Nanocrystalline Materials for Removal of Reduced Sulfur and Nitrogen from Fuel Gas

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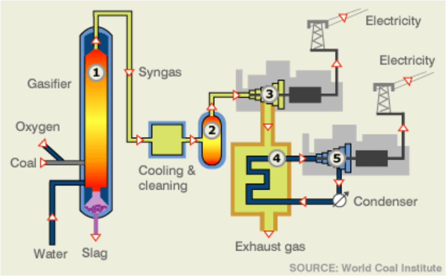
Washington, DC | U.S. EPA SBIR Phase I Kick-Off Meeting | April 5–6, 2007

Problem Statement

Coal, the primary fuel for electricity generation in the United States and other countries, is expected to have an increasing role in the future. Conventional coal-fired electricity generation has resulted in numerous environmental problems, notably emissions of sulfur and nitrogen compounds, both of which have been linked to acid rain and emissions of particulates. Conventional coal-fired technologies only partially solve these problems. Modern coal integrated gasification combined cycle (IGCC, figure below) systems offer significant advantages including improved efficiency and dramatically reduced emissions of air pollutants



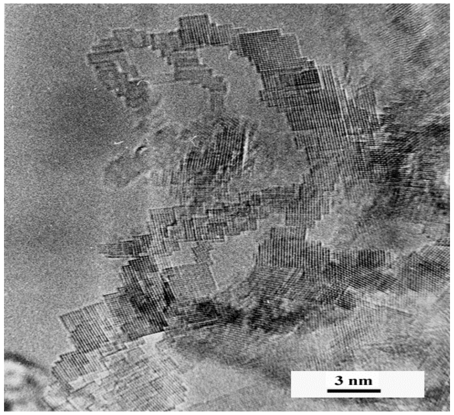
Modern IGCC system

The current IGCC technologies utilize low temperature cleanup methods for removal of sulfur and nitrogen pollutants that require cool-down of the fuel gas prior to its incineration and limit overall efficiency of the plant. Development of effective hot gas cleanup technologies that operate at gasification operating temperatures is highly desired as it would simplify the IGCC systems, increase their efficiency, and lower their capital and operational costs. Pollutants that cause particular concern in coal generated fuel gas include reduced sulfur (H_2S and COS), reduced nitrogen (NH_3 and HCN), and mercury.

Technology Description

NanoScale's metal oxides are nanocrystalline solid sorbents with high surface areas, small crystalline sizes, and enhanced chemical reactivity that makes them highly effective in a variety of applications. Due to the small crystallite sizes (usually 2-10 nanometers in size), nanomaterials have a large fraction of edge and corner sites containing 3 and 4 coordinated ions which are much more reactive than the ions/atoms in the bulk or on the surface, as shown in figure below. Such morphology results in enhanced chemical reactivity of nanocrystalline metal oxides and their high effectiveness in many applications.

NanoScale's proprietary synthesis methods are easily scalable and environmentally friendly. At production scale, NanoActive® adsorbents are cost effective and practical for industrial scale applications.



High resolution electron microscope picture of nanocrystalline MgO sorbent

Expected Results

In Phase I research, NanoScale will establish the feasibility of a system based on nanocrystalline metal oxides for purification of combustion gas streams contaminated by reduced sulfur and nitrogen compounds. The Phase I program will involve preliminary testing of potential sorbents and catalysts, selection of the most promising formulations, and overall demonstration of the feasibility of the proposed technology. Specifically three groups of nanocrystalline materials are promising candidates for the hot fuel gas cleanup application: (1) zinc oxide-based sorbents for moderate temperature high capacity H_2S and COS cleanup, (2) supported copper oxide sorbents for high temperature H_2S, COS, and possibly mercury cleanup, and (3) nickel-based supported catalysts for high temperature NH_3 and HCN decomposition. These materials will be synthesized and tested during the proposed project. The testing will include both laboratory scale experiments as well as pilot-scale demonstration in real fuel gas conditions at the Western Research Institute (WRI, Laramie, WY).

Phase II research will be focused on optimization of the selected formulations and on demonstration of their control abilities under realistic experimental conditions. Extensive testing will be conducted on various adsorbent forms using a fixed-bed adsorbent column or fluidized bed reactor. These tests will be designed to simulate "real life" conditions present in coal fired gasification systems. The Phase II testing will be carried out in collaboration with General Electric using the pilot scale IGCC system located in Irvine, CA.

Potential Environmental Benefits

Benefits offered by nanocrystalline sorbents, including enhanced chemical kinetics and increased removal capacities, have been demonstrated for many toxic chemicals and pollutants. Similar effects are expected for sulfur and nitrogen compounds. Equally important, the approach proposed by NanoScale utilizes manufacturing methods that are easily scalable, cost efficient, and environmentally friendly. This distinguishes NanoScale's approach from other groups that study nanocrystalline materials and frequently use bench top synthesis methods that cannot be easily scaled-up to industrial scale. Some of these approaches, like sol-gel synthesis or vapor deposition methods, are too costly to be commercially viable in large scale industrial settings. Materials proposed for testing in this proposal do not require use of such expensive manufacturing processes.

Development of effective hot gas cleanup technologies will allow for environmentally responsible utilization of coal for energy production

This research is funded by USEPA SBIR Program, Contract # EP-D-07-038