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Production of Thermally Stable Solids from CO_2 Capture using Ammoniated Brine

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Extended Abstract

Currently, emission of CO_2 from fossil fuel combustion has been widely known as a major cause of global warming. The level of CO_2 concentration in the atmosphere has continuously been increasing to over 400 ppm, thus requiring a serious attention to lower it. An interesting CO_2 capture idea is adapted from the Solvay process that produces sodium carbonate (Na_2CO_3) using a salt solution, NH_3 and CO_2. Instead of producing CO_2 via a thermal decomposition as in the Solvay process, it can be modified to capture the released CO_2 from various sources such as power plant and industrial factories and, at the same time, to treat a high salt concentration wastewater as disposed from a desalination plant [1]. Several literatures have reported a success combination approach to capture CO_2 and reduce alkali ions in a reject brine [2,3]. However, there has been none of them focusing on the sequestration of CO_2 in form of a thermally stable solid at room temperature and atmospheric pressure and how to enhance the formation of it.

Therefore, this work focuses on CO_2 capture using ammoniated brine and also studies factors affecting the formation of the thermally stable solid Na_2CO_3. Synthetic brines of various NaCl concentrations were prepared in a bubble column reactor and ammoniated with NH_3 to the pH of about 13. Then, for each experiment, CO_2 made up with N_2, when needed, was bubbled through the liquid column in the reactor. The unabsorbed CO_2 at the effluent was monitored versus time with an IR-CO_2 analyzer. The solid products were collected, dried, and analyzed using SEM, XRD, and TGA after the absorption. The SEM images reveal that the solid products are nearly spherical and agglomerated for every brine concentration tested. XRD results confirmed that Na_2CO_3 was formed as a major thermally stable solid product of the CO_2 capture. The other components of the solid products as analyzed by thermal decompositions using TGA were found to be several carbon-containing compounds including $NaHCO_3$, $(NH_4)_2CO_3$ and $(NH_4)HCO_3$. Based on the amount of products by weight, the ammonium salts were found to be the main carbon captured products but they could be decomposed easily from room temperature to about 80°C. When carbon formed a compound with sodium as Na_2CO_3, it became more stable thermally providing an interesting approach for CO_2 sequestration. It was found that increasing the sodium concentration could significantly increase both CO_2 capture loading and yield of Na_2CO_3. Similarly, increasing ammonia concentration from 30 to 43 weight percent could enhance CO_2 absorption for every brine concentration tested. Moreover, increasing the CO_2 flow rate and absorption temperature was found to decrease CO_2 absorption and the formation of Na_2CO_3 due mainly to the lowered gas-liquid contact time and lowered CO_2 solubility, respectively. Finally, the maximum yield of Na_2CO_3 of 76 wt% could be obtained at 20°C, atmospheric pressure, CO_2 flow rate of 100 mL/min, NH_3 concentration of 43 wt% and NaCl concentration of 17.5 wt%.

References

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