VALUE-ADDED PRODUCTS FROM FGD SULFITE-RICH SCRUBBER MATERIALS

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ABSTRACT

OBJECTIVES: According to the American Coal Ash Association, about 29.25 million tons of flue gas desulfurization (FGD) byproducts were produced in the USA in 2003. Out of 29.25 million tons, 17.35 million tons were sulfite-rich scrubber materials. At present, unlike its cousin FGD gypsum, the prospect for effective utilization of sulfite-rich scrubber materials is not bright. In fact, almost 16.9 million tons are leftover every year. In our pursuit to mitigate the liability of sulfite-rich FGD scrubber materials' disposal, we are attempting to develop value-added products that can commercially compete. More specifically, for this Innovative Concept Phase I project, we have the following objectives:

- to characterize the sulfite-rich scrubber material for toxic metals,
- to optimize the co-blending and processing of scrubber material and natural byproducts,
- to formulate and develop structural composites from sulfite-rich scrubber material, and
- to evaluate the composites' mechanical properties and compare them with current products on the market.

After successfully demonstrating the viability of our research, a more comprehensive approach will be proposed to take these value-added materials to fruition.

ACCOMPLISHMENTS TO DATE: In our pursuit to develop value-added wood substitute products from sulfite-rich FGD scrubber material, we collected samples of scrubber material from a power plant, which burns Midwestern coal. This scrubber material had not undergone stabilization with fly ash and was in a wet cake form. The following experiments were undertaken to achieve our objectives:

1. The wet cake was air dried and then subjected to arsenic (As), boron (B), cadmium (Cd), mercury (Hg), and selenium (Se) analyses. The analyses of these elements were undertaken at a commercial laboratory. The concentration of As, B, Cd, Hg, and Se were < 4.8 mg/kg, 61 mg/kg, < 0.95 mg/kg, 0.28 mg/kg, and 6 mg/kg, respectively.
2. Because the potential re-emission of mercury from FGD scrubber materials, be they sulfate-rich or sulfite-rich, during their utilization is of concern, we are also examining the mercury concentration in the wet scrubber material produced weekly. We ascertained mercury concentration in the scrubber material using EPA Method 7473. There were variations in the mercury concentration from week to week, though the water associated with the scrubber material had a Hg concentration < 3 μg/kg.
3. In another set of experiments, we explored how various fibrous materials would affect the strength of wood substitute composites formed from sulfite-rich scrubber material. Four natural fibrous materials were chosen for this purpose. The composites tested for their flexural strength provide strong evidence that the type of fibrous material chosen has a critical effect on the strength. The strength of the composites formulated from scrubber material and natural fibers ranged from 12.5 MPa (1813 psi) to 30 MPa (4350 psi).

4. We also explored whether byproducts derived from annual crops can alter the strength of the wood-substitute composites developed from sulfite-rich scrubber material. Two natural protein concentrates derived from two different crops were obtained and were tested. It appeared that 2 wt% natural proteins improved the strength of the composites from 2 MPa (290 psi) to 30 MPa (4350 psi). Enhanced concentration of natural proteins did not further increase the strength. It is worthwhile to point out those commercial wood products we tested in our laboratory, e.g., particle floor board, OSB, and sawdust board, had a flexural strength of 16 MPa (2320 psi), 25 MPa (3625 psi), and 29 MPa (4205 psi), respectively.
5. We investigated how the addition of cheap polymeric material along with lignin extracted from crop byproducts can affect the mechanical properties of the composites formulated from sulfite-rich scrubber materials. This was undertaken because the thrust of our research is to develop wood-substitute products, thus our products should be amenable to conventional wood tools, i.e., they can be cut with regular saws and can be routed using conventional routers besides being able to be nailed. The strength linearly increased from 3 MPa as the polymeric concentration increased. In fact, for 30 wt% polymeric material our products' flexural strength was in excess of 48 MPa (6960 psi). This should be contrasted with commercial plywood we tested whose strength was 40 MPa (5800 psi).
6. Besides developing wood substitute materials, we are interested in developing lumber materials from sulfite-rich scrubber byproducts. Toward that end, we have recently formulated composites from scrubber material and natural byproducts whose strength exceeds 60 MPa (8700 psi). Our initial results also show great promise that this strength can be considerably further enhanced by incorporating nanoparticles of the cellulose extracted from wheat straw using a cheap but an effective approach developed by us.

FUTURE WORK: During the next six months, the following research activities are planned:

- To map the fate of mercury as the wood-substitute composite materials are formulated from sulfite-rich FGD scrubber material.
- To further enhance the mechanical performance of our wood-substitute products by optimizing the co-processing of the natural byproduct additives and scrubber material. The major thrust of this task will be to maximize the scrubber material content without compromising the advantages of our potential products over natural wood products.
- To explore whether we can exploit our recent nanocomposite research to further exceed the strength of our wood-substitute products.
- To identify the technological parameters needed to upscale the size of our products.

LIST OF PAPERS: 1. G. Markevicius and V. M. Malhotra, "Agricultural Byproducts Derived Nanocomposites and Composites: ultrasonic cavitation approach", Presented at 229th, ACS National Meeting, San Diego, CA, March 13-15, 2005.
2. V. M. Malhotra and F. Botha, "New Strategies in the Utilization of the FGD Gypsum and Sulfite-rich Scrubber Materials", to be presented at World of Coal Ash Conference, Lexington, KY, April 11–15, 2005.

STUDENTS WORKING ON THE PROJECT: G. Markevicius (Ph.D. student), J. E. Musselman (undergraduate student) and W. G. Fogerson (undergraduate student)