Proceedings of the 4th International Conference on Environmental Pollution and Remediation
Prague, Czech Republic, August 11-13, 2014
Paper No. 76

Efficiency Enhancement of Mineral Carbonation in Calcium Sulfate Using CO_2 Micro Bubbles

Jun-Hwang Bang, Wonbaek Kim, Soo Chun Chae, Kyungsun Song
Korea Institute of Geoscience & Mineral Resources (KIGAM)
124 Gwahang-no, Yuseong-gu, Daejeon 305-350, Republic of Korea
jhbang@kigam.re.kr; wbkim@kigam.re.kr; chae@kigam.re.kr; kssong@kigam.re.kr

Keywords: CO_2 fixation, Carbonate mineralization, Microbubbles.

Extended Abstract

The decrease of anthropogenic CO_2 causing greenhouse effect has been needed more than ever. Carbonate mineralization is a way of cutting CO_2 emission down by fixing CO_2 as carbonate minerals. This method is practical because it uses the well-known chemical reaction of precipitating $CaCO_3$ [Zevenhoven and Fageriund]. The reaction requires alkali (earth) metal ions such as Ca^{2+} or Mg^{2+}, and OH^- to speciate CO_2 to CO_3^{2-}. Henry's law suggests that low temperature and/or high pressure are required to enhance the solubility of CO_2 in an aqueous phase. However, those conditions are not recommended for CO_2 fixation because lower temperature and high pressure require large energy. Tiny bubbles in an aqueous phase can retard the retention time of the gas due to their small specific volume, less buoyancy, and large surface tension in comparison to large bubbles. Resultantly, the use of microbubbles which typically refer to the bubbles smaller than 50 microns [Matsumoto et al.] is expected to increase CO_2 concentration in the Ca^{2+} supplying aqueous phase. Microbubbles are generated by microbubble generator which is a reconstructed centrifugal pump with a gas injection part and a specially made nozzle discharging the microbubbles and aqueous phase. This study shows that the CO_2 fixation efficiency can be enhanced by using CO_2 microbubbles, and optimized experimental conditions of the reactant concentrations for the largest conversion ratio of CO_2.

Ca^{2+} was supplied by $CaSO_4 \cdot 2H_2O$ suspension at various concentration in Milli-Q water. The NaOH stock solution of 6 M was prepared and added into the suspension. The purity of gaseous CO_2 was 99.9%. Microbubble generator circulated CO_2 and the suspension until pH of the suspension reached to steady state near neutral. After the termination of the experiments, the suspension was filtered by 0.2 micron pore size-nylon membrane to collect the particles for the X-ray diffraction (XRD) analysis. The control experiments have been carried out bubbling CO_2 using a 3 cm sized conventional air diffuser under the identical experimental condition. The XRD result revealed large quantity of $CaCO_3$ suggesting that the conversion efficiency of CO_2 was high in this method. The concentration ratio of the reactant, hydroxyl ion to calcium ion, was a crucial factor affecting the efficiency of carbonate mineralization. The 100% conversion efficiency was achieved when the ratio was in the range of 2-3. Increasing the volume of NaOH stock solution expanded the differences of conversion efficiency between the air diffuser and microbubbles. It was clearly demonstrated that the use of CO_2 microbubbles significantly enhanced the CO_2 fixation efficiency in comparison to the case of conventional air diffuser.

References

M. Matsumoto, T. Fukunaga, K. Onoe, Polymorph control of calcium carbonate by reactive crystallization using microbubble technique, Chem. Eng. Res. Des. 88 (12) (2010) 1624-1630.

R. Zevenhoven, J. Fagerlund, Fixation of carbon dioxide into inorganic carbonate: the natural and artificial weathering of silicate, in: M. Aresta (Ed.), Carbon Dioxides as Chemical Feedstock, Wiley-VCH, Germany, 2010, p. 360.