Synthesis of belite and ye'elimite cements doped with fluxing agents

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ABSTRACT

Belite and ye'elimite cements are promising alternatives to Portland cement due to their lower CO_2 emission and energy demand. This study investigates the effect of sulfate molar ratios and fluxing agent doping additions on the formation of belite and ye'elimite phases. The primary objective is to promote the formation of the reactive α' belite phase, which exhibits higher reactivity than the commonly formed β-belite phase. The cement clinker is synthesized from pure chemical reagents with the additions of SO3 molar ratios at 0.9, 0.95, 1.0, 1.05, and 1.1. Fluxing agents giving Na_2O and B_2O_3 and $CaSO_4$are used as dopants to investigate their influence on the phase formation. The resulting clinker phases are characterized using X-ray diffraction for phase identification and scanning electron microscopy for microstructural analysis. The clinker composition that achieves the target phases, including α' belite and b-belite, is selected for comparative investigation of mechanical properties after hydration. Compressive strength tests are conducted at 1, 3, and 7 days to evaluate the cement's mechanical performance. Phase development and microstructures of the hydrated cement phases are also studied.

INTRODUCTION

In recent years, the construction industry has become increasingly focused on reducing the carbon footprint of cement production. Traditional Portland cement (PC) production is responsible for a significant portion of global CO_2 emissions, primarily due to the high temperatures required to decompose limestone and form clinker. As a result, there has been growing interest in alternative cements that have a lower environmental impact. One such alternative is Belite-Calcium Sulfoaluminate (BCSA) cement, which has been found to release significantly less carbon dioxide during its production compared to Portland cement. This makes BCSA cement an attractive option for sustainable construction practices.

BCSA cement typically consists of Belite (C_2S), Calcium Sulfoaluminate ($C_4A_3\$$), and other phases, and is known for its rapid strength development and reduced environmental impact. However, understanding the influence of various factors on the formation of these phases is crucial for optimizing its properties. One such factor is the sulfate content in the cement. Sulfate plays a vital role in the formation of the Calcium Sulfoaluminate ($C_4A_3\$$) phase, and the amount of sulfate could potentially affect the formation and stability of this phase, as well as other phases in the BCSA cement.

To further understand the formation of phases in BCSA cement, this study also explores the impact of Na_2O (sodium oxide) , B_2O_3 (boron oxide) and $CaSO_4$ as dopants. These compounds are known to influence the phase formation and the overall properties of cementitious materials. The incorporation of Na_2O and B_2O_3 could potentially alter the crystallization behavior and phase composition of the cement, which is critical for tailoring its properties for specific applications.

EXPERIMENTAL

- SiO_2
- C_aCO_3
- Gypsum
- $Al(OH)_3$

Drying & Sieving

varying dopant SO3 mol% at 0.9,0.95,1.0,1.05,1.1 (with fixed dopant Na_2O&B_2O_3)

Mixing in Ballmill

Firing at 1250°C

Clinker

Clinker Characterization (XRD,SEM)

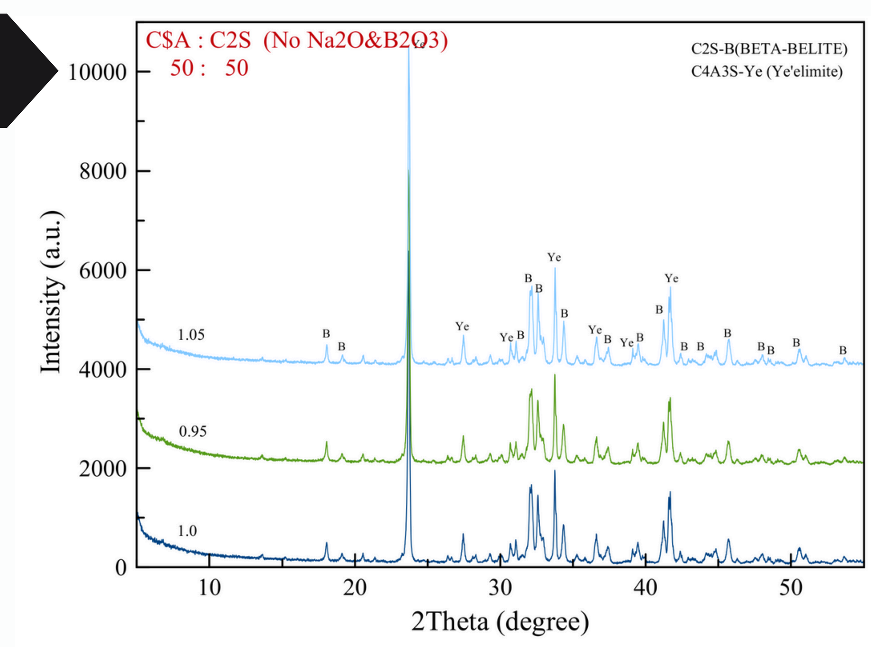
+ Gypsum

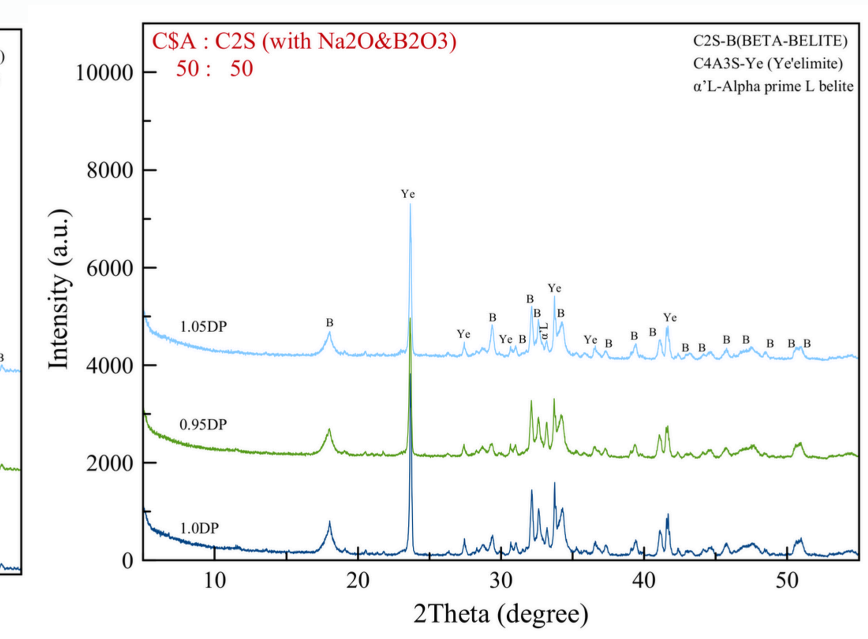
Hydration 1, 3, and 7 days

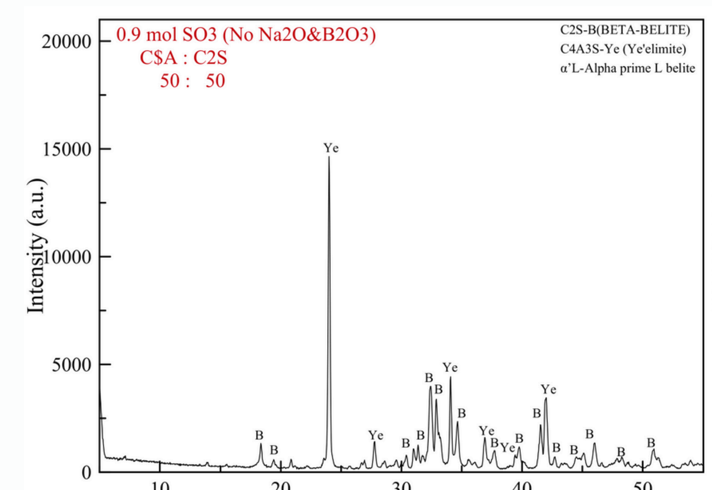
Compressive strength
Density
XRD

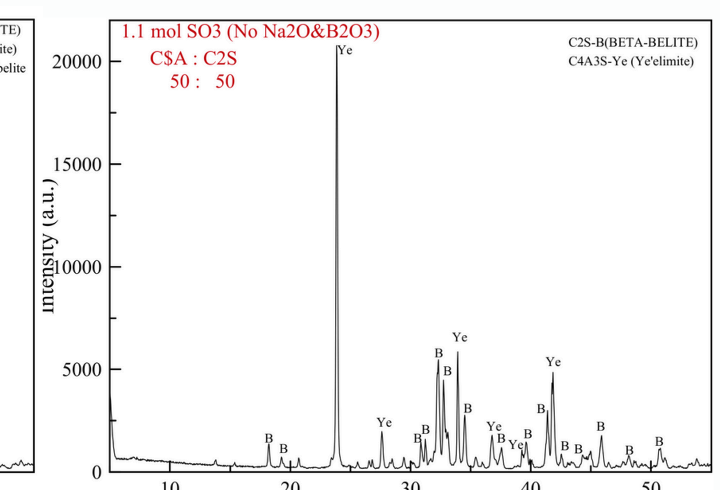
RESULT & DISCUSSION

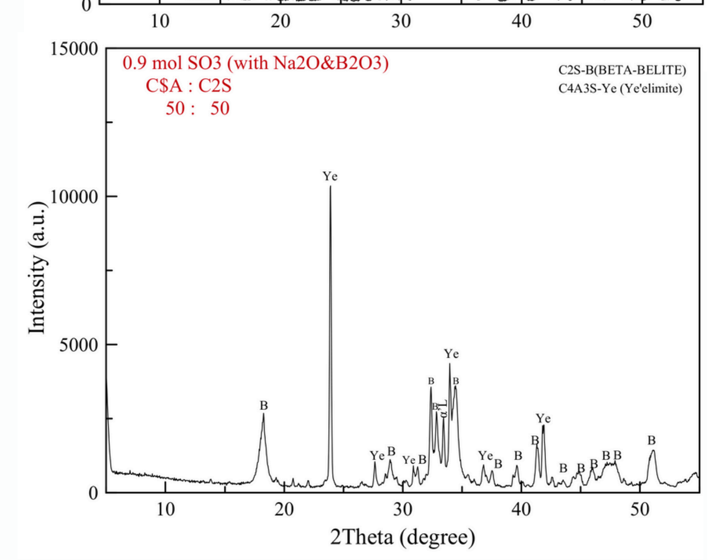
XRD

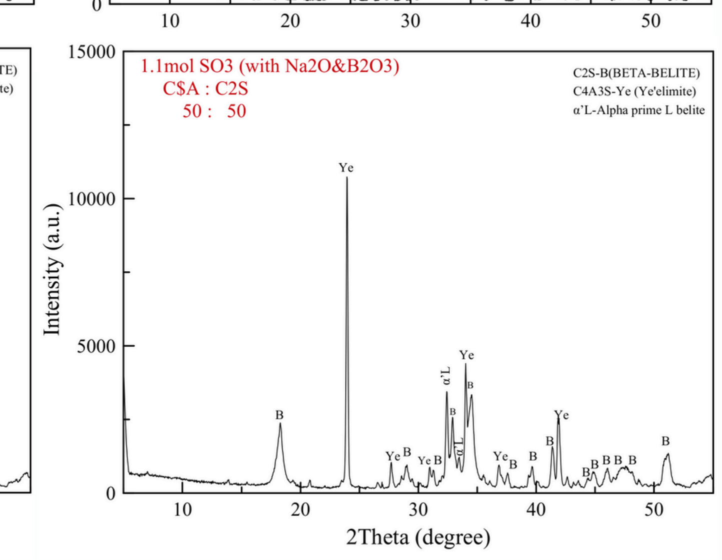


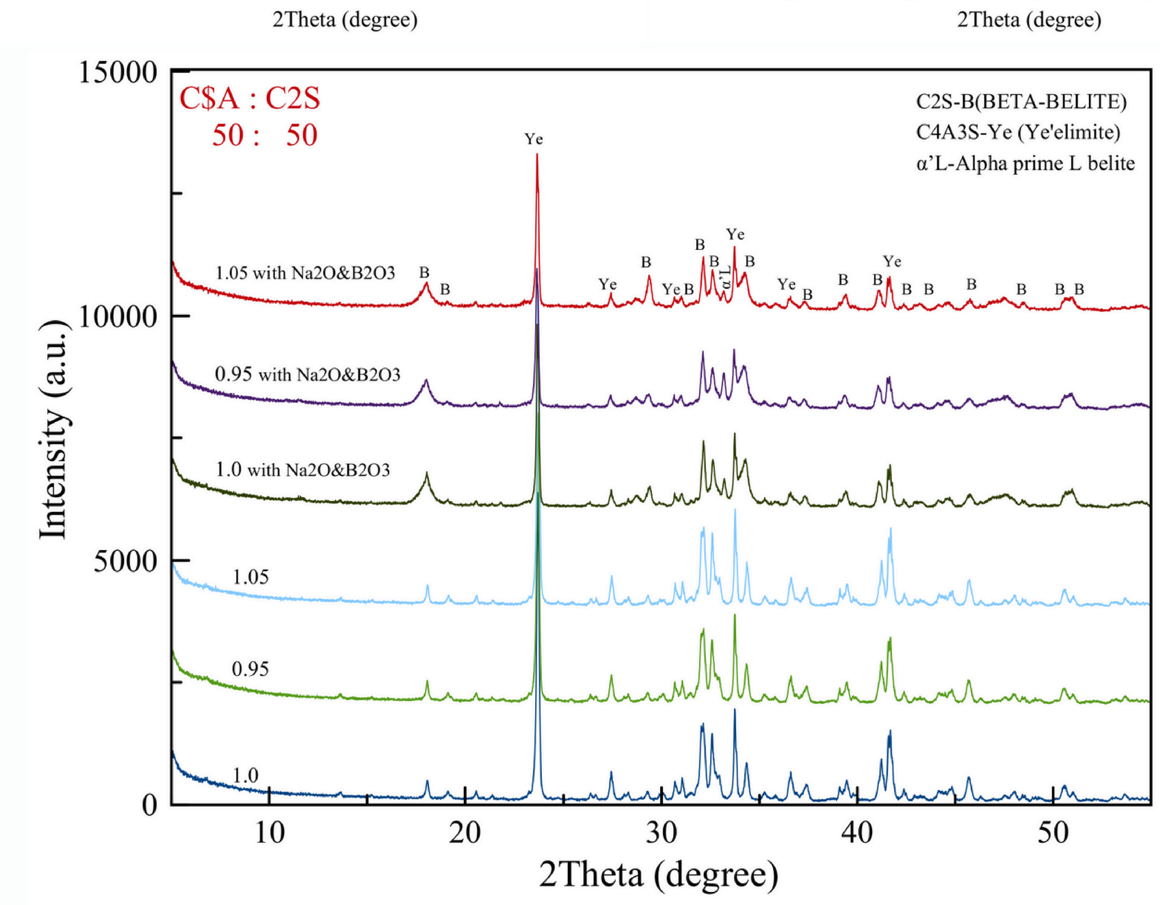






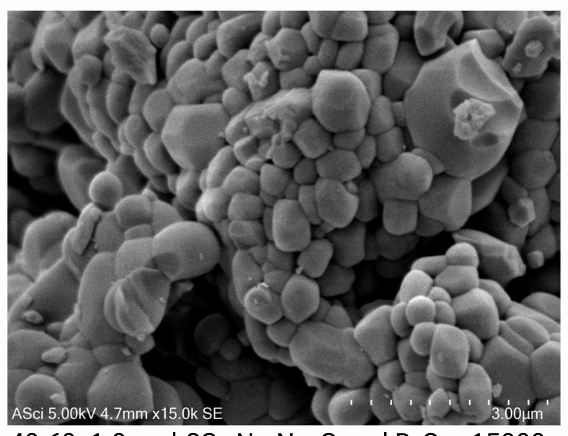




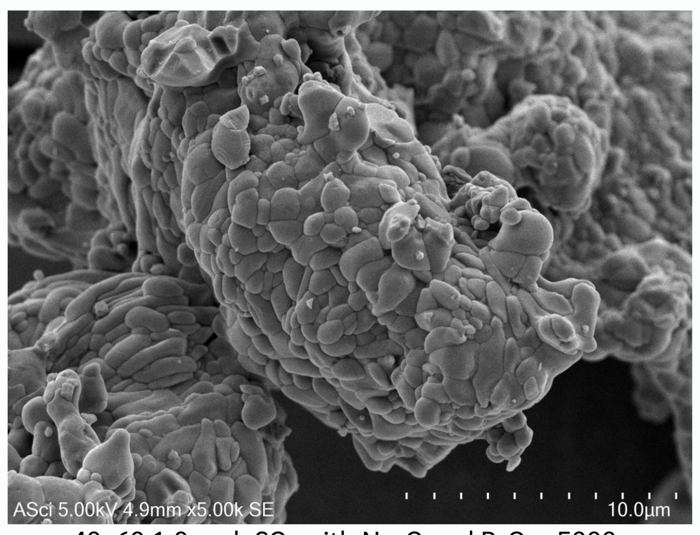


SEM

40 :60 1.0 mol SO_3 No Na_2O and B_2O_3 5000x



40:60 1.0 mol SO_3 No Na_2O and B_2O_3 15000x



40 :60 1.0 mol SO_3 with Na_2O and B_2O_3 5000x

CONCLUSIONS

Based on the experimental results, it can be observed that the optimal molar amount of SO_3 for promoting the formation of yeelimite and belite is an increase or decrease of 0.1% mol. Additionally, dopants such as N_2O and B_2O_3 act as catalysts in the formation of alpha'L belite, a highly reactive phase compared to conventional belite. This enhanced reactivity contributes to faster cement setting, higher early compressive strength, and improved chemical resistance, which are key properties that enhance the performance of BCSA cement for various applications.

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REFFERENCE

- Adam Sabbah*, Semion Zhutovsky,Effect of sulfate content and synthesis conditions on phase composition of belite-ye'elimite-ferrite (BYF) clinker 0008-8846/© 2022 Elsevier Ltd
, - Wang, G.; Huang, X.;Wu, Y.; Zhang, Q.; Ma, S.; Li, W.Hydration and Properties of Cementin the Belite- Ye'elimiteTernesiteSystem. Materials 2022, 15,2792.https://doi.org/10.3390/ma15082792