TITLE: DEVELOPMENT OF A CALCIUM-BASED SORBENT FOR HOT GAS CLEANUP

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ABSTRACT

OBJECTIVE

The overall objective of this project is the development of a superior calcium-based sorbent for hot gas cleanup in integrated coal gasification, combined-cycle (IGCC) systems for generating electric power. The sorbent should be capable of removing H_2S and COS from hot coal gas and should withstand repeated loading and regeneration. Specific tasks include the following:

1. Utilize various methods including pelletization, briquetting, slip casting, and impregnation of porous substrates to prepare potential sorbents for testing.

2. Screen prepared materials for compressive strength, attrition resistance, and adsorption capacity.

3. Subject the most promising materials to repeated adsorption and regeneration to determine their durability.

ACCOMPLISHMENTS TO DATE

Several methods employed by other workers to prepare sorbent materials for various applications have been used to prepare calcium-based materials. These methods include impregnating porous alumina substrates with calcium oxide, sintering mixtures of alumina and excess calcia or mixtures of silica and excess calcia, and pelletizing and curing mixtures of limestone and various hydraulic cements. Several commercially available alumina catalyst carriers were obtained and impregnated with up to 20% calcia by weight, but the resulting materials were not effective sorbents for H_2S. A number of composite materials were prepared by high temperature sintering of various mixtures containing calcia and either silica or alumina. Sintering was preceded by pelletization or briquetting of the powder mixtures. While some of the resulting pellets were capable of adsorbing adequate amounts of H_2S, the pellets lacked long term stability.

The best results have been achieved by pelletizing and curing mixtures of powdered limestone and a calcium aluminate hydraulic cement. Pelletization has been carried out in a revolving drum under moist conditions followed by steam curing to harden the pellets. The compressive strength and adsorption capacity of the resulting pellets depends on the proportion of limestone to cement and pelletization procedure. Pellets with acceptable crushing strength and adsorption capacity have been produced with particular fomulations.

SIGNIFICANCE TO FOSSIL ENERGY PROGRAM

The development of advanced integrated coal gasification combined-cycle (IGCC) power generating systems calls for a sorbent capable of removing H_2S and COS from coal gas at near gasifier operating temperature which can be 1255°K (1800°F) or more. Among various materials which have been proposed for this service, limestone offers several advantages including low cost and widespread availability. Moreover, after limestone is calcined, the resulting CaO in theory can capture 95% or more of the sulfurous species in coal gas when applied within a temperature range of 1070 to 1570°K (1470 to 2370°F). However, since lime is soft and friable, it has been widely regarded as a material to be used once and then discarded. Unfortunately, materials containing CaS cannot be placed directly in a landfill where they will react slowly with moisture and CO_2 under ambient conditions to form H_2S. By developing a calcium-based material which is a good sorbent as well as being regenerable and durable, hot gas cleaning can be greatly advanced.

PLANS FOR THE COMING YEAR

The most promising sorbent materials will be perfected and subjected to extensive testing and characterization. Testing will include determining the effects of repeated adsorption and regeneration and the effects of steam and carbon dioxide on the stability of the material.

ARTICLES, PRESENTATIONS, AND STUDENT SUPPORT

Conference Presentations

- T.T. Akiti, Jr., and T.D. Wheelock, "Development of an Advanced Calcium-based Sorbent for Hot Gas Cleanup," presented at the 1999 Spring National Meeting of AIChE, Houston, Texas, March 17, 1999.
- T.T. Akiti, Jr., and T.D. Wheelock, "Development and testing of an advanced calcium-based sorbent for desulfurizing hot coal gas," presented at the Annual Meeting of the Iowa Academy of Science, Ames, Iowa, April 23, 1999.
- T.T. Akiti, Jr., and T.D. Wheelock, "Development and testing of Portland cement based sorbents for hot gas cleanup," presented at the Annual Meeting of the Iowa Academy of Science, Mason City, Iowa, April 25, 1998.
- J. Zhu and K.P. Constant, "Development of impregnated alumina with calcium nitrate for hot gas cleanup," presented at the Annual Meeting of the Iowa Academy of Science, Mason City, Iowa, April 25, 1998.
- J. Zhu, K. Constant, L.K. Doraiswamy, and T.D. Wheelock, "alumina, Silica and Calcia Composites used as Regenerable Sorbents for Coal Gas Cleanup," presented at the Annual Meeting of the Iowa Academy of Science, Ames, Iowa, April 23, 1999.

Students Supported under this Grant

- T.T. Akiti, Jr., a graduate (Ph.D.) student in chemical engineering at Iowa State University
- J. Zhu, a graduate (M.S.) student in materials science and engineering at Iowa State University
- Stephen Dak, an undergraduate student in chemical engineering at Iowa State University
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