Rev Environ Sci Biotechnol (2024) 23:739–799
https://doi.org/10.1007/s11157-024-09695-2

REVIEW PAPER

Breakthrough innovations in carbon dioxide mineralization for a sustainable future

Ramesh Kumar · Woo Jin Chung · Moonis Ali Khan · Moon Son · Young-Kwon Park · Sang Soo Lee · Byong-Hun Jeon

Received: 13 March 2024 / Accepted: 27 June 2024 / Published online: 27 July 2024

Abstract Greenhouse gas emissions and climate change concerns have prompted worldwide initiatives to lower carbon dioxide (CO_2) levels and prevent them from rising in the atmosphere, thereby controlling global warming. Effective CO_2 management through carbon capture and storage is essential for safe and permanent storage, as well as synchronically meeting carbon reduction targets. Lowering CO_2 emissions through carbon utilization can develop a wide range of new businesses for energy security, material production, and sustainability. CO_2 mineralization is one of the most promising strategies for producing thermodynamically stable solid calcium or magnesium carbonates for long-term sequestration using simple chemical reactions. Current advancements in CO_2 mineralization technologies,focusing on pathways and mechanisms using different industrial solid wastes, including natural minerals as feedstocks, are briefly discussed. However, the operating costs, energy consumption, reaction rates, and material management are major barriers to the application of these technologies in CO_2 mineralization. The optimization of operating parameters, tailor-made equipment, and smooth supply of waste feedstocks require more attention to make the carbon mineralization process economically and commercially viable. Here, carbonation mechanisms, technological options to expedite mineral carbonation, environmental

Ramesh Kumar and WooJin Chung have contributed equally to this work.

R. Kumar · B.-H. Jeon (✉)
Department of Earth Resources and Environmental Engineering, Hanyang University, 2226 Wangsimni-ro, Seongdong-gu, Seoul 04763, South Korea
e-mail: bhjeon@hanyang.ac.kr

W. J. Chung
Department of Environmental Energy Engineering, Kyonggi University, Suwon 16227, Republic of Korea

M. A. Khan
Chemistry Department, College of Science, King Saud University, 11451 Riyadh, Saudi Arabia

M. Son
Center for Water Cycle Research, Korea Institute of Science and Technology (KIST), Seoul 02792, Republic of Korea

M. Son
Division of Energy and Environment Technology, KIST-School, University of Science and Technology, Seoul 02792, Republic of Korea

Y.-K. Park
School of Environmental Engineering, University of Seoul, Seoul 02504, Republic of Korea

S. S. Lee (✉)
Chemical Sciences and Engineering Division, Argonne National Laboratory, Lemont, IL 60439, USA
e-mail: sslee@anl.gov