Abstract

[Research Title]

Development of the novel hybrid energy assisted quick lime production process to achieve a great decarbonization

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Principal Investigator :	Fukumura Takuya
(PI ORCID) :	
Principal Institution :	National Institute of Technology, Ichinoseki College Ichinoseki City, Iwate, JAPAN Tel: +81-191-24-4773 Fax: +81-191-24-2146 E-mail: fuku@ichinoseki.ac.jp
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[Abstract]

The rapid escalation of global warming is primarily linked to the rising concentration of carbon dioxide (CO_2) in the atmosphere. As part of global efforts to mitigate climate change, Japan has committed to achieving net-zero CO_2 emissions by 2050. During the production of quicklime (calcium oxide, CaO) from limestone ($CaCO_3$), a significant amount of CO_2 is emitted, with approximately half of its weight originating from the carbonate. In this research, we propose a novel and groundbreaking production process for CaO and calcium hydroxide ($Ca(OH)_2$) through a mechanochemical reaction involving unused-$CaCO_3$ resources such as discarded shells and lime pellets from the decarbonation process in water purification plants, and solid sodium hydroxide (NaOH), wherein CO_2 is not released from $CaCO_3$. The process is reasonably applicable to the converting of gypsum ($CaSO_4 \cdot 2H_2O$) which is the primary chemical compound in plasterboard, into CaO and $Ca(OH)_2$ to address waste material issues.

The preliminary reaction experiments conducted using a planetary ball mill, which imparts high physical energies to the reactants, demonstrated that the addition of water to the initial mixture of $CaCO_3$ and NaOH resulted in simultaneous high mechanochemical reaction efficiency and easy handling for powder material of $Ca(OH)_2$ and sodium carbonate (Na_2CO_3). The separation process of $Ca(OH)_2$ and Na_2CO_3 was successfully optimized. Furthermore, by combining mechanochemical reaction using a vibration mill, which is larger in size than a planetary mill, and optimum separation process, the purification of $Ca(OH)_2$ was successfully achieved.

$Ca(OH)_2$ was obtained from gypsum and a small amount of NaOH in the wastewater. The NaOH in the wastewater originated from the bottle washing process when returnable bottles were used. The quality of the resulting $Ca(OH)_2$ was influenced by impurities, particularly fluoride. To address this issue, we implemented a determination and separation process for gypsum, which included the removal of fluoride. According to the result of the life cycle assessment (LCA), the production of carbon-free lime from unused calcium carbonate and sulfate resources was necessary to obtain NaOH in lower carbon footprint, utilizing unused waste sources. Furthermore, it is important to optimize novel combinations of industries with diverse backgrounds, such as the process developed in this study.

[References]

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