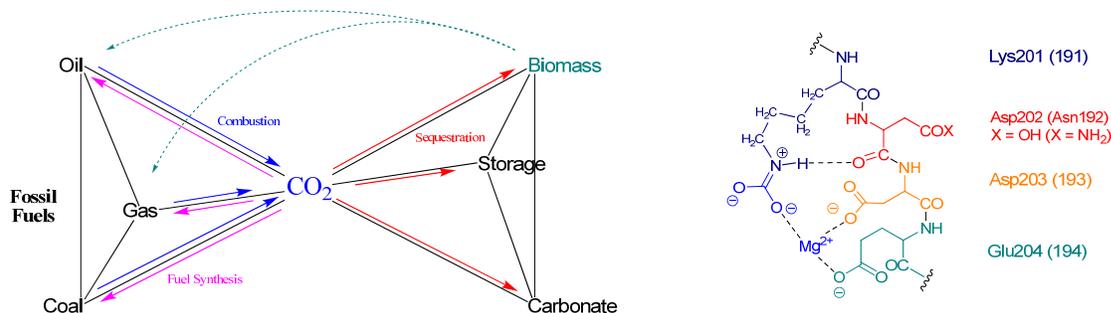


## Advanced Biomimetic Materials for Reversible CO<sub>2</sub> Capture from Air

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The world is rightly focused on climate change. The U.N. Intergovernmental Panel on Climate Change (IPCC) identified carbon capture and storage (CSS) as a critical technology for reducing emissions, not only from power plants but also from industries that manufacture cement, chemicals and steel. The capture of CO<sub>2</sub> from air and its long-term storage also presents the method of last resort to combat excessive atmospheric CO<sub>2</sub> concentrations. IPCC concluded that the world has to reverse the increase of greenhouse gas emissions by 2020 to avert disastrous environment consequences.

Modern societies largely rely on the fossil fuels to generate energy (electricity, heat, etc.) and as fuels for transportation, and the principle mode of fossil fuel use involves its direct combustion to water and carbon dioxide. Efforts to reduce CO<sub>2</sub> emissions are directed at improving the combustion efficiency and/or at the development of technologies for carbon capture and storage (CCS). The fuel combustion efficiency depends on the type of fuel (coal, gaseous or liquid hydrocarbons, H<sub>2</sub>), the oxidizing agent (air, O<sub>2</sub>-enriched air, steam), and combustion conditions (pres., temp., cat.). It is the primary aim of CCS technologies to capture CO<sub>2</sub> at the source and its long-term storage. The 2007 MIT study<sup>1</sup> “The Future of Coal” concluded that “CCS is the critical enabling technology that would reduce CO<sub>2</sub> emissions significantly while also allowing coal to meet the world’s pressing energy needs.”



The three major approaches to CCS involve post-combustion scrubbing, oxyfuel, and pre-combustion decarbonization technologies. It is the goal of our research to develop advanced materials for CO<sub>2</sub> scrubbing.<sup>2</sup> Nature has evolved five pathways for autotrophic CO<sub>2</sub> fixation<sup>3</sup> and our approach is inspired by the mechanism of the photosynthetic carbon assimilation via the Calvin-Bassham-Benson cycle.<sup>4</sup> The mechanism of the Rubisco-catalysis involves the activation by way of carbamylation of active-site Lys by an activator CO<sub>2</sub> (<sup>A</sup>CO<sub>2</sub>), and the carbamate thus formed is stabilized by complexation to Mg<sup>2+</sup> and by NH<sup>+</sup>OC hydrogen-bonding. We present results of theoretical and mechanistic studies of organic materials that mimic Rubisco’s capacity for reversible CO<sub>2</sub> capture and discuss the fixation of these materials on porous, solid supports to achieve large-scale CO<sub>2</sub> scrubbing from ambient air.

1 The Future of Coal – Options for a Carbon Constrained World. Deutsch, J.; Moniz, E. J., co-chairs. An independent MIT study, March 2007. <<http://web.mit.edu/coal/>>.

2 (a) Capturing carbon dioxide directly from the atmosphere. Zeman, F. S.; Lackner, K. S. *World Resources Review* **2004**, *16*, 62–68. (b) Climate Strategy with CO<sub>2</sub> Capture from the Air. Keith, D. W.; Ha-Duong, M.; Stolaroff, J. K. *Climatic Change* **2006**, *74*, 17-45.

3 A Fifth Pathway of Carbon Fixation. Thauer, R. K. *Science* **2007**, *318*, 1732-1733.

4 Rubisco: Structure, regulatory interactions, and possibilities for a better enzyme. Spreitzer, R. J.; Salvucci, M. E. *Ann. Rev. Plant. Biol.* **2002**, *53*,449-475, and references cited there.