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NOVEL PROCESS FOR DEPOLYMERIZATION OF COAL TO C_2-C_4 HYDROCARBONS

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PERSONNEL

In addition to the Principal Investigators, research personnel participating in this project during the reporting period included:

Mr. Annapragada Rao, Graduate Student

OBJECTIVES AND SCOPE OF THE RESEARCH PROJECT

An envelope of parameter values has been experimentally identified in our laboratory, heretofore unexplored, for the catalytic depolymerization of coal which leads to yields of C_2-C_4 hydrocarbons in excess of 50 weight percent of the coal, in a direct, single-stage process under mild conditions. The chemistry observed is fundamentally different from all coal conversion processes, both liquefaction and gasification, previously reported in the literature. The process-derived recycle liquid solvent will be characterized, and is expected to constitute a super-critical phase under conditions of temperature and pressure imposed by the chemistry of the system. Using a special reactor incorporating windows for visual observation, the operation of a catalyst bed fluidized by super-critical, coal-derived fluids will be examined. The capability of such a super-critical, coal-derived fluid to control agglomeration of a strongly caking coal, in the catalyst bed, will be evaluated, and satisfactory control developed. Solvent upgrading of the recycled liquids will be applied as may be required.

Information obtained from a coal liquefaction project proceeding under my direction indicates that a two-stage system may be advantageous for the present work. A two-stage gasification system will be constructed and operated. Kinetic data will be obtained from the two-stage system, reaction velocity constants and activation energies determined, and these data compared with the kinetic data from a single-stage system obtained by us in a companion project in my laboratory. Using these data, and other information obtained in these projects, an evaluation will then be made concerning which type of system would best serve as a basis for recommendation for further development of a prototype for possible scaleup.

ACTIVITY FOR THE REPORTING PERIOD

Experiments for conversion of coal to light hydrocarbon gases in a single stage have been conducted in a batch reactor. Experiments were performed at five temperatures, ranging from 440 to 500 ^{0}C. A dual-functional catalyst was used, consisting of sulfided nickel-molybdenum supported on alumina, mixed with silica-alumina cracking catalyst. Representative data from those experiments are presented below. They reveal why it appeared necessary to perform experiments in a two-stage reactor system before an optimum prototype system could be designed.

In Figure 1, it is observed that the production of liquids from coal, at all of the temperatures presented, occurs rapidly, reaching maximum values in less than five minutes. By contrast, Figure 2 reveals that production of hydrocarbon (HC) gases proceeds much more slowly, and continues throughout the time period of the experiment (60 minutes). Figure 3, containing data for conversion at 500 ^{0}C, reveals that the continued production of HC gases is accompanied by a corresponding reduction in liquids, indicating that perhaps most of the HC gases are produced from cracking of the liquids. Figure 4 reveals that, at a temperature of 500 ^{0}C, most of the HC gases are in fact produced from the liquids.

In experiments performed in a separate project, directed toward production of liquids in very short times of a few seconds, it has been demonstrated even more definitevely that liquids are produced from coal in very short times, while further conversion to produce HC gases from the liquids requires much longer times. For example, in an experiment conducted in a microreactor, 82% by weight of the coal was converted to liquids in a time of three seconds, with only about 3% by weight of the coal appearing as HC gases. A significant amount of HC gases did not appear until a time approaching 10 seconds.

The data from those two sets of experiments, performed under very different experimental conditions, when taken together pursuaded me that one could not conclude that a process based only upon experimental data derived from a single-stage reactor would represent the optimum system for design of a prototype reactor system. For this reason, the direction of the research on this project was changed to first examine the two-stage system, with liquids production to occur in Stage 1, followed by conversion of the liquids to HC gases in Stage 2.

A two-stage system has been assembled. Stage 1 provides for production of liquids from coal in a batch reactor. Stage 2 is a computer-operated, continuous reactor, with on-line analysis of products, to permit rapid accumulation of kinetic data. This system is ready for shake-down testing, and full operation. A detailed description of the system and its capability will be included with the next report.

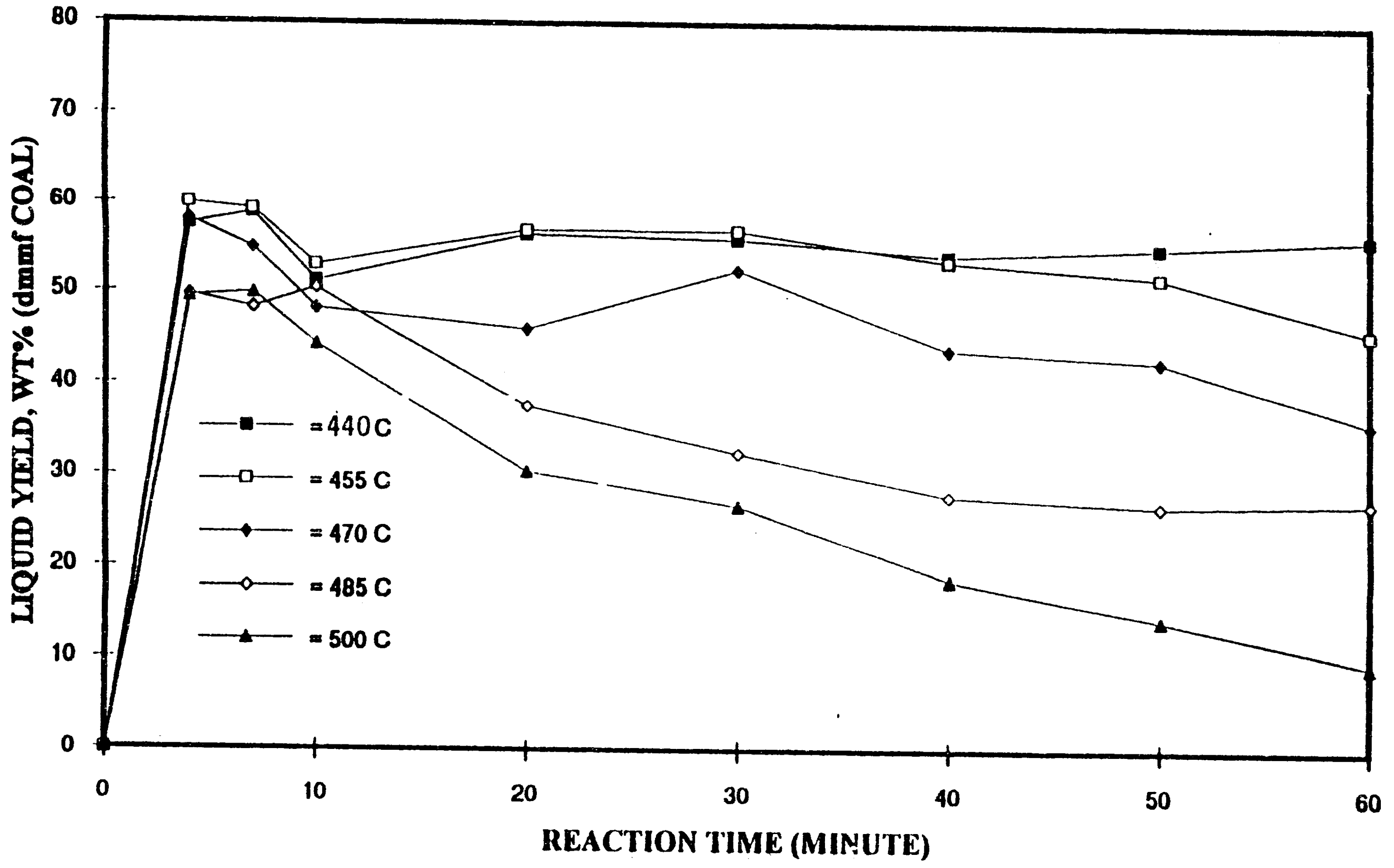

Figure 1. Effect of Reaction Time on wt% Liquids in Product

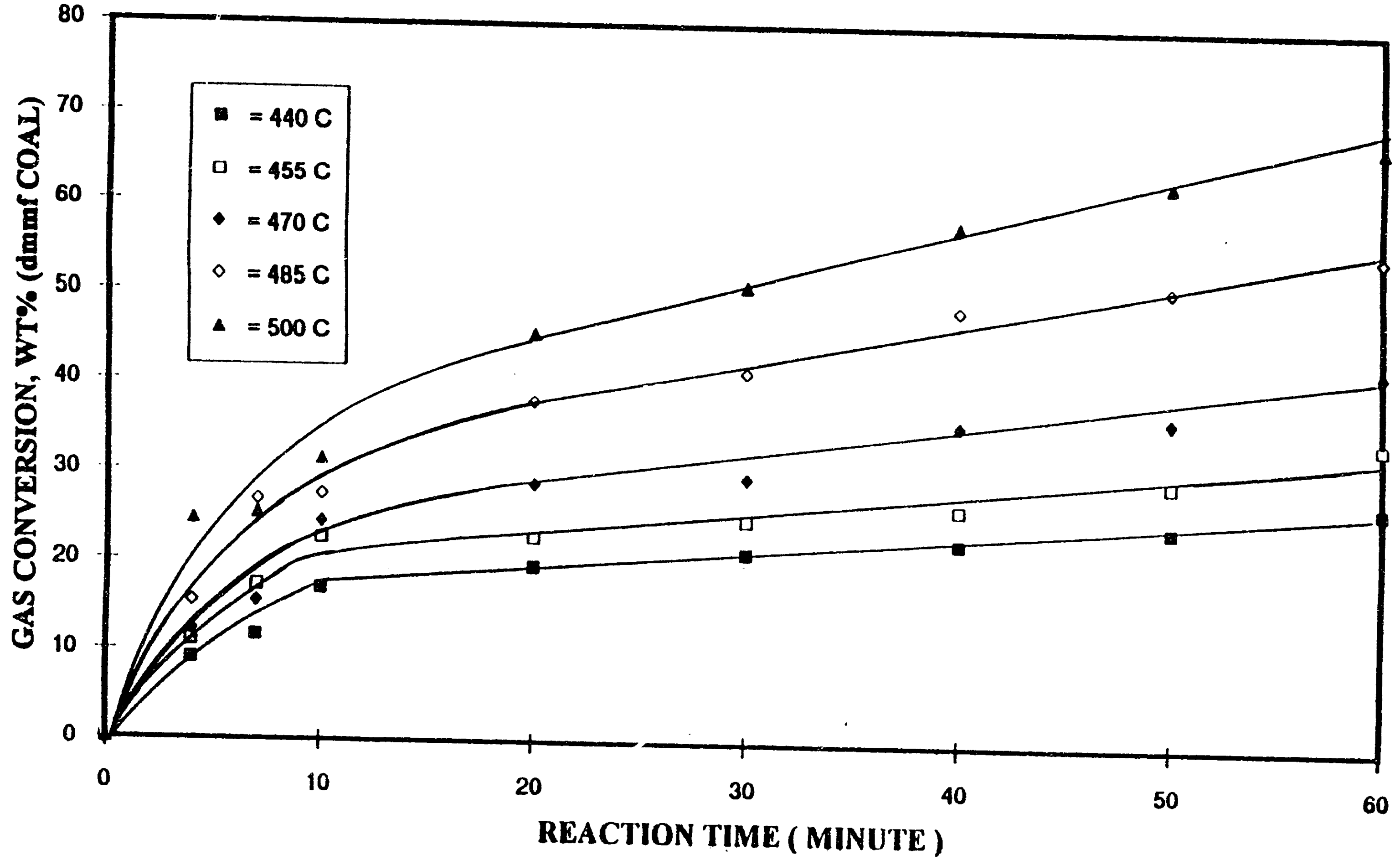

Figure 2. Effect of Reaction Time on Gas Conversion

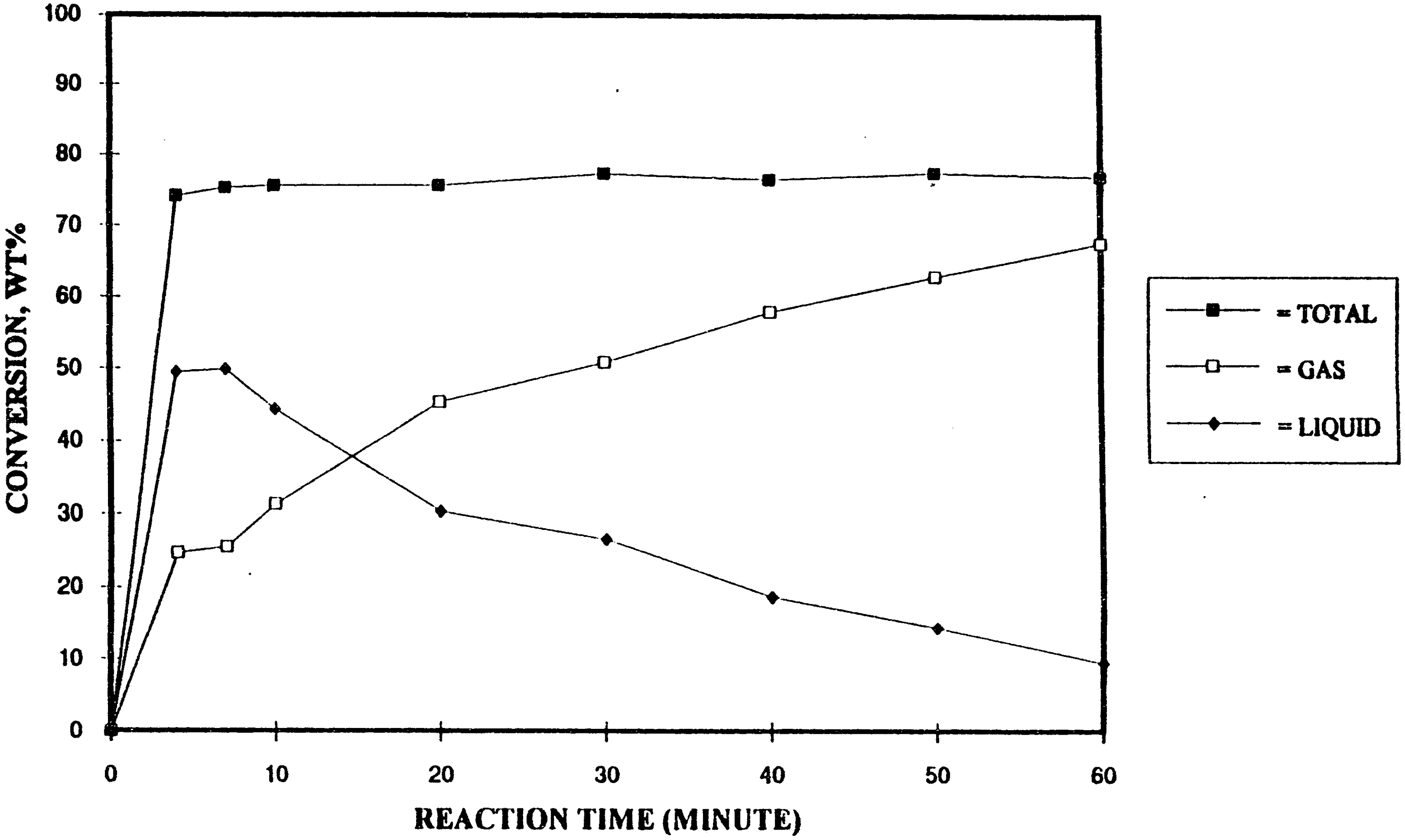

Figure 3. Relationship among Coal, Liquid and Gas Conversion at 500 ^{o}C

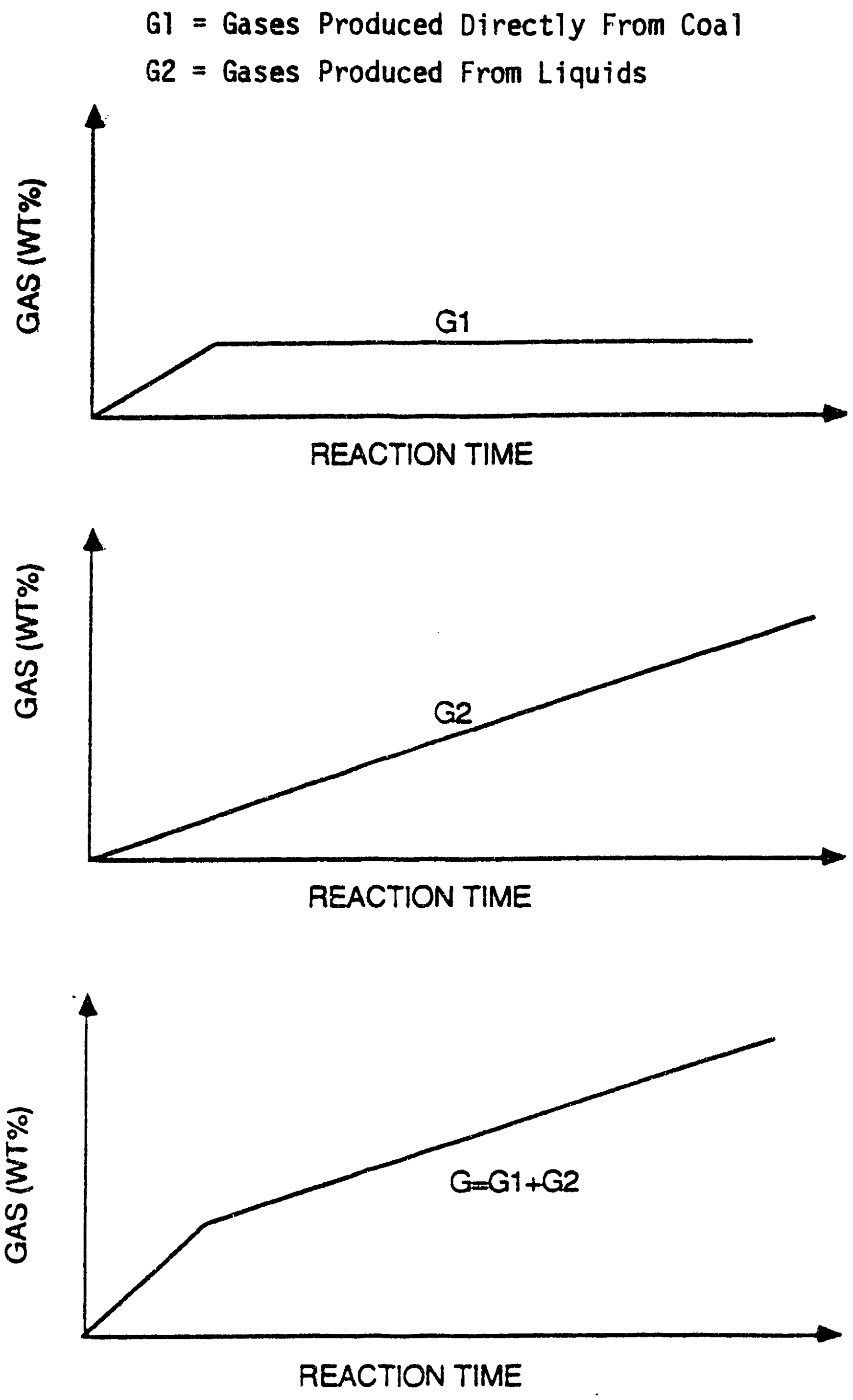

Figure 4. Gases Produced from Different Sources

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