ABSTRACT

The Illinois State Geological Survey (ISGS) has conducted six years of research in developing a high-surface-area hydrated lime (HSAHL) process. The process has been successfully scaled-up from a small, laboratory-scale unit to a batch, bench-scale hydrator (5-7 lbs/batch), to the present 20-100 lb/hr continuous process optimization unit (POU). Pilot-scale tests conducted with HSAHL under conditions of burning high-sulfur Illinois (IL) coals have achieved up to 90% SO₂ capture in various dry sorbent injection (DSI) systems. These removals are adequate to bring IL coals into compliance with acid rain legislation goals for the year 2000 (1.2 lb SO₂/MM Btu). Patent applications have been filed in the United States, Australia, Canada, Japan, and the European Patent Office designating all member states.

The goal of the program is to advance the development of the HSAHL process and facilitate the transfer of this technology to the commercial market as rapidly as possible in order to preserve or increase the use of IL coal by utilities. A 20-100 lbs/hr process optimization unit (POU) was designed; a total of 100 hours of testing was successfully conducted with the hydration reactor, producing several hundred pounds of product with properties similar to those of the products prepared in batch reactors. An integrated POU will be used to generate design, construction, and operation data necessary for the private sector to scale-up the process to a commercial level.

The ISGS, working in association with Dravo Lime Company (DLC) and Kennedy Van Saun (KVS), designed and proposed to construct and operate a one-ton per hour (1T/hr) pilot facility to produce HSAHL for demonstration tests at two IL utilities at Hennepin and at Springfield. Due to the lack of funds to construct the pilot plant, a decision was made to produce the HSAHL by a batch process. The ISGS identified a chemical company, (Optima Chemicals (OC), Douglas, GA) and provided engineering assistance for making about 50 tons of HSAHL. The HSAHL will be tested at IL Power's (IP) Hennepin station during the week of January 11, 1993.

Arthur Conn and Associates, Ltd. (ACAL), completed an economic analysis study. The projected costs of HSAHL have been estimated to be between $10-$25/ton higher than commercial hydrated lime. However, the costs of sulfur removal ($/ton SO₂) in DSI systems is about $217 for the HSAHL versus $252 for the commercial hydrate (sorbent costs only for 50% SO₂ removal).

pages 1 through 21 contain proprietary information
EXECUTIVE SUMMARY

Background

A process to make HSAHL has been developed at the ISGS. The product captures up to 90% sulfur dioxide (SO₂), nearly 70% more than the best performing commercial hydrates, in various DSI processes. These SO₂ removals are enough to bring Illinois (IL) coals into compliance with acid rain legislation goals for the year 2000 (1.2 lb SO₂/MM Btu). Research Corporation Technologies (Tucson, AZ), a marketing and licensing organization, has accepted the responsibility for patent prosecution, marketing, and licensing of the ISGS invention.

In the ISGS process, lime is hydrated at atmospheric pressure with an aqueous solution of the reagent (one-step process) followed by an optional post-hydration wash step (two-step process). The process is capable of producing a hydrate with a surface area ranging between 35 and 50 m²/g using commercial quicklimes as feed materials. With either the one-step or the two-step hydration methods, hydrates with even higher surface areas (up to 85 m²/g) can be made using specially-prepared limes.

During the past five years more than 500 experiments have been conducted to optimize the ISGS hydration process and identify key parameters influencing hydrate properties. These tests were conducted both at gram quantities in a laboratory-scale unit and in a bench-scale, batch hydrator capable of producing 5-7 pounds of hydrated lime per batch. The dependence of the hydrate properties important for SO₂ capture (surface area, porosity, particle size and crystallite size) on the hydration operating conditions and type and quality of lime have been investigated.

Objectives and Goals

The objectives of this project have been revised due to a large grant for the period November 1, 1990 through June 30, 1992, from the IL Department of Commerce and Community Affairs (DCCA) under the Governor's Challenge Grant Program.

The purpose of the project is to design, build and operate an integrated, continuous lime hydration process optimization unit (POU) capable of producing 20-100 pounds of hydrate per hour. The HSAHL will be tested in pilot-scale DSI systems at U.S. EPA (Triangle Park, NC), Research Cottrell Environmental Services and Technologies (RCEST, Irvine, CA), Consolidation Coal Company (CCC, Library, PA), and possibly at the U.S. DOE (Pittsburgh, PA). The goals of the project during FY91 were to design the POU, purchase equipment, and conduct shakedown tests with the hydration reactor. The goals of FY92 were to generate design, construction, and operation data necessary
for the private sector to scale-up the process to a commercial level, produce samples for further testing, and to evaluate the economics of the process.

**Accomplishment of Project Objectives**

The POU, consisting of a lime feeder, pumps, hydrator, product recovery vessel, and condenser, was assembled in June 1991. Twenty tests, a total of 100 hours of operation, were successfully performed with the hydration reactor. The mechanical operability and performance of the hydrator and other components of the POU were demonstrated in these tests. More than 1000 pounds of product was produced. The properties of products compared well to those of products prepared from the same lines in a smaller batch hydrator. The scale-up and continuous operation do not appear to adversely affect the quality of the hydrated lime. In addition, a series of extensive tests were performed with both the continuous hydrator and a batch unit to provide critical data required to size and select equipment for a 1T/hr HSAHL pilot plant.

An improved hydrator was designed and fabricated. The improved reactor was successfully tested for about ten hours, producing over 250 pounds of product. A process instrumentation diagram (PID) for the POU was prepared. The PID provides location of all measurement and safety devices as well as major equipment. Ancillary equipment including platform scales and an oxygen analyzer were purchased. Safety instrumentation and measurement devices are being assembled on a control panel unit to provide continuous monitoring and control of the integrated POU during testing.

ACAL completed an economic analysis study. The projected costs of the HSAHL have been estimated to be between $10-25/ton higher than commercial hydrated lime. Based on these estimates, the costs of sulfur removal ($/ton SO₂) in DSI systems is about $217 for the HSAHL versus $252 for the commercial hydrate (sorbent costs only based on 50% removal at Ca/S = 2 for commercial hydrate and 50% removal at Ca/S = 1.25 for HSAHL).

An economic analysis was also undertaken at the ISGS to evaluate the cost benefits of using HSAHL in utilities burning high-sulfur IL coals. The results of this study revealed that utilities could save between $0.5-5M/year (depending on the plant size, which ranged from 100-500 MW) by using HSAHL instead of commercially available hydrated lime in DSI systems.

**Progress Toward Commercialization**

The results of the shakedown tests with the hydration reactor indicated no serious problems with continuous operation and scale-up of the process. Process conditions for optimizing
product based on the type of DSI process have been developed in batch hydration reactors. This "know how" will also help facilitate the marketing and the transfer of the ISGS hydrated lime to industry for commercialization.

ISGS filed for a U.S. patent application in July 1990. The patent application was amended to include new data generated recently and claims based on optimum products required for three different DSI processes (furnace sorbent injection, boiler economizer, and Coolside). In July 1991, the patent applications were filed in Australia, Canada, Japan and the European Patent Office designating all member states. In September 1992, the U.S. Patent examiner reviewed the patent and allowed 70 out of 78 claims cited in the patent. Research Corporation Technologies, a marketing and licensing organization, has assumed the entire cost of applying for and defending the patent and negotiating licenses with industrial partners in order to facilitate commercialization.

The ISGS provided and will continue to provide process information necessary to scale-up the process to a commercial level. In January to March 1992, the ISGS investigators and two consultants to the project assisted DLC and KVS to design a 3T/hr and a 1T/hr pilot-scale facility to produce HSAHL for testing at IL utilities. Due to the lack of funds to construct the pilot plant, a decision was made to produce the HSAHL by a batch process. The ISGS identified and provided engineering assistance to a chemical company (Optima Chemicals (OC), Douglas, GA) to make about 50 tons of HSAHL. The products will be tested at IP's Hennepin station during the week of January 11, 1993.