WP1

„Research on the utilization of the slags“

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EVROPSKÁ UNIE
Evropské strukturální a investiční fondy
Operační program Výzkum, vývoj a vzdělávání

MINISTERSTVO ŠKOLSTVÍ, MLÁDEŽE A TĚLOVÝCHOVY

2019 – 2022
Smart Metallurgical Waste Management

Main objective of WP1:

Increasing of the material utilization of the slags from both qualitative and quantitative point of view.

Tasks:

1. Characterization of the slags and classification of their properties.
2. Selection of the slags suitable for metallurgical recycling and performing of the recycling tests.
3. Selection of the slags suitable for the utilization as the inorganic binders and performing of the relevant tests indicating the potential of the slags for their utilization in the building industry.
4. Study of the reasons for volume instability of the slags.
5. Verification of the practical potential of the proposed concepts.

Types of the slags:

Blast furnace slags

BFS1

BFS2

Furnace slags

FS1

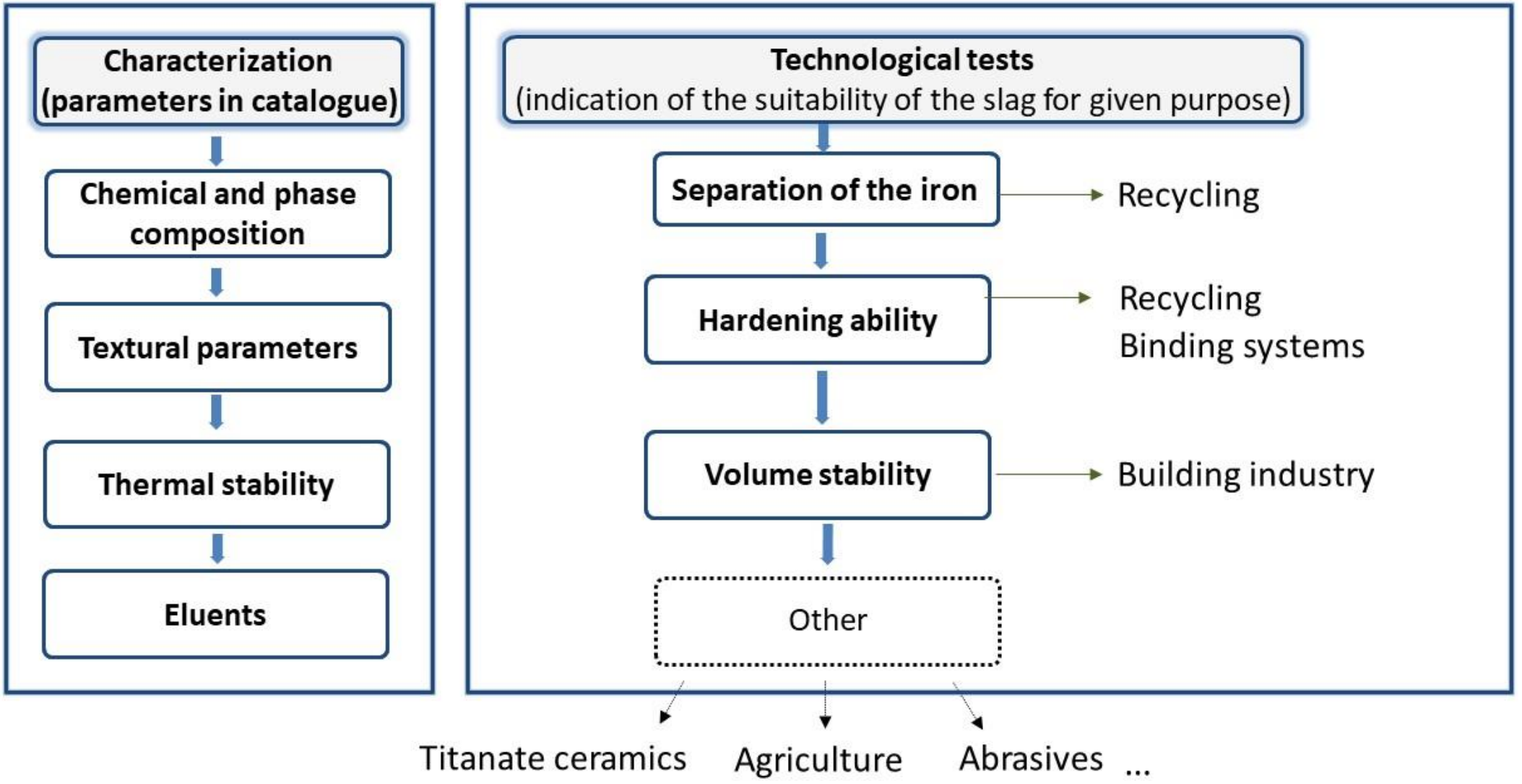
FS2

Ladle slags

LS1

LS2

Tests:


Characterization (parameters in catalogue)
Chemical and phase composition
Textural parameters
Thermal stability
Eluents
Technological tests (indication of the suitability of the slag for given purpose)
Separation of the iron
Recycling
Hardening ability
Recycling
Binding systems
Volume stability
Building industry
Other
Titanate ceramics
Agriculture
Abrasives
...

Chemical composition of the slags (XRFS)

Slag	CaO	SiO_2	Al_2O_3	MgO	Fe_2O_3	MnO	CaO(free)	ρ ($g*cm^{-3}$)
BFS1	41.54	37.54	7.12	0.6	0.24	0.6	< 0.01	2.94
BFS2	38.2	40.42	9.24	8.57	0.31	0.66	< 0.01	2.94
FS1	31.7	14.4	2.68	5.27	36.7	5.7	2.05	3.65
FS2	37.23	10.32	1.8	8.71	34.0	4.47	4.55	3.83
LS1	48.9	11.1	21.7	4.9	2.13	1.23	0.96	2.86
LS2	44.17	17.84	10.15	7.82	7.2	1.32	0.99	2.95

Alkali activation

Volume stability

Recycling of iron

Activation with water

Chemical composition of the eluents from the slags

Slag	Al	Na	K	Mg	Ca	Si	Cr	Fe	pH
	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	µg/l	µg/l	
BFS1	0.98	3.15	6.1	0.154	96	25	< 150	< 100	8.77
BFS2	0.954	4.67	4.66	0.29	114	19.3	< 30	70	10.9
FS1	0.63	7.7	12.8	0.073	674	2.53	< 150	160	8.87
FS2	<0.100	3.70	2.73	0.031	1010	0.560	< 30	<50.0	10.8
LS1	222	48	11.7	0.024	261	4.51	< 150	193	9.75
LS2	51.7	35.2	7.24	<0,02	233	0.980	< 30	<50.0	10.6

CaO(free)

36% Fe_2O_3

2% Fe_2O_3

Recycling of magnetic part:

Dry sample

Original sample

Milled sample

Water suspension

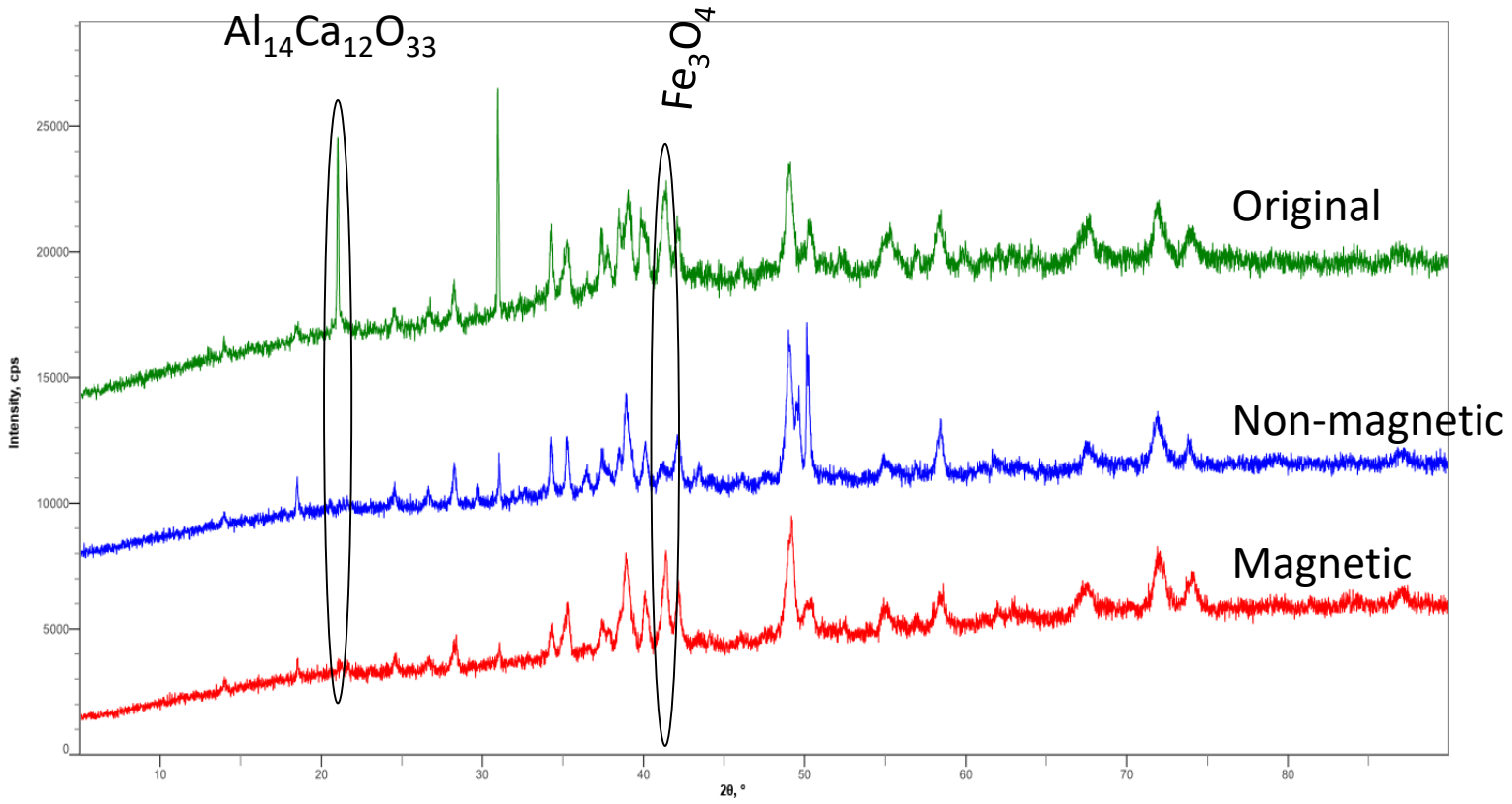
Milled sample

Separated fraction

Sample	Original sample (%)	Milled sample (%)	Milled sample in water(%)
FS1	78	100	65
FS2	18	100	37

Importance of the particle size, disintegration

Comparison of the original, non-magnetic and magnetic part



Plan:

- Repeating the tests with higher amount of the slags
- Detail characterization of the magnetic and non-magnetic fractions
- Searching of the other methods of the separation of iron based components

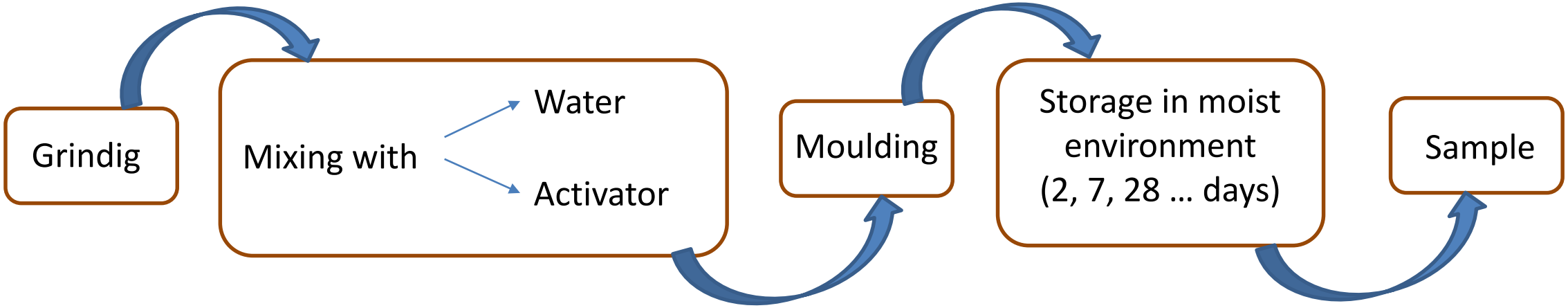
Binding properties of the slags:

Compaction
Recycling - pellets, briquettes

- Hydration with water
- Activation with suitable activator (CaO)

Alternative inorganic binder
Building industry

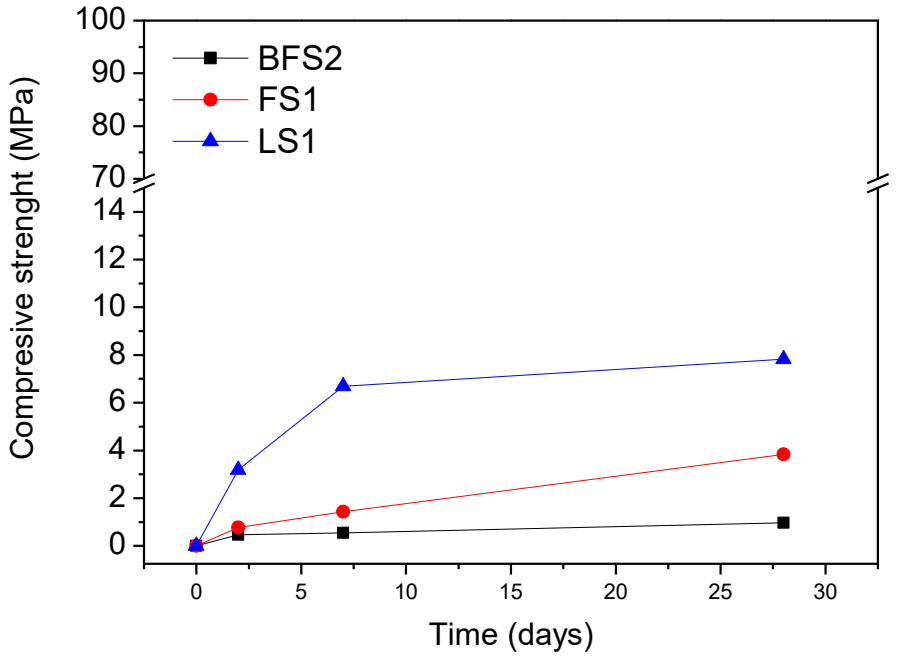
- Alkali activation with water glass
- Alkali activation with alternative activator



Measured parameter … development of the compressive strength

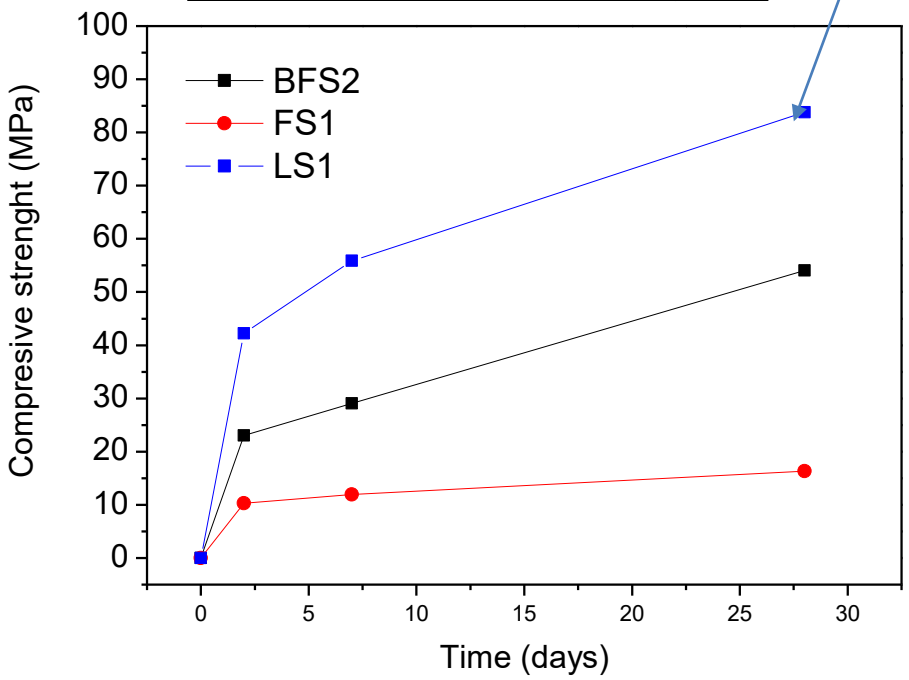
Development of the compressive strength

Activation with water



Activation with water glass

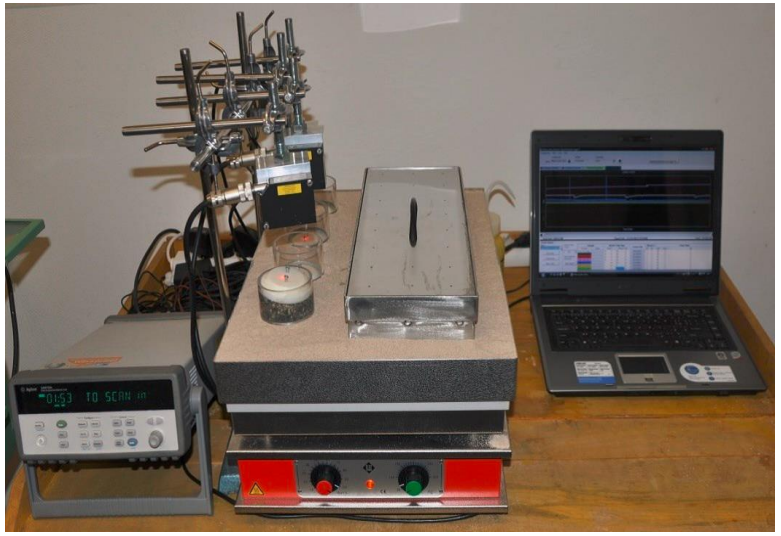
Higher than OPC



Plan:

- Focus on the ladle slags
- Stability in a water
- Thermal stability

Volume stability:



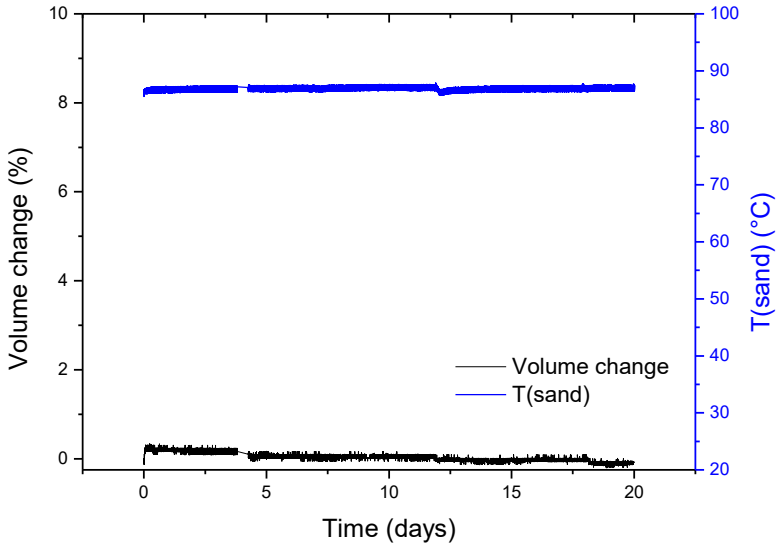
Sieved, size fraction 1 – 3mm

Conditions - sand temperature 80°C

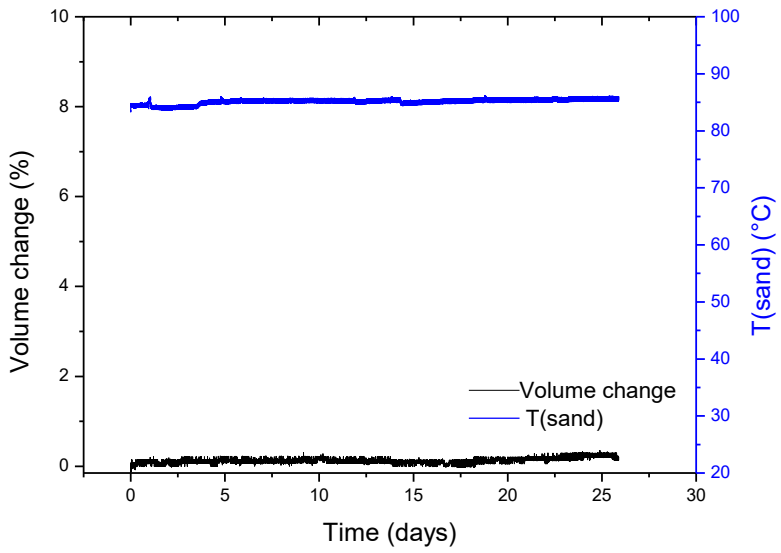
Automatic data registration

↑ Volume

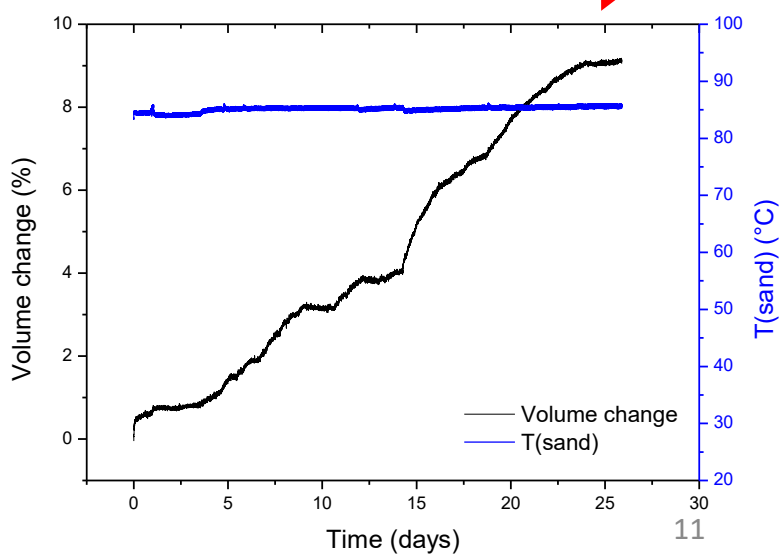
BFS1



FS1

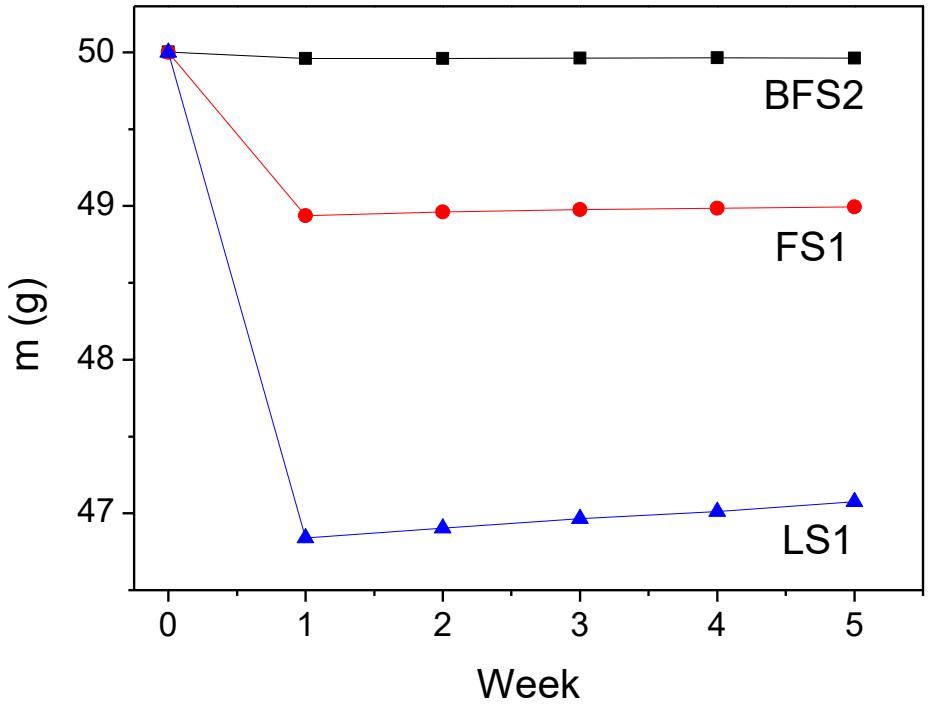


LS1



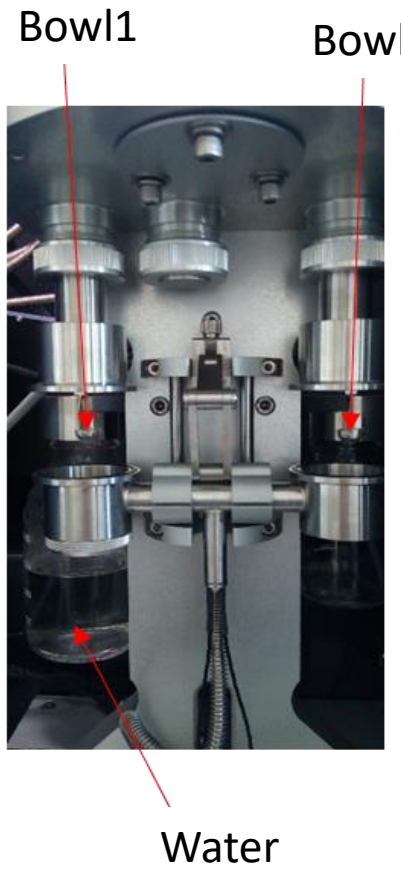
Moisture sorption:

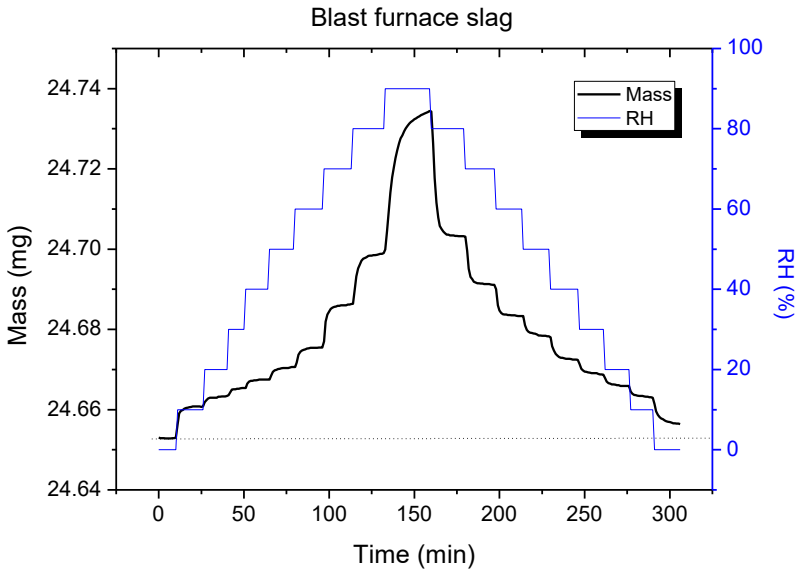
Sample: 50g, as received
Conditions: 20°C, 50% RH

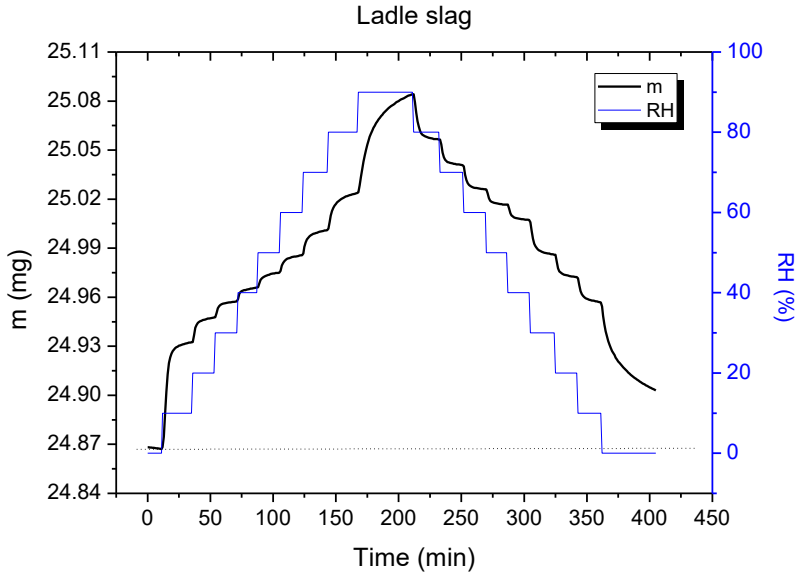


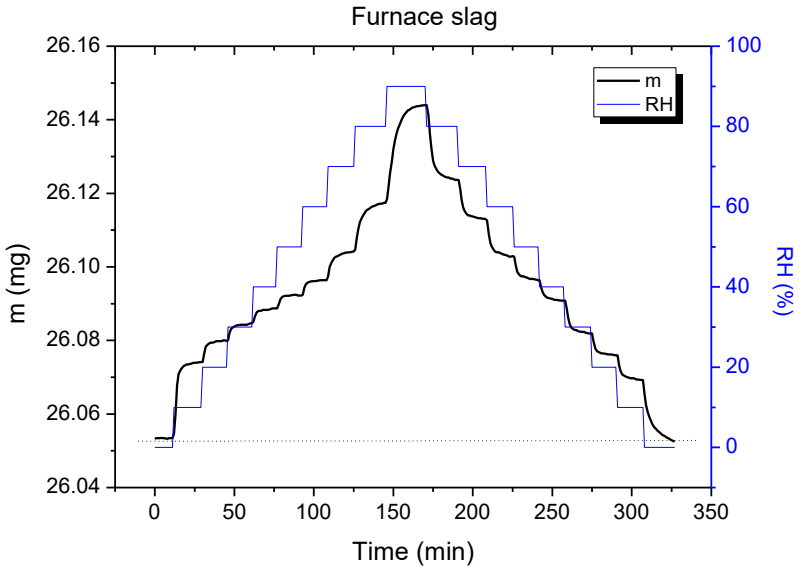
Water sorption – DVS measurement

Sample: 20mg, milled < 0.1 mm
Conditions: 25°C, 0 – 90 %RH









Plan:

- Tests at higher temperatures
- Tests of stability in water
- Characterization of the samples after the test

Agriculture:

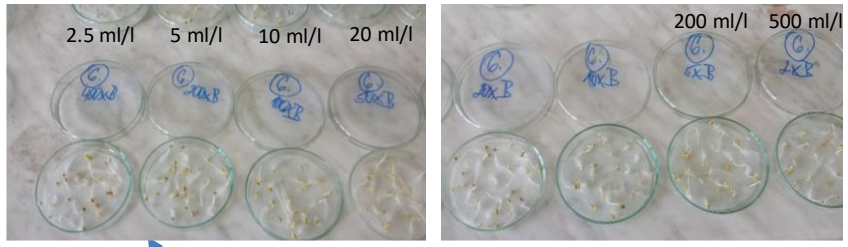
Slag fractions < 0.1mm and < 4mm

↓

Aqueous leachates 1:10 (slag/water)

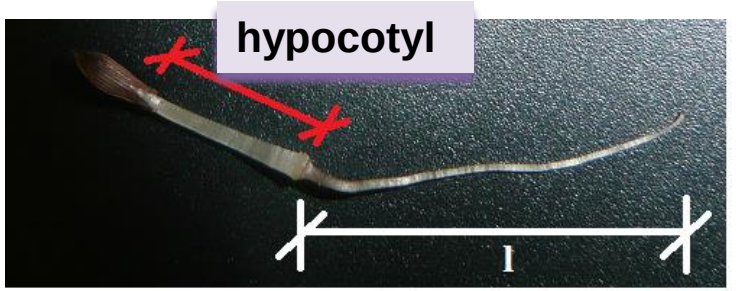
↓

Growing of of the roots of white mustard seeds



20 seeds of white mustard,
Filtration paper, 5ml of eluents

72 h., 20±2 °C, dark



***l*-lenght of the root**

Results

Sample	Effect
$BFS2_{<0,1\ mm}$	S
$FS1_{<0,1\ mm}$	44.67
$LS1_{<0,1\ mm}$	S
$BFS2_{<4\ mm}$	S
$FS1_{<4\ mm}$	5.39
$LS1_{<4\ mm}$	S

S … stimulation

Titanate ceramic:

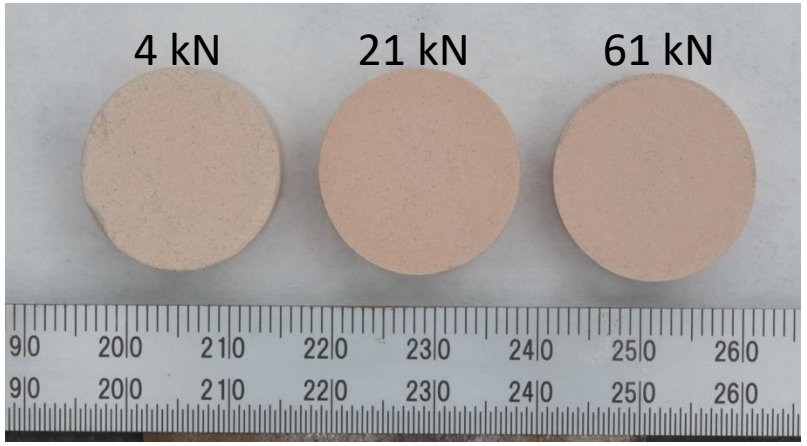
A.V. Gorokhovsky, J.I. Escalante-Garcia, E. Sanchez-Valdes, I.N. Burmistrov, D.V. Kuznetsov. Synthesis and characterization of high-strength ceramic composites in the system of potassium titanate – Metallurgical slag. *Ceramics International*, Volume 41, Issue 10, Part A, 2015, Pages 13294-13303.

Slag from the Si-Mn production

	Content of the oxide (wt%)								
Slag no	Na_2O	K_2O	CaO	MgO	MnO	Al_2O_3	Fe_2O_3	SiO_2	SO_3
No 1	0.7	0.6	18.6	12.8	15.0	8.1	2.0	40.2	2.0
No 2	0.4	2.4	12.5	10.0	18.8	10.5	1.8	41.8	1.8

\+ Polytitanates → High strenght ceramics
Compressive strength - 1000 MPa

BFS + Titanates —Temp.→



Plan:

- Characterization
- Sintering at higher temperatures
- Tests with ladle slags

Thank you for your attention

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