STEP Cement: Cost Competitive, Zero Carbon Dioxide Emission Process for the Production of Cement

Technology #012-010-licht

The production of cement is an energy intensive industrial process that accounts for an estimated 5-6% of all human-generated carbon dioxide (CO₂) emissions. Society consumes over $3 \times 10^{12}$ kg of cement annually and the cement industry releases 9 kg of CO₂ for each 10 kg of cement produced. The majority of the CO₂ is released from the conversion of limestone (CaCO₃) to lime CaO, but another 30-40% is generated from the combustion of fossil fuels, such as coal, natural gas, etc.

Dr. Stuart Licht, a researcher at George Washington University, has developed a novel process based on anomalies in molten salt/oxide solubility to generate CaO with greatly reduced or even eliminated CO₂ emissions. The aqueous solubility of CaCO₃ is three orders of magnitude less the solubility of CaO. This is reversed at high temperatures in molten carbonates, which allows the endothermic, electrolytic one pot synthesis and precipitation of CaO. The co-product is either CO or pure carbon, depending on the temperature of the carbonate:

Below 800º C:

\[
\text{CaCO}_3 + Q \text{Solar} + E_{\text{Electrolysis}} \rightarrow \text{CaO} \downarrow + C + O_2
\]

Above 800º C:

\[
\text{CaCO}_3 + Q \text{Solar} + E_{\text{Electrolysis}} \rightarrow \text{CaO} \downarrow + CO + \frac{1}{2} O_2
\]

If we assume market prices of $35/ton CaO for raw materials, $61/ton CaO for heat, and $77/ton CaO for electricity, the direct material cost of production is $173, less the value of the carbon or carbon monoxide. At a reasonable pure carbon value ($120/ton), the net cost of CaO is on the order of $43/ton, which is substantially lower than the market price of $110/ton reported in the spring of 2014. If a large scale Concentrator Solar Power plant (CSP) is used for power, the variable cost of the thermal energy is near zero, and the economics are much more compelling. Note: CSP’s have been demonstrated on an industrial scale as cost effective electrical generation stations.

Inventors

Stuart Licht