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Real-Time Investigation of CO_2 Sequestration via Wet Carbonation of Silicates Using In Situ Raman Spectroscopy for Sustainable Cement Use

The steady rise in carbon dioxide (CO_2) emissions from fossil fuel combustion as well as from Cement production, remains a major environmental concern, prompting urgent action to mitigate climate change. In support of the Paris Agreement's goal to limit global temperature rise to below 2°C—ideally 1.5°C—there is a growing emphasis on carbon capture strategies that not only reduce emissions but also promote circular carbon use in industrial processes.

Among emerging approaches, wet mineral carbonation offers a promising pathway for CO_2 sequestration, especially within the cement industry. The use of carbonated silicate-based materials as Supplementary Cementitious Materials (SCMs) provides a dual benefit: reducing emissions while recycling CO_2 into valuable construction materials. Although wet carbonation is known for its fast reaction kinetics in aqueous media, a deeper understanding of its reaction mechanisms is needed to optimize performance.

This study explores the wet carbonation of wollastonite and olivine, calcium- and magnesium-rich silicates respectively, using in situ Raman spectroscopy. The technique enables real-time monitoring of reaction progress, phase changes, and carbonation product formation. These insights are complemented by XRD, XRF, SEM-EDX, TGA, and calcimetry to provide a comprehensive understanding of the process.

The results highlight Raman spectroscopy's unique capability to detect subtle transformations during carbonation, making it a powerful, fast analytical tool in studying time-sensitive reaction kinetics. Notably, wollastonite demonstrated significant CO_2 uptake, enhanced by grinding-induced surface activation. These findings not only affirm the potential of wollastonite in CO_2 sequestration but also underscore the value of in situ spectroscopic techniques in optimizing mineral carbonation processes for industrial applications

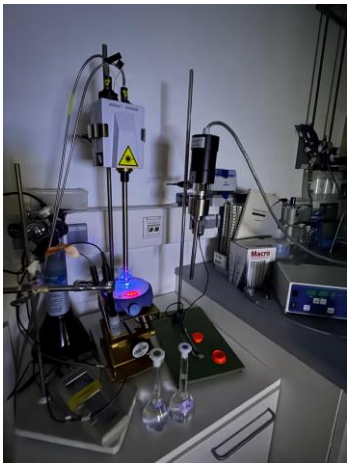

Figure 1: In Situ Raman Spectroscopy Setup