R & D facts

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Carbon Sequestration

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Surface Immobilization Nanotechnology for CO_2 Capture

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Summary

Carbon dioxide is considered to be one of the major greenhouse gases directly influencing global climate change. It is estimated that 36% of the United States' anthropogenic CO_2 is produced from coal/fired power plants. Consequently, the capture and sequestration of CO_2 from flue gas streams is an essential step for carbon management in the environment.

The capture and separation of CO_2 can be achieved by using solvents, cryogenic techniques, membranes, and solid sorbents. Among them, aqueous amine solutions have been widely used. Although an amine solution is effective for CO_2 absorption, it presents a corrosion problem to equipment and it degrades through oxidation. However, solid sorbents offer a number of advantages, including low energy requirement for sorbent regeneration, and elimination of corrosion problems. The development of an economic CO_2 separation process requires a highly efficient CO_2 sorbent. The sorbent must possess high CO_2 - capture capacity, long-term use and the ability to be regenerated with a small difference in adsorption and desorption temperatures. One potential approach for preparing such a sorbent is to graft CO_2 adsorption sites on a high surface area support. Obviously, the more adsorption sites grafted on the surface, the higher the capacity for CO_2 capture. Therefore, a new technique for immobilizing high amounts of amine compounds, which are accessible by CO_2, on the same substrate surface is needed to develop low-cost and highly-efficient solid sorbents for CO_2 capture.

This project will take full advantage of the electrostatic layer-by-layer self-assembly (LBL) technique, which is a very useful and novel nanotechnology for fabrication of multilayer coatings. LBL nanotechnology has the following advantages:

- The process provides a novel approach to develop ultrathin coatings on any shape of substrate at room temperature.
- The coating can be very stable.
- Different materials can be assembled in a pre-designed order.
- The process is relatively straightforward and can be automated and scaled-up for mass production.
- The process is environment-friendly.
- The process allows super-molecular structures to be built with molecular control.
- The process permits control of coating thickness, uniformity and roughness on the nanometer scale.

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Approach

Several approaches have been investigated for CO_2 capture, and among them, amine grafted solid sorbents have shown great promise. However, the amount of amines that can be immobilized is still relatively small, and further enhancement of CO_2 capture capacity is beneficial. The long-term goal of this research is to reduce the release of greenhouse gases to the atmosphere from flue gas streams by developing novel technologies for CO_2 capture. The rationale is that the proposed nanotechnology provides a novel approach for grafting substantially larger amounts, for instance 100 times more, of amine compounds and also possibly other polymers than currently studied solid sorbents. This study will lead to the development of highly-efficient and multi-functional novel solid sorbents.

Expected Benefits:

The electrostatic layer-by-layer self-assembly (LBL) is the most promising method for preparation of multilayer nanocoatings of controlled thickness and molecular architecture. Novel sorbents are expected to be developed using this nanotechnology, and the developed sorbents will have the following features:

- Low-cost: the LBL process is simple, and the amines (e.g., PEI, PAA) used are cheap.
- Highly-efficient: extremely high amounts of amine compounds, for example 100 times the currently studied sorbent systems, will be immobilized on the sorbent as a porous multilayer coating.

Expected Outcomes:

A multidisciplinary collaboration has been established to conduct the proposed project. The team includes an Assistant Professor at WVU as principal investigator (PI), a Professor at Pitt, and a Scientist at NETL. This team is particularly well-prepared to undertake the proposed research. This is because the collaboration will take advantage of the complementary expertise of the PI in nanotechnology and bioengineering, of the CO-PI in reactor/process design as well as modeling, and of the NETL scientist in physics and chemistry. The success of the project will result in further collaborations, not only on the development of novel sorbents but also on the development of novel membrane systems, among the NETL and the regional universities. This will enhance the in-house research at NETL.