness of activated char prepared simply from coal for the sorption of organics and heavy metals from water. The spent char product, upon drying, would make an excellent fuel to raise steam and produce electricity, incinerating the sorbed organics and retaining sorbed inorganics with mineral matter in the process. Non-activated char prepared from coal is much less effective in absorbing organic pollutants from water. Such a product would not be suitable for use in a sorption/incineration process for the disposal of water pollutants. Surprisingly, coal ash is almost as effective as coal char in absorbing organics. Of course, coal ash is not combustible, and would not be suitable for the incineration of sorbed water pollutants. However, it is entirely possible that a mixture of coal ash and activated chare could be used to sorb organic pollutants from water, and the mixture could be subsequently incinerated to destroy organic compounds. There is every reason to believe that the results of this research would be applicable to the use of other carbonaceous materials, including particularly wood and crop residues. Thus the approach outlined in this report could be used wherever there are readily available carbonaceous materials and a need to remove pollutants from water.

8. Publications, Reports, Papers, Talks Presented

None to date; several are in preparation.

9. Training Accomplished

Two graduate students have worked on Master's research and two on Ph.D. research as part of this grant. In addition, an undergraduate student participated in research on this program.

10. References

None for this report.