TITLE: ENGINEERING A NEW MATERIAL FOR HOT GAS CLEANUP

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ABSTRACT

OBJECTIVE

The overall objective of this project is the engineering development of a superior, reusable, calcium-based sorbent for desulfurizing hot coal gas. This has required investigating different calcium-bearing materials and preparation conditions to produce a sorbent capable of removing H_2S from hot coal gas and also capable of withstanding repeated loading and regeneration as well as physical stress.

ACCOMPLISHMENTS TO DATE

Previous work had shown that a promising sorbent could be made by first pelletizing pulverized limestone and then covering the limestone pellets with a protective shell made of a strong, porous material. The resulting core-in-shell pellets offered several potential advantages since the cores could be made of a highly reactive but physically weak material while the shells could be made of an inert and relatively strong material. Furthermore, the pellets could be produced from low cost materials by means of an inexpensive, two-stage pelletization process utilizing a revolving drum.

The present project has shown that plaster of Paris ($CaSO_4 \cdot 1/2\ H_2O$) is superior to limestone for the pellet cores and that a mixture consisting of 80% alumina particles and 20% limestone particles is highly suitable for the pellet shells. It has been found that calcination of the pellets at 1100°C causes partial sintering of the shell material and produces strong, porous shells with an acceptable crushing strength. Further treatment of the pellets by an established cyclic reduction and oxidation method converts the calcium sulfate to a highly reactive form of CaO. Although the absorptive capacity of the plaster-based cores is somewhat lower than that of limestone-based cores of equal volume, the rate of reaction of plaster-based cores is greater than that of limestone-based cores. However, with either material the rate of reaction with H_2S is rapid, and it does not vary greatly with temperature in the range of 840 to 920°C. The greatest difference in the two materials lies in their response to repeated sulfidation and regeneration by a cyclic oxidation and reduction process. While the reactivity of the limestone-based cores declines rapidly from one loading cycle to the next, the reactivity of the plaster-based cores declines

much more slowly and appears to stabilize. The cause of this interesting phenomenon is under investigation since it may lead to a method for completely stabilizing the sorbent.

SIGNIFICANCE TO FOSSIL ENERGY PROGRAM

The regenerable calcium-based sorbent resulting from this work could improve the overall efficiency of generating electric power from coal by several methods under development which involve gasification followed by hot gas cleaning and utilization of the hot gas in either gas turbines or fuel cells. The sorbent may be the only practical material for desulfurizing the gas at gasifier outlet temperatures, and since it can be regenerated and reused, it can avoid a huge waste disposal problem.

ARTICLES, PRESENTATIONS, AND STUDENT SUPPORT

Journal Articles

- T. T. Akiti, Jr., K. P. Constant, L. K. Doraiswamy, and T. D. Wheelock, "Development of an Advanced Calcium-based Sorbent for Desulfurizing Hot Coal Gas," *Adv. Environ. Res.*, **5**, 31-38 (2001).
- T. T. Akiti, Jr., K. P. Constant, L. K. Doraiswamy, and T. D. Wheelock, "A Regenerable Calcium-based Sorbent for Desulfurizing Hot Coal Gas," *Ind. Eng. Chem. Res.*, **41**, 587-597 (2002).
- T. T. Akiti, Jr., K. P. Constant, L. K. Doraiswamy, and T. D. Wheelock, "An Improved Core-in-Shell Sorbent for Desulfurizing Hot Coal Gas," *Adv. Environ. Res*. (in press).

Conference Presentations

- T. T. Akiti, Jr. (speaker) and T.D. Wheelock, "Development of a core-in-shell sorbent for desulfurizing hot coal gas," 112th Annual Meeting, Iowa Academy of Science, Des Moines, Iowa, April 21, 2000.
- J. Zhu, D. Hasler, and K. Constant, "Calcia and alumina composites for desulfurization of high temperature coal gas," 112th Annual Meeting, Iowa Academy of Science, Des Moines, Iowa, April 21, 2000.
- D. Hasler, K. Constant, and T. D. Wheelock, "A calcium-based sorbent for high temperature desulfurization," 113th Annual Meeting, Iowa Academy of Science, Des Moines, Iowa, April 20, 2001.

Submitted Presentations

- D. Hasler and T. D. Wheelock, "A pelletized core-in-shell sorbent for desulfurizing coal gas," 114th Annual Meeting, Iowa Academy of Science, Des Moines, IA, April 19, 2002.
- T. D. Wheelock and D. J. L. Hasler, "A reusable calcium-based sorbent for desulfurizing hot coal gas," 5th International Symposium on Gas Cleaning at High Temperature, Morgantown, WV, September 17-20, 2002.

Students Supported under this Grant

- T. T. Akiti, Jr., a graduate student who received a Ph.D. degree in chemical engineering in 2001
- David Hasler, a graduate (Ph.D.) student in chemical engineering
- Michael Chesnut, an undergraduate student in chemical engineering
- Stephen Dak, an undergraduate student in chemical engineering
- Tanya Harris, an undergraduate student in chemical engineering