Innovation & Technology

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Geopolymer Camp

Alternative applications of geopolymers in the environmental industry

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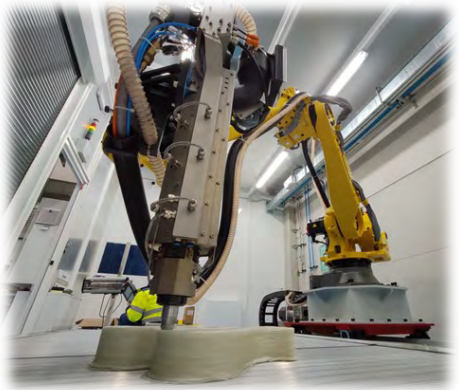
Testing & Analysis | **Industrial Services** | **R&D&i**

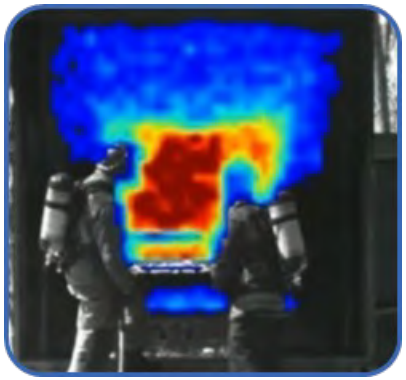
690	6	+750	280	15,6 M€	292.435
R&D&i Projects In the last 10 years	Active Patents As of 31/12/2020	Clients Annual average In the last 5 years	Employees 39 PhDs 61% men 39% women	Anual Income 2019	Technical Reports As of 31/12/2020

Experts in

- Laser technologies
- Industrial robotics and 3D printing
- Environmental approaches
- **Advanced materials**



Geopolymer research line



Geopolymer in AIMEN

2015 … 2023 ……

Environmental applications:

Management of radioactive wastes

Adsorption in wastewater treatments

Geopolymer in AIMEN

Construction applications:

Precast panels

Insulation

Drainage

Small buildings

High temperature resistant geopolymers

Future: Geopolymer 3D Printing

Electrically conductive geopolymers

Introduction:

Organic Liquids cementation

- ❑ **OPC:** Organic liquids affects hydration reactions and phase separation occurs.
- ❑ **Geopolymers:** Their reaction is not affected by the nature of the O.L.

METAKAOLIN-BASED GEOPOLYMER

Parameters:

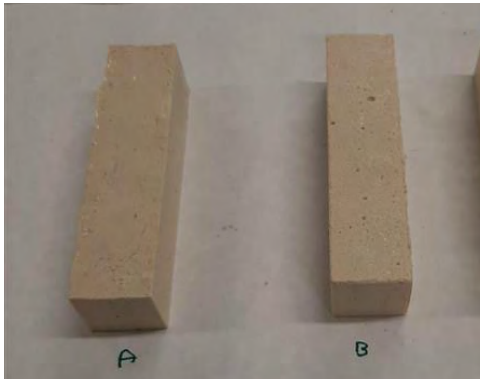
- **Incorporation methods**: Direct and pre-emulsión
- **O.L**. : engine oil and scintillation cocktail.
- **Activators**: Na and K silicates.
- **Curing treatmeants**: Ambient or heat.

Goals:

- Compressive strength>10MPa
- O.L. Immobilization > 30% v/v without bleeding and leaching

Management of radioactive wastes

Results:



Bleeding or phase separation

O.L addition:
↓ strength

O.L. wt%	Compressive strength/MPa
0	41,6
	45
10	36,8
	38,7
20	22,6
	22,9
25	17,4
	18,9
30	9,8
	8,7

DIRECT vs PRE-EMULSION:
Pre-emulsion↑ bleeding

Preparation	Curing	Bleeding	Mean
DIRECT	Room temperature	1,68%	1,20%
		0,85%	
	heat	2,99%	3,05%
		3,12%	
PRE-EMULSION	Room temperature	6,78%	4,46%
		2,93%	
	heat	Very high!	

Curing treatments:
Heat: ↓ strength ↑ bleeding

Nomenclature	Curing	Flexural strength/Mpa	Compression strength/Mpa
Pre30AmbA	ambient	1,9	9,7
Pre30AmbB		1,7	10,5
Pre3080A	80 °C 2h	1,6	6,7
Pre3080B		2	6,7

Leaching tests:

Control sample

Sample	Days	HCO3- (ppm)	OC mgC/L	TC	IC
0% waste	3	605	4	123	119
	7	294	0	61	58
	14	97	0	19	19
	21	10	0	2	2
	28	11	0	2	2

Oil

Samples	Days	HCO3- (ppm)	OC mgC/L	TC	IC
OIL-30%	3	737	12,4	158	145
	7	219	0	43	43
	14	49	0	10	10
	21	24	0	5	5
	28	16	0	3	3
	35	35	0	7	7
	42	23	0	5	5
	70	37	0	7	7

Oil-40%	3	416	1,2	83	82
	7	165	0	33	33
	14	5	0	1	1
	21	63	0	12	12
	28	30	0	6	6
	35	14	0	3	3
	42	6	0	1	1
	70	3	0	1	1

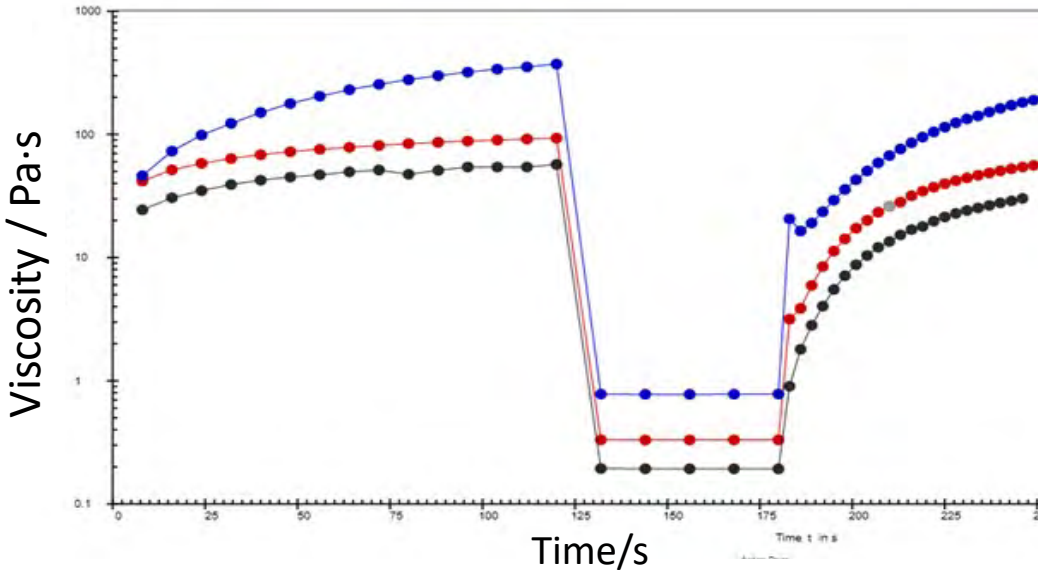
Scintillation cocktail

Sample	Days	HCO3- (ppm)	OC mgC/L	TC	IC
Scintillation cocktail 30%	3	214	37	79	42
	7	1306	96	352	257
	14	105	29	50	21
	21	50	23	33	10
	28	29	21	27	6
Scintillation cocktail 20%	3	147	35	64	29
	7	178	31	66	35
	14	259	29	80	51
Scintillation cocktail 10%	3	275	29	83	54
	7	158	24	55	31
	14	122	21	45	24

Rheology:

3-INTERVAL TEST

Low shear rate / High shear rate / Low shear rate



Black 0%, red 20% and blue 40%

Best results

(without bleeding or leaching)

- 38% v/v of oil obtaining 18MPa with Na activator.
- 40% v/v of oil obtaing 14MPa with K activator.

↑ % O.L. ↑ viscosity

Dynamic viscosity (mixer):

- **40%=0,72 Pa·s,**
- **20%=0,32 Pa·s**
- **0%=0,18 Pa·s**

Static viscosity (after mixing):

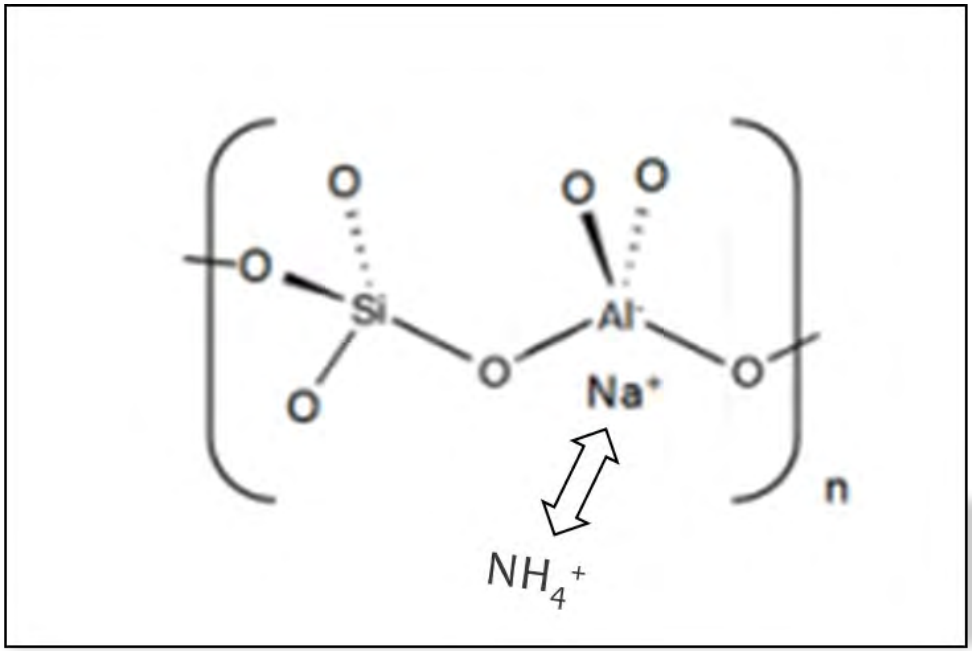
- **40% = 431,2 Pa·s**
- **20%= 93,3 Pa·s**
- **0%= 57,05 Pa·s**

Recovery of viscosity (after 30sec)

- **40% = 18%**
- **20%= 27%**
- **0%= 26%**

Introduction:

Ammonium: NH_4^+
Eutrophication



Geopolymer good adsorbent:

- **Chemistry structure:** sodium cations easily exchangable.
- **Easily modified** to increase porosity.
- **Sustainable and low operational cost adsorbent**.

Ionic Exchange process

Adsorption in wastewater treatmeants

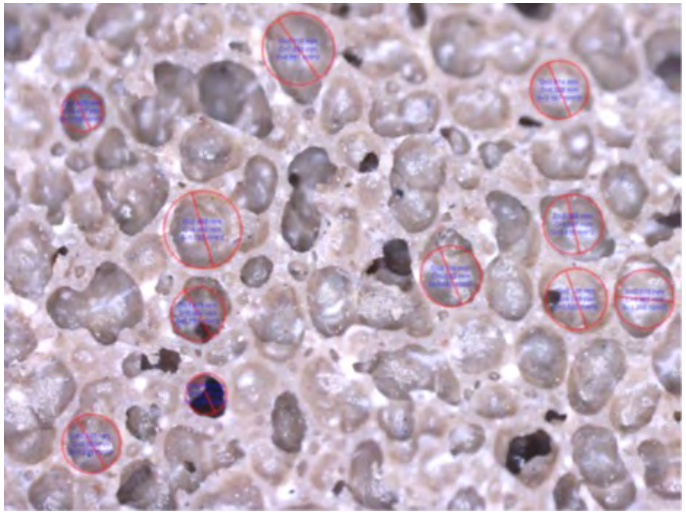
Promising adsorbent formulation:

Parameters	Units	Values
SiO_2/Al_2O_3	Molar ratio	1,5
SS/NaOH	Molar ratio	1,2
NaOH	Molarity	10
Granite waste	%Substitution	20
H_2O_2	%	1
Hardening time	Hours	24
Curing temperature	°C	25

Metakaolin-based porous geopolymer
20% of granite waste (GW)
1% H_2O_2 foaming agent

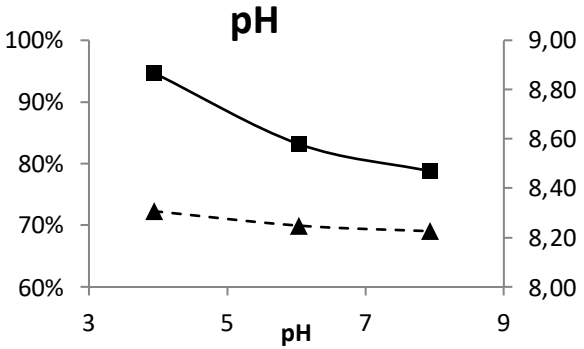
$$H_2O_2 + OH^- \rightarrow HO_2^- + H_2O$$
$$HO_2^- + H_2O_2 \rightarrow H_2O + O_2 + OH^-$$

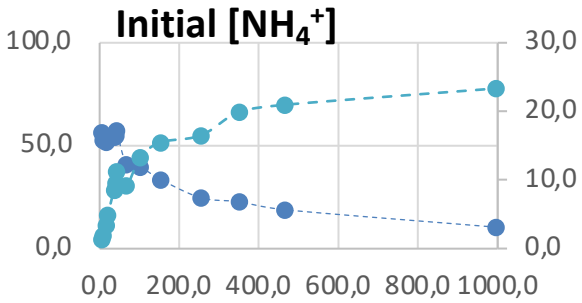
6,1MPa compressive strength
58,99% porosity

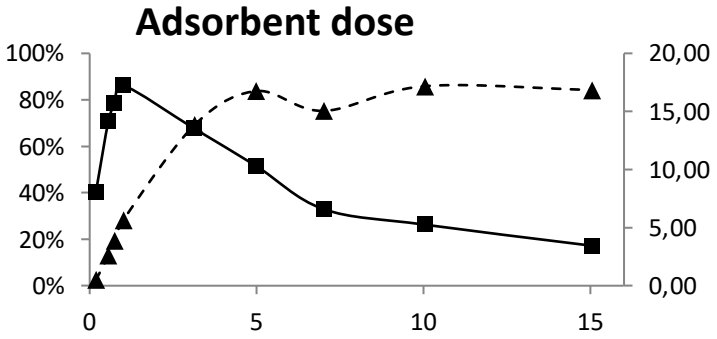


Adsorption in wastewater treatmeants

Batch tests



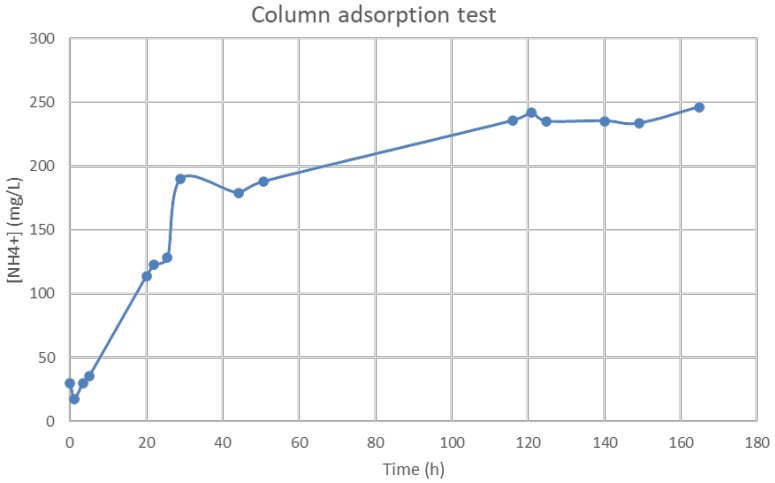




Q_m = 23mg/g

highest removal: 5g/L and pH=4

Continous tests:



First hours: 93% ammonium removal

One day: 50% ammonium removal

120h: saturation

Adsorption in wastewater treatmeants

125L cylinder geopolymer (Container)

125L grave geopolymer (Wetland)

Pilot plant (Xiloga Landfill, Galicia-Spain)

Results

Monitoring for 1 day every hour.

	Tank	Container (cylinder)	Wetland (grave)
pH	12,2	11,6	13,3
EC (mS/cm)	22,5	11,7	60,4
NH_4^+ (mg/L)	91	59	17

Total removal: 80%
Slightly superior to zeolites

High electrical conductivity
High pH due to alkalis leaching

Adsorption in wastewater treatmeants

Summary

Geopolymer as radioactive waste immobilizer:

- ❑ Direct method and ambient curing best techniques
- ❑ Scintillation cocktail was leached more than oil.

Best results:

- ❑ 38% v/v of oil obtaining 18MPa with Na activator.
- ❑ 40% v/v of oil obtaing 14MPa with K activator.

Geopolymer as NH_4^+ adsorbent:

- ❑ Sustainable and low operational cost adsorbent.
- ❑ Lab tests: 93% ammonium removal first hours and q_m=23mg/g.
- ❑ Pilot plant: 80% ammonium removal, slightly superior to zeolites.

Future works:

- ❖Techniques/treatments to reduce the alkalis leaching.
- ❖Treatments to reuse adsorbents in several adsorption cycles.
- ❖3D printing: Innovative designs to maximize adsorption

aimen
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Thanks for your attention

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