Synthesis and Characterization of Glass-ceramics From Magnetic Separation Tailings of Ferrochromium Slag

Mei Zhang, Zhitao Bai, Min Guo, Fuming Wang

University of Science and Technology Beijing

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Part 1 Background

1 Background

High carbon ferrochromium slag (HCFS) is a by-product from the production of ferrochromium. Producing one ton of high carbon ferrochromium can generate 1.3-1.7 tons ferrochromium slag.

Production of high carbon ferrochrome

High carbon ferrochrome slag

1 Background

Present situation

HCFS is not only the hazardous waste, but also the secondary resources.

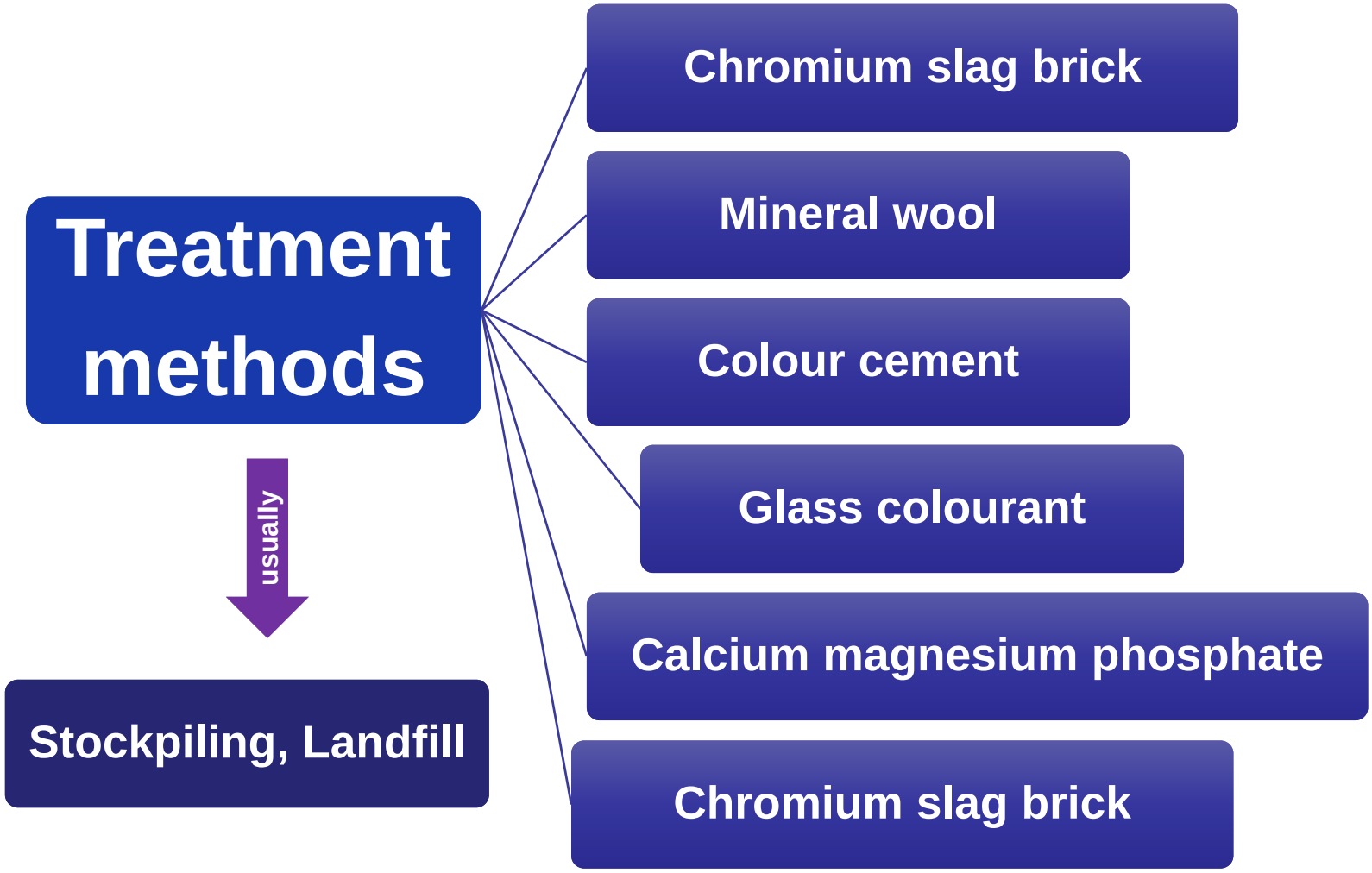
Soluble chromate in the slag

Affect → Growth of plants and animals

Damage → Ecological environment

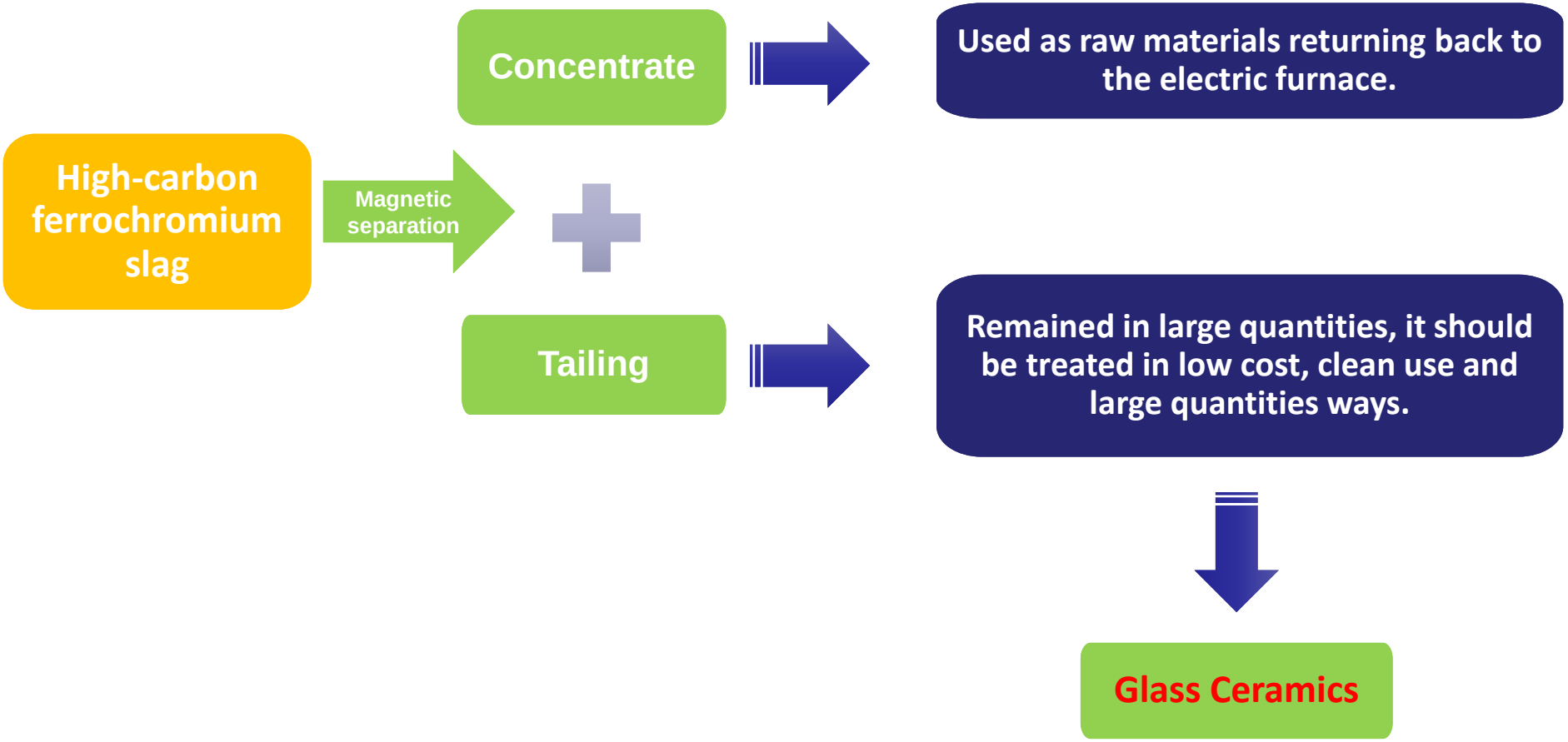
Shortage of chromium resources in China

1 Background



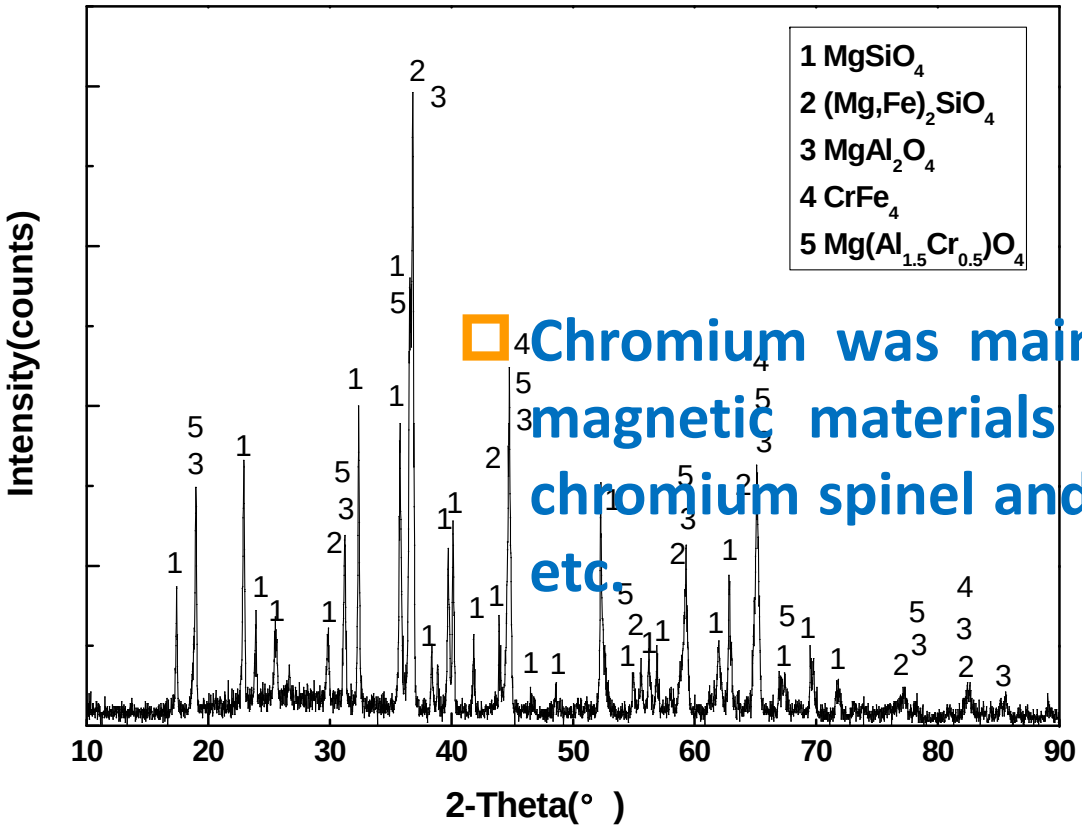
1 Background

New conception



Part 2 Experiment

2 Experiment | Materials



XRD patterns of HCFS

- Chromium was mainly existed in magnetic materials such as iron chromium spinel and ferrochrome etc.

2 Experiment | Materials

Materials

After the magnetic separation, the tailing were obtained using as raw materials.

Chemical characterization of raw materials (wt %).

Raw Materials	SiO_2	MgO	Al_2O_3	CaO	Na_2O	Cr_2O_3	Fe_2O_3	K_2O	CaF_2
Tailing	31.89	33.61	24.5	1.99		5.15		0.11	
WG	75.68	3.40	0.94	8.95	9.73	0.024	0.27	0.68	

2 Experiment | Materials

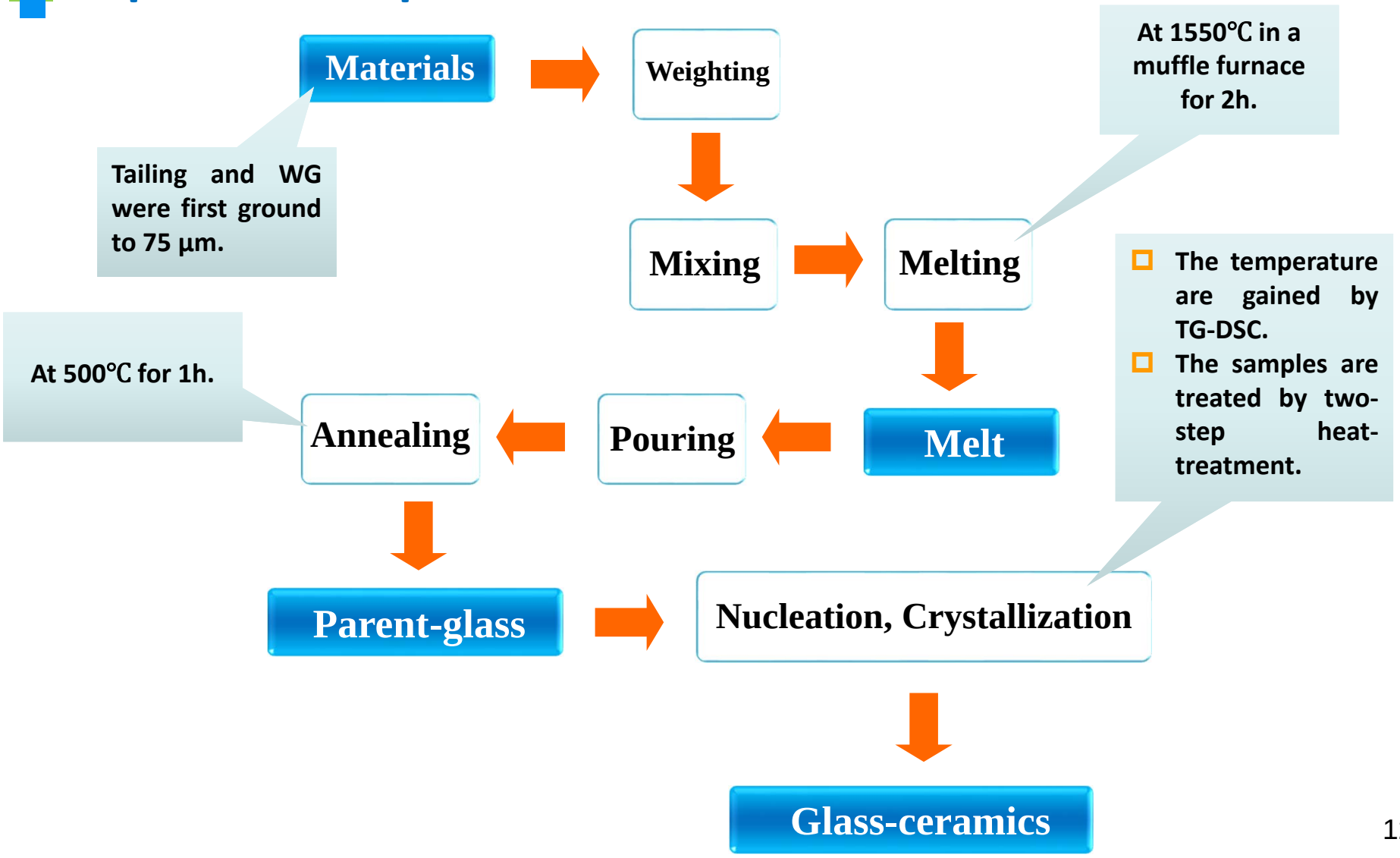
- Waste glass (WG) was selected for the composition adjustment,
- limestone and soda (≤ 75μm) were used as the fining agent,
- fluorite (≤ 75μm) was added as the flux.

Compositions of the samples (mass/g).

Sample NO.	Tailing	Waste glass (WG)	$CaCO_3$	Na_2CO_3	CaF_2(extra addition)	Mass ratio of tailing and WG, R(T/W)
1#	30.0	50.0	15.0	5.0	5.26	0.60
2#	35.0	45.0	15.0	5.0	5.26	0.78
3#	40.0	40.0	15.0	5.0	5.26	1.00
4#	45.0	35.0	15.0	5.0	5.26	1.29
5#	50.0	30.0	15.0	5.0	5.26	1.67

2 Experiment | Method

Experimental procedures



Part 3

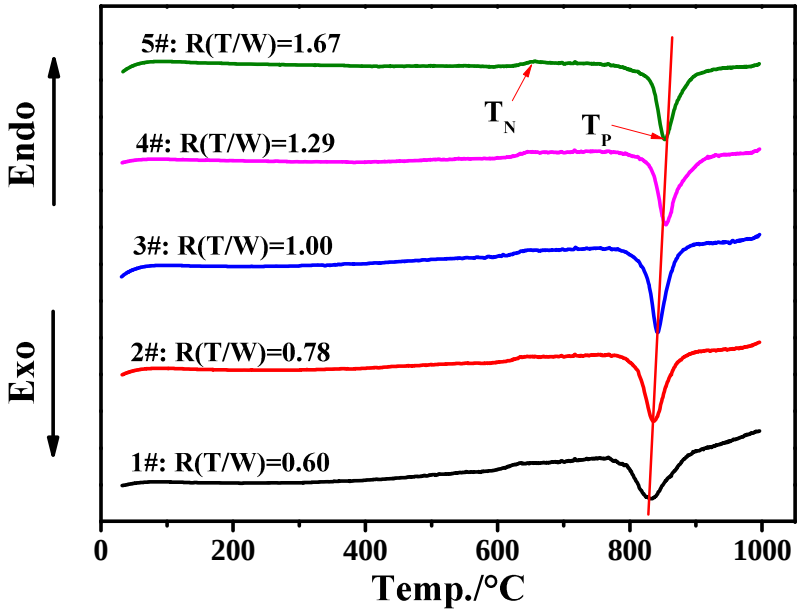
Results and Discussions

- TG-DSC Analysis
- Phase characterization
- Microstructure analysis
- Leaching performance

3 Results and Discussion

TG-DSC Analysis

The nucleation temperatures (Tn) and crystallization temperatures (Tg) were detected using Differential Scanning Calorimetry (DSC, NETZSCH-STA409).



The DSC curves of samples

Nucleation and crystallization temperature of the samples.

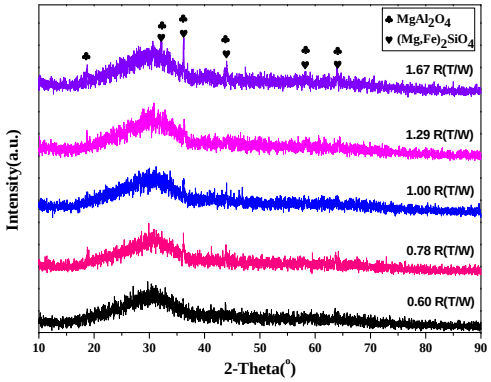
R(T/W)	0.60	0.78	1.00	1.29	1.67
Nucleation temperature/℃	640	648	652	656	663
Crystallization temperature/℃	865	868	873	878	882

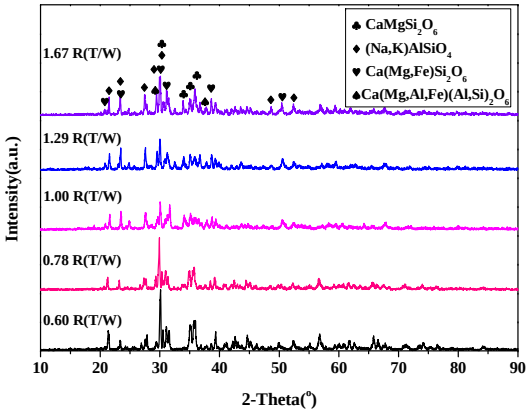
3 Results and Discussion

XRD Analysis

Parent glass

Glass-ceramics



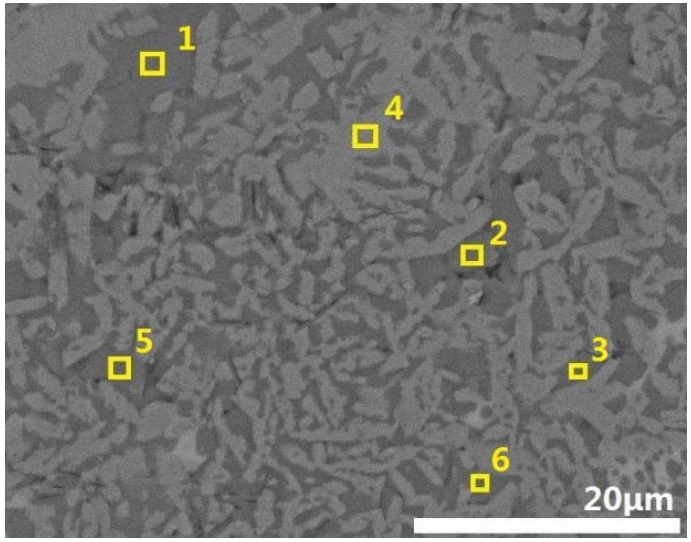


The photo of the samples and the corresponding XRD

- Main phases of the glass-ceramics were diopside ($CaMg(SiO_3)_2$), nepheline ($(Na,K)AlSiO_4$), pyroxene ($Ca(Mg,Fe)Si_2O_6$, and $Ca(Mg,Al,Fe)(Al,Si)_2O_6$), respectively.

3 Results and Discussion

Microstructure



The microstructures of the samples.

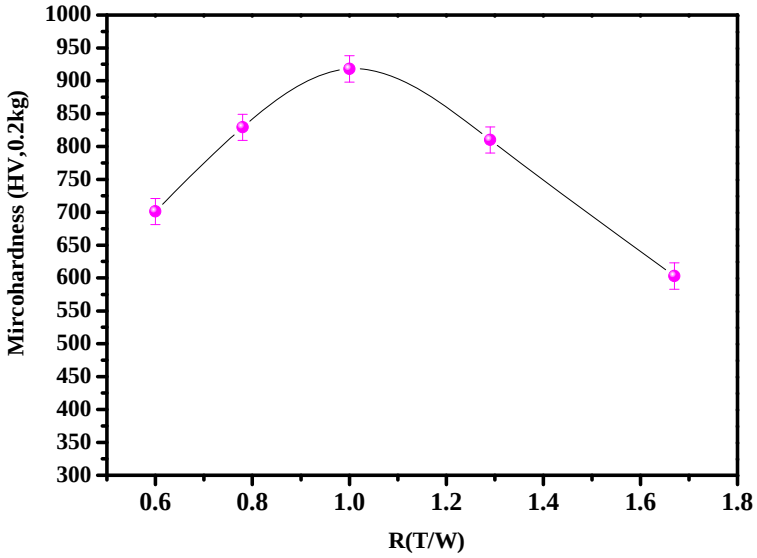
- Gray: nepheline
- White: diopside

EDS analysis of the samples.

Point NO.		Element norm. C (wt %)							
		O	Mg	Al	Ca	Na	Cr	Fe	Si
1	Gray	38.76	4.04	14.93	3.43	19.07			19.97
2		39.31	4.38	16.35	2.08	19.54			18.24
3		37.42	4.67	14.74	4.38	18.14			18.56
4	White	36.53	11.54	4.83	21.90	1.90	0.80	1.26	22.20
5		38.40	11.10	4.67	21.03	2.15	0.75	1.14	23.26
6		38.35	11.30	4.45	21.70	1.19	0.61	1.27	24.63

3 Results and Discussion

Mechanical properties

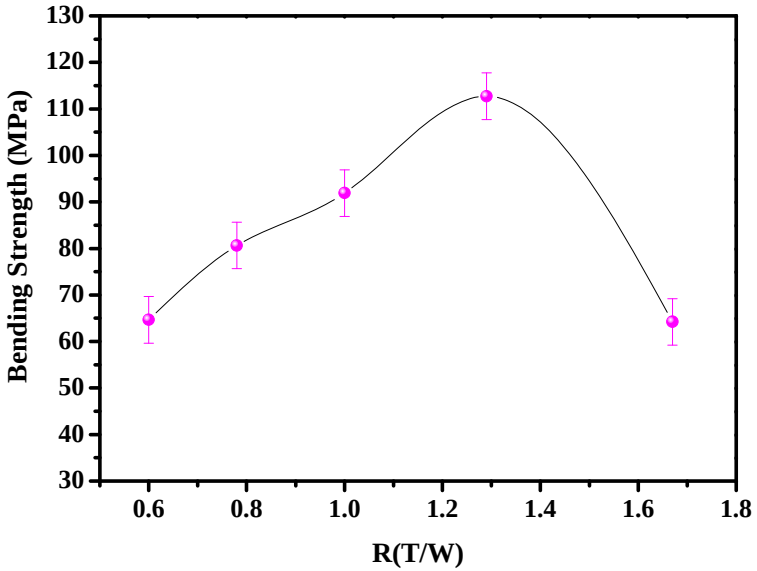


The micro-hardness results of the samples.

- R(T/W)↑, Microhardness↑↓.
- R(T/W)=1.00, MAX=9188MPa, it is higher than other glass-ceramics made from metallurgical slags whose microhardness are about 7000MPa.

3 Results and Discussion

Mechanical properties



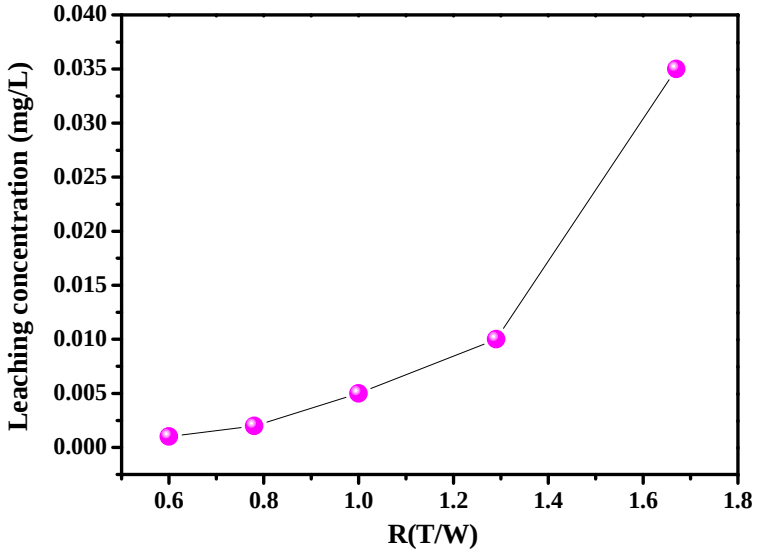
The bending test results of the samples.

- R(T/W)↑, bending strength ↑↓.
- R(T/W)=1.29, MAX=112MPa.

3 Results and Discussion

Leaching test

The leaching performance of the glass-ceramics was tested by the toxicity characteristic leaching procedure (TCLP) developed by the U.S. Environmental Protection Agency (EPA).



The leaching test results of the samples.

- When R(H/W)=1.67, MAX=0.257 mg/L.
- It is far lower than the international standard of toxic emission of chromium (5.0mg/L).
- The glass-ceramics are environmental friend.

Part 4 Summary

4 Summary

- Glass-ceramics have been prepared from the magnetic separation tailings of high ferrochromium slag.
- With the increase in R(T/W), the nucleation and crystallization temperature increases.
- The microhardness and bending strength increase with the increase in R(T/W), whereas when the value of R(T/W) beyond 1.29, the bending strength begins to decrease.
- The optimal bending strength and microhardness of HCFT-based glass-ceramics are 112 MPa and 9188 MPa, respectively.
- The maximum leaching concentration of total chromium ions is 0.257 mg/L, which is far lower than the international standard of toxic emission of chromium.

➢ **The utilization of high-carbon ferrochromium slag developed in this work not only has important theoretical and practical significance considering from energy saving, emission reduction and environmental protection, but also provides a new idea for the clean utilization of other heavy toxic metallurgical slags.**

Thanks For Your Attentions!