

Towards Sustainable Energy and Environment: Carbon Capture, Utilization and Storage

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With the increase of the global population and the growth of the world economy and industrial sector, global energy consumption has also been increasing. Considering that the fossil fuels will still be one of the major energy sources for the foreseeable future, measures need to be taken to control the atmospheric CO₂ concentration. Carbon capture, utilization and storage (CCUS) technologies are one of the approaches to decarbonize the power and industrial sectors. Among various options, carbon mineralization is one of the less studied CCUS technologies, which mimics the natural weathering of silicate minerals. As CO₂ reacts with silicate minerals, carbon is stabilized in the form of insoluble solid carbonates for permanent carbon storage. If this reaction is carried out in an ex-situ reactor system, solid carbonates, high surface area silica and other minor components such as iron oxide can be produced with tailored properties and separated as value-added products. In addition to natural minerals and mine tailings, alkaline industrial wastes such as iron and steel slags can also be used as feedstock for carbon mineralization. Most of the industries producing alkaline solid wastes (e.g., steelmaking, cement and aluminum plants) are also point sources of anthropogenic CO₂. Thus, carbon mineralization using their own solid waste streams and CO₂ leads to multifaceted environmental benefits including CCUS and solid waste treatment. Furthermore, industrial wastes often contain other valuable components such as rare earth elements. The challenge is that silicate minerals and alkaline solid wastes are chemically complex and their dissolution kinetics are very slow. In order to address these challenges and opportunities, we have focused on the fundamental understanding of dissolution and carbonation behaviors of alkaline silicate materials and integration of step-wise separations of rare-earth elements from these unconventional resources.