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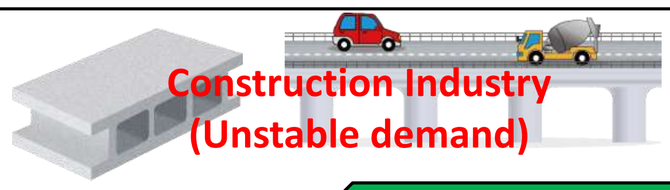
Synthesis of Hydrogrossular and Hydroxysodalite from Blast Furnace Slag using Alkali Fusion for Fixation of HCl Gas

T. Wajima and T. Takahashi
Department of Urban Environment Systems, Chiba University
1-33, Yayoi-cho, Inage-ku, Chiba 263-8522, Japan

Introduction

Blast furnace slag (290 kg/t-pig iron)

Now

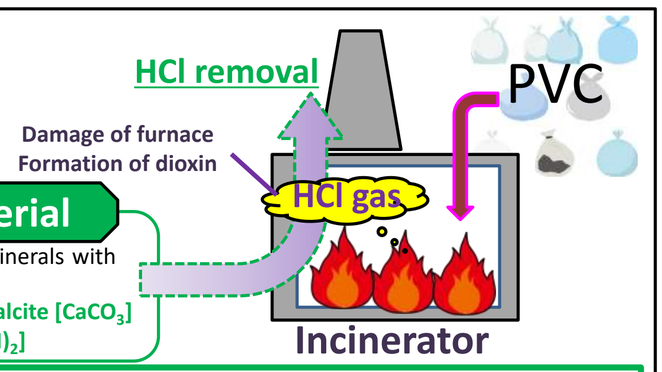


Construction Industry (Unstable demand)

New utilization

HCl fixation material

Slag can be converted into the minerals with Cl fixation ability;
Katoite [$Ca_3Al_2(SiO_4)_{0.8}(OH)_{8.8}$], Calcite [$CaCO_3$]
Hydroxysodalite [$Na_8Al_6Si_6O_{24}(OH)_2$]



In this study

The product including hydrogrosslar and hydroxysodalite was tried to synthesized from BF slag using alkali fusion with addition of Al content to improve the HCl fixation ability. The mineral phases in the product with addition of Al content was investigated, and the fixation ability of each product for HCl gas at high temperature was examined.

Experimental

Blast furnace slag

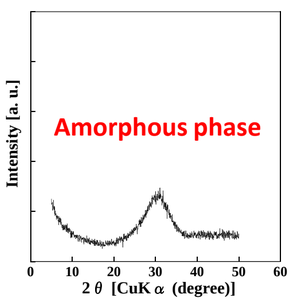


Fig. XRD patterns of raw slag.

Table Chemical composition of raw slag.

	Content (%)
CaO	57.0
SiO_2	25.8
Al_2O_3	9.4
MgO	2.6
Fe_2O_3	0.8
P_2O_5	0.5
SO_3	1.6

NaOH

Slag/NaOH=5/8

Alkali fusion

Electric furnace

Heating temperature: 600°C
Heating time: 6 hours

$Al(OH)_3$

Fused Slag/$Al(OH)_3$ = 2.5/ 0-0.5

Hydrothermal synthesis

Heating temperature: 120°C
Heating time: 24 hours

Products

Cl removal test

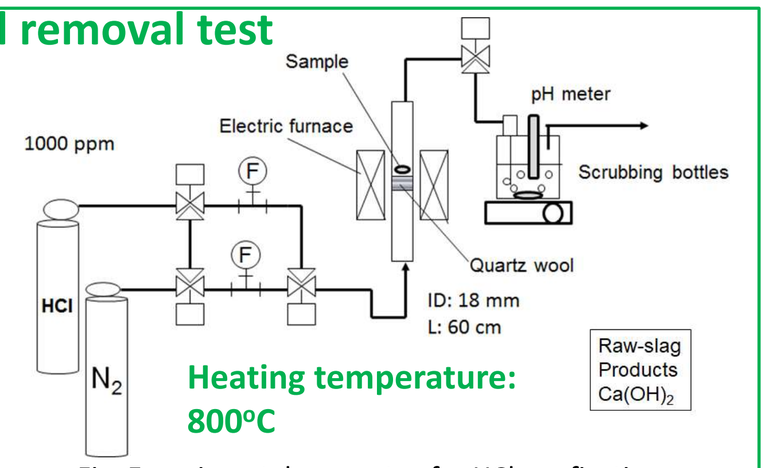


Fig. Experimental apparatus for HCl gas fixation.

Mineral phase change | **Cl elution test**

Results

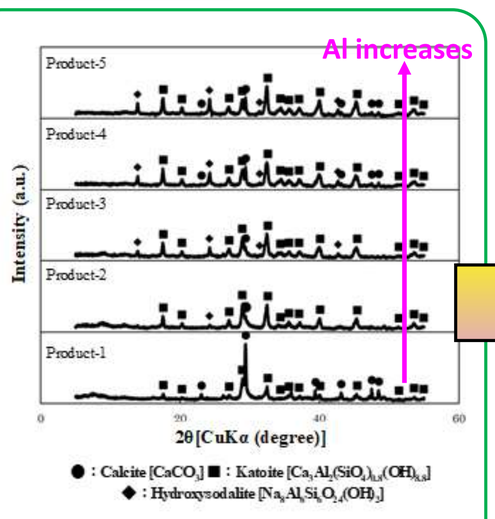


Fig. XRD patterns of the products.

Table. Mineral phases of the products.

	$Al(OH)_3$/Fused slag	Mineral phases
Product-1	0	Cal. Kat.
Product-2	0.05	Cal. Kat.
Product-3	0.1	Cal. Kat. HS.
Product-4	0.15	Cal. Kat. HS.
Product-5	0.2	Cal. Kat. HS.

Cal.:Calcite, Kat.: Katoite, HS.: Hydroxysodalite

All mineral phases in the obtained products have HCl gas removal ability at high temperature.

HCl removal test

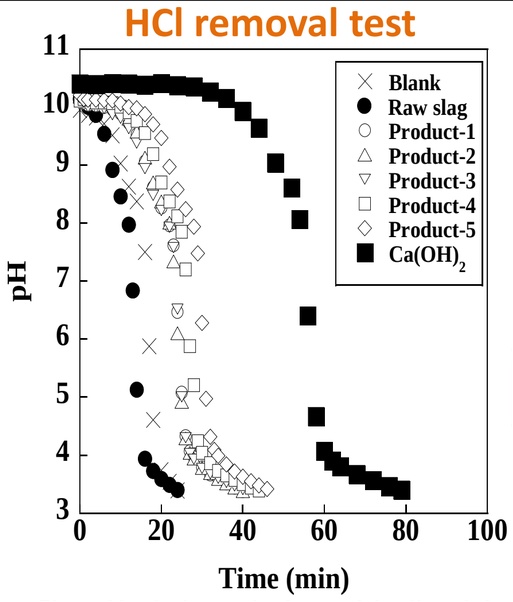


Fig. pH of the solution with dissolving HCl gas after passing through raw slag, $Ca(OH)_2$ and the product.

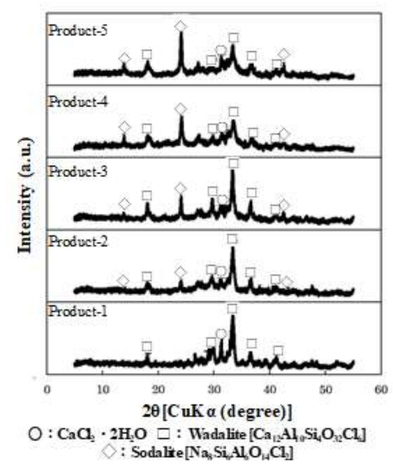


Fig. XRD patterns of the products after HCl removal test.

Wadalite [$Ca_{12}Al_{10}Si_4O_{32}Cl_6$]
Sodalite [$Na_8Al_6Si_6O_{24}Cl_2$]
$CaCl_2 \cdot 2H_2O$

Cl fixation!

Table. Cl content in the product before and after HCl removal test.

	Cl content (mg/g)					
	Product-1	Product-2	Product-3	Product-4	Product-5	$Ca(OH)_2$
Before test	0.9	0.8	0.9	0.8	0.7	0.1
After test	35.9	39.8	34.7	28.1	29.4	219.0

Table. Soluble Cl content in the product before and after HCl removal test.

	Soluble Cl content (mg/g)					
	Product-1	Product-2	Product-3	Product-4	Product-5	$Ca(OH)_2$
Before test	0.9	0.8	0.8	0.8	0.7	0.1
After test	3.1	3.0	3.2	3.5	3.6	219.0

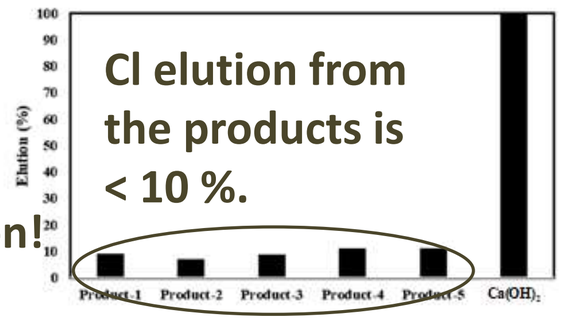


Fig. Elution percentage of Cl content from the products and $Ca(OH)_2$ after HCl removal test.

$5Ca_3Al_2(SiO_4)_{0.8}(OH)_{8.8} + 12HCl \rightarrow Ca_{12}Al_{10}Si_4O_{32}Cl_6 + 3CaCl_2 + 28H_2O$
$Na_8Al_6Si_6O_{24}(OH)_2 + 2HCl \rightarrow Na_8Al_6Si_6O_{24}Cl_2 + 2H_2O$
$CaCO_3 \rightarrow CaO + CO_2$
$CaO + 2HCl \rightarrow CaCl_2 + H_2O$

Conclusion

The chemical conversion of the BF slag to a scavenger including hydrogrossular and hydroxysodalite through alkali fusion was performed. The slag was transformed to a precursor with reactive phases by alkali fusion, the fused slag was mixed with $Al(OH)_3$ powder to put into distilled water, and the product was synthesized by heating at 120 oC for 24 h. The product including katoite, hydroxysodalite and calcite was synthesized, and can remove HCl at high temperature and showed lower solubility of Cl after the HCl removal compared to lime [$Ca(OH)_2$]. These results suggest that the product can be applied for the HCl gas removal from a high-temperature effluent gas and be reclaimed or used for cement production after the HCl removal.