

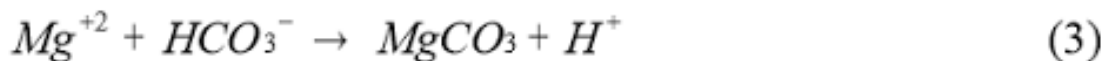
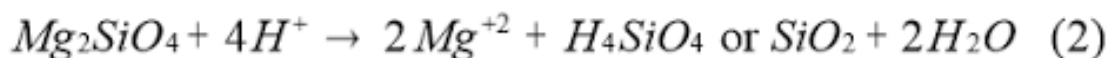
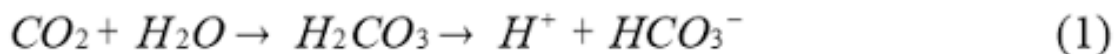
Mitigating Carbon Dioxide Levels Through Novel Sequestration Techniques

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Rising levels of CO₂ is a major concern for the coming century as climate change continues to occur. One major source of this greenhouse gas are the many power plants in existence, particularly coal and oil burning plants. These plants singlehandedly account for approximately 30% of the greenhouse emissions globally. These plants, as all power plants do, produce an incredible amount of heat, though are only so efficient in creating electricity from this heat. In fact, the average fossil fuel based plant's efficiency has remained approximately 33% for the last 4 decades. We plan to utilize this feature when attempting to limit emissions. Our goal is to limit the emittance of CO₂ through carbon sequestration, or more specifically mineral carbonation, which will store the CO₂ inside harmless and stable, on the scale of millions of years, carbonates, such as magnesium carbonate. This will be accomplished through the creation of carbonates from carbonic acid and another cation. While the reaction is exothermic, it does have a rather high activation energy. Our proposal is to place sites of mineral carbonization near the heat source in these plants to provide sufficient energy for this reaction to occur. Ideally this heat will be transferred to the reaction using the same water as is used to spin turbines

To perform the reactions necessary for mineral carbonation, there are three required chemicals: water, carbon dioxide, and a metal-containing silicate, such as forsterite, a magnesium rich form of olivine. Water is easily procured, while carbon dioxide is produced by the burning of fossil fuels. Forsterite, an ultramafic igneous rock, is sufficiently common for this process to be economically feasible on a large scale. There are other potential third reactants as well, but as of now one of the most successful trials conducted was done utilizing forsterite.

In essence, the process of mineral carbonation involves three reactions, presented below:



The first equation describes the creation of carbonic acid, when CO₂ and H₂O combine, and then the subsequent release of a hydronium ion, since the compound is acidic. The hydronium ions then react with forsterite to produce magnesium ions and either saturated or unsaturated silicon dioxide. The magnesium will react with bicarbonate to produce magnesium carbonate and an additional hydronium ion. The magnesium carbonate, as well

as the silicate, is a stable compound and can then be safely disposed of or sold, depending on the demand for either product at the time.

With regards to temperature of the reactions, the solutions must be heated to a temperature between 150 degrees celsius and 200 degrees celsius for maximum effect. However, heated steam within a coal power plant can easily reach over 500 degrees celsius, more than warm enough to allow for the reaction to occur. After being used to spin turbines, the steam will then be used to heat up this reaction before being cooled for reuse. This saves any energy that it would take to heat up the reaction should they be conducted off site.

Next, having seen the feasibility of the system, the actual impact of the system was looked at. The average coal power plant produces 2.6 billion pounds of CO₂ every year. This is equal to approximately 1180 billion grams per year, or about 27 billion moles. Currently, with the addition of gas dispersion, the most successful reaction results in 91 pct stoichiometric conversion of the silicate to the carbonate in 24 hours, at a temperature of 185 degrees celsius and a CO₂ pressure of 115 atm. Given 500,000 tons, or approximately 3.2 billion moles, of forsterite at that rate of conversion, there would be a total of about 625 million pounds of CO₂, or approximately 24% of the average factories yearly emissions, of carbon captured every year. To put that in perspective, that would be the equivalent of taking over 52 thousand cars off of the road for just one factory. While 500,000 tons is a lot of rock, it is easily manageable by coal factories, which can burn up to 11 million tons of coal per year.

Current methods involve transportation and storage of reactants that cost \$8-\$17 per ton of CO₂. Another method known as ex situ mineral carbonation costs \$50-\$300 per year. Our method reduces the cost as transportation of the CO₂ is unnecessary. We also reduce the energy usage required to perform this reaction, using excess heat from the coal itself.

Finally, the product of this reaction, magnesium carbonate, has a variety of industrial uses. One primary use is in the construction of refractory bricks, though it is also used in flooring, fireproofing, fire extinguishing compositions, cosmetics, dusting powder, and toothpaste. In fact, magnesium carbonate has an approximate price per pound of \$4. Given our 500,000 tons of forsterite, or 3.2 billion mols, we produce slightly over 5.8 billion mols of magnesium carbonate. This is equivalent to about 1.09 million pounds, which would be worth over 2 million dollars even at half of our estimate price.

Our method of chemical carbonation is not only relatively effective, but it is also adaptable. Once the necessary infrastructure has been added to a factory, it becomes very easy to adapt to new technologies. The forming of carbonates works with a wide array of compounds beyond just magnesium. Silicon and calcium are just two to name that could be used in a similar setup.

We demonstrated mathematically with forsterite because certain studies indicated its favorability over other mineral in certain settings. However, should more efficient or cost effective compounds should arise, they can easily be implemented in place of current technologies. The reaction simply occurs in a slurry that the CO₂ flows through, and that slurry could easily be replaced at any time. Which leads to final benefit of this setup, ash spray. Since the emissions will travel through a slurry before being sent up the smokestack, lose particles in the smoke will be caught up in the slurry and kept from the atmosphere. Should different condition with regards to temperature or pressure be needed, different

amounts of heated water and tank space could be used to adjust based on any future studies. Between the diversity of potential minerals, adaptability of the system, and potential economic compensation, this proposal would appear easily implementable for any major factory across the country.