Sol-Gel Microencapsulation of $NaNO_3$ as Phase Change Material for Thermal Energy Storage

ENERHIGH

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SOL-GEL MICROENCAPSULATION OF $NaNO_3$ AS PHASE CHANGE MATERIAL FOR THERMAL ENERGY STORAGE

INTRODUCTION

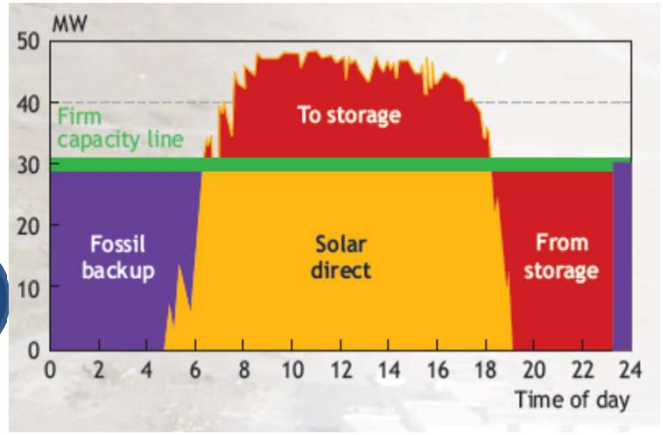
SOLAR ENERGY produces electricity by concentrating solar energy

Concentrated energy is used to heat up a fluid, produce steam and activate turbines that produce ELECTRICITY

Energy demand may not correspond with energy production

No greenhouse gas emission

Key technology for mitigating climate change



THERMAL ENERGY STORAGE solves the time mismatch between solar energy supply and electricity demand

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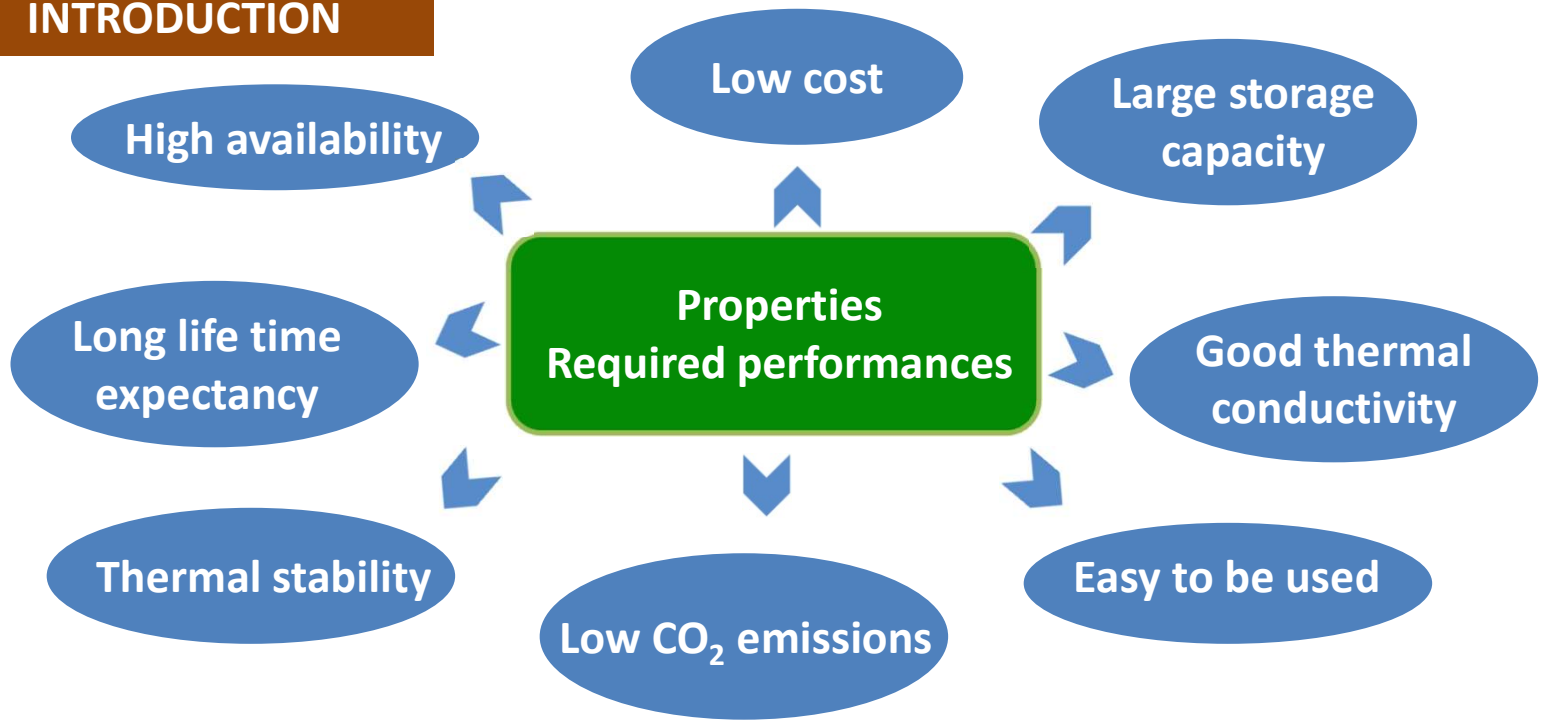
INTRODUCTION



MAIN LIMITATIONS

- LACK OF STABILITY through THERMAL CYCLES
- CORROSION PROBLEMS at HIGH TEMPERATURES

390 ºC
in parabolic trough collectors

565 ºC
in central receivers

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INTRODUCTION

LIMITATIONS

STABILITY THROUGH THERMAL CYCLES

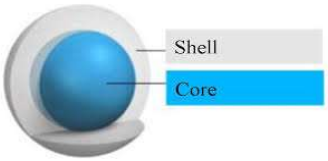
CORROSION PROBLEMS

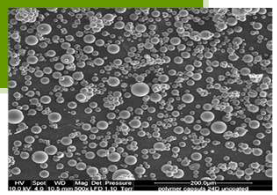
www.pcmproducts.net/

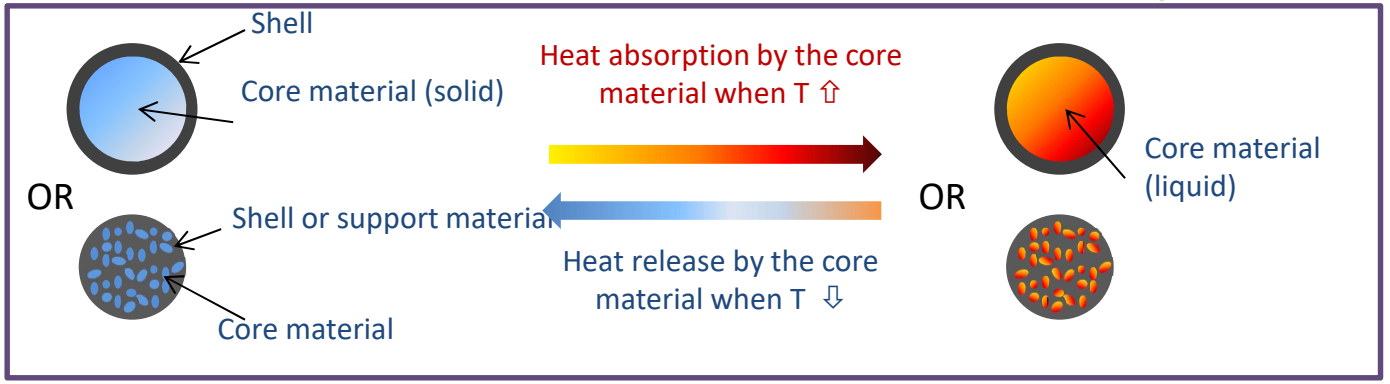
Macroencapsulation

(>1 mm)

MICROENCAPSULATION







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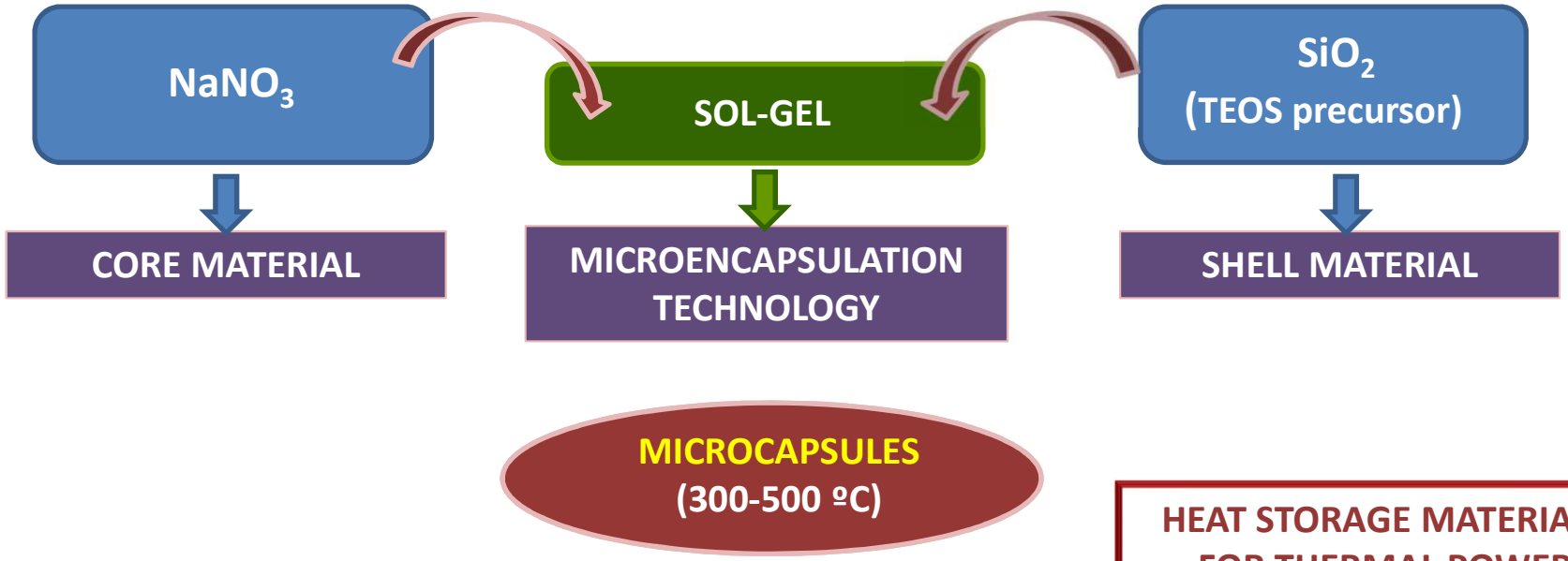
MATERIALS AND EXPERIMENTAL TECHNIQUES

MICROENCAPSULATION METHODOLOGY



HEAT STORAGE MATERIALS FOR THERMAL POWER PLANTS

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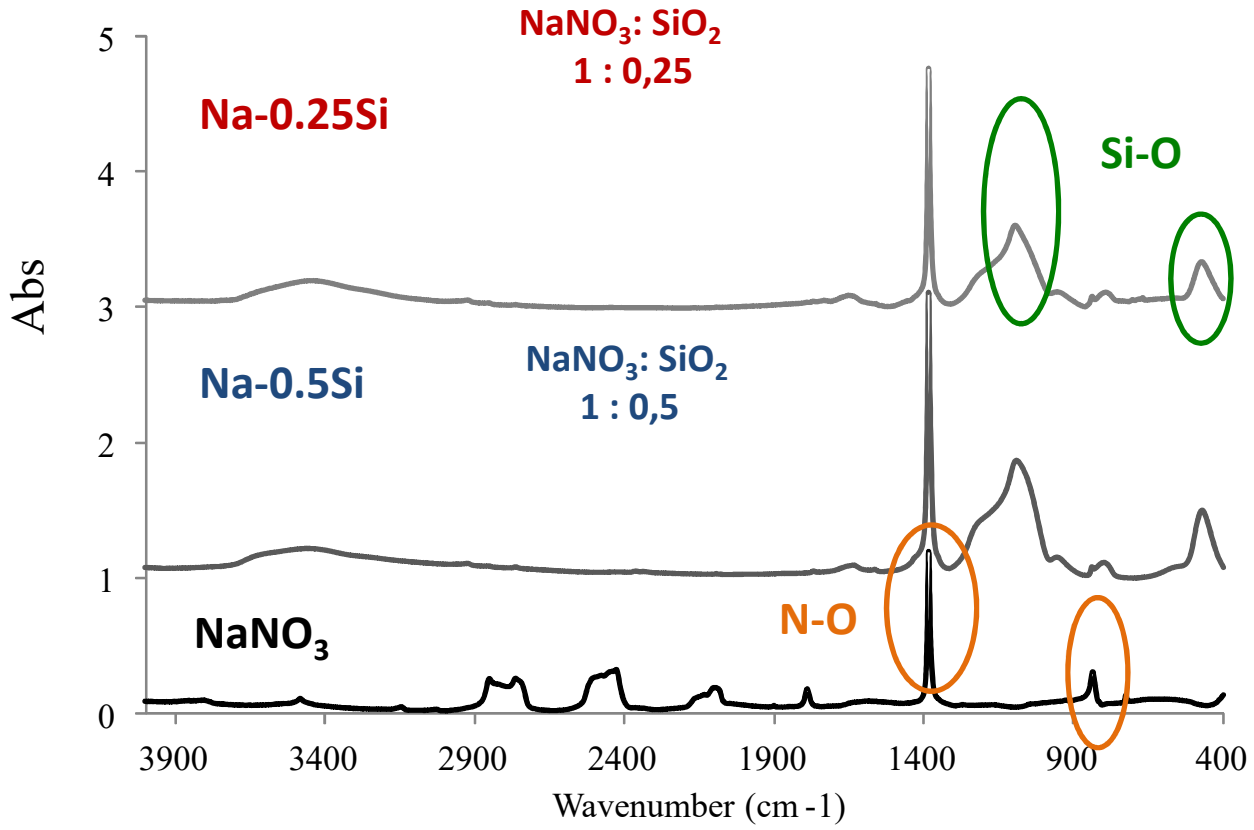
RESULTS

IR spectroscopy



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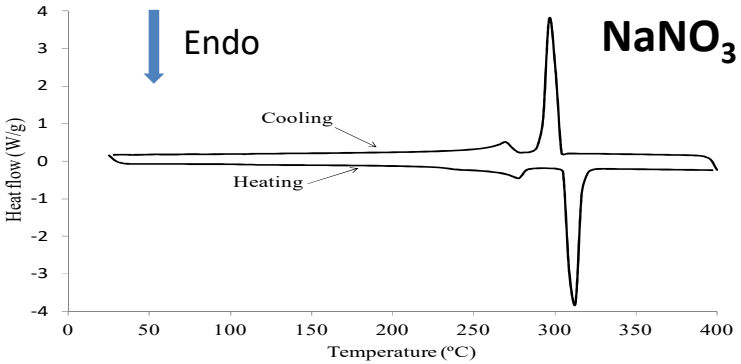
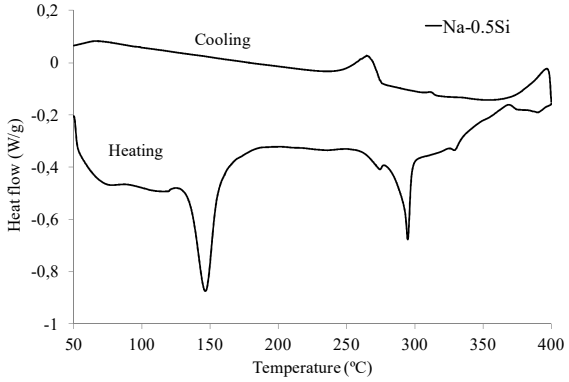
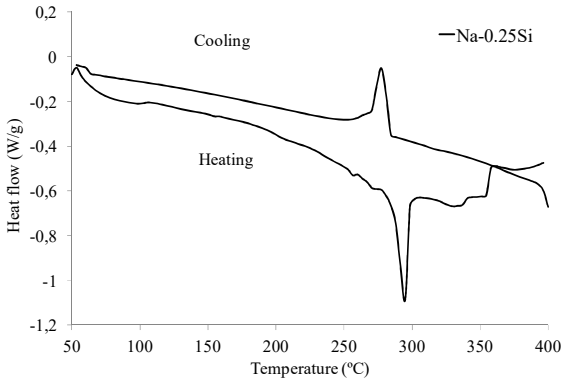
RESULTS



Differential Scanning Calorimetry (DSC)

Na-0.5Si





Na-0.5Si

SAMPLE	HEATING		COOLING	
	Tm (ºC)	ΔHm (J/g)	Tc (ºC)	ΔHc (J/g)
$NaNO_3$	306.8	158.1	304.0	159.4
Na-0.5Si	294.2	25.1	264.7	11.2
Na-0.25Si	293.4	29.0	277.5	21.0

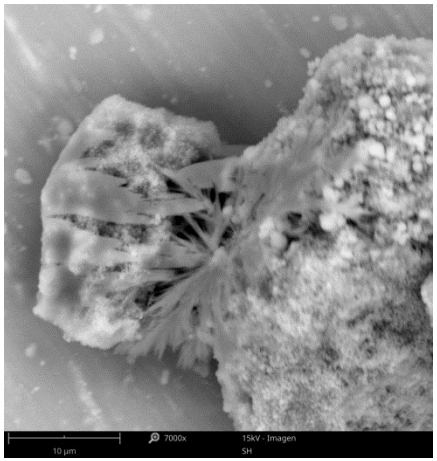
SOL-GEL MICROENCAPSULATION OF $NaNO_3$ AS PHASE CHANGE MATERIAL FOR THERMAL ENERGY STORAGE

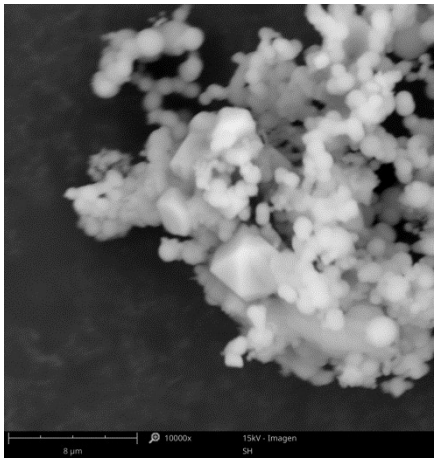
RESULTS

Scanning Electron Microscopy

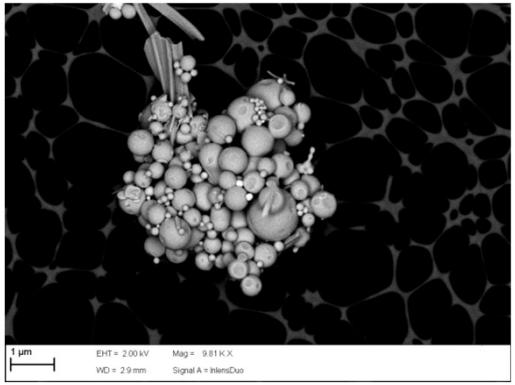
Na-0.5Si

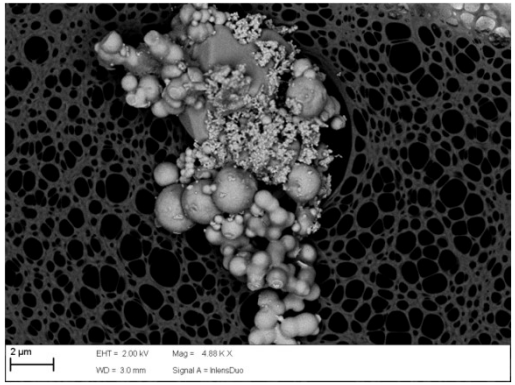
Na-0.25Si





SEM





FESEM

SOL-GEL MICROENCAPSULATION OF $NaNO_3$ AS PHASE CHANGE MATERIAL FOR THERMAL ENERGY STORAGE

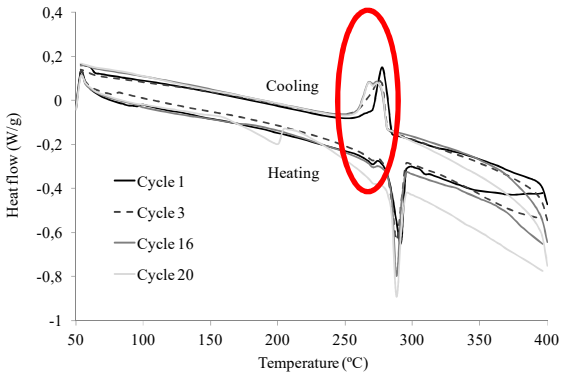
RESULTS

50 to 400 ºC and 400 to 50 ºC

Differential Scanning Calorimetry (DSC)

Na-0.5Si	HEATING		COOLING	
	Tm (ºC)	ΔHm (J/g)	Tc (ºC)	ΔHc (J/g)
Cycle 1	294.2	25.1	264.7	11.2
Cycle 2	283.7	10.9	268.8	10.7
Cycle 3	283.5	11.5	269.5	9.6
Cycle 16	282.3	5.4	266.3	5.9

Na-0.25Si	HEATING		COOLING	
	Tm (ºC)	ΔHm (J/g)	Tc (ºC)	ΔHc (J/g)
Cycle 1	270.5; 293.9	26.2	281.0; 267.0	25.7
Cycle 2	270.5; 290.5	19.5	276.8; 267.5	21.5
Cycle 3	270.5; 288.2	20.0	275.1; 267.0	22.1
Cycle 16	270.5; 288.1	20.0	274.3; 270.5	22.0
Cycle 20	270.5; 288.2	21.9	274.8; 270.0	22.7

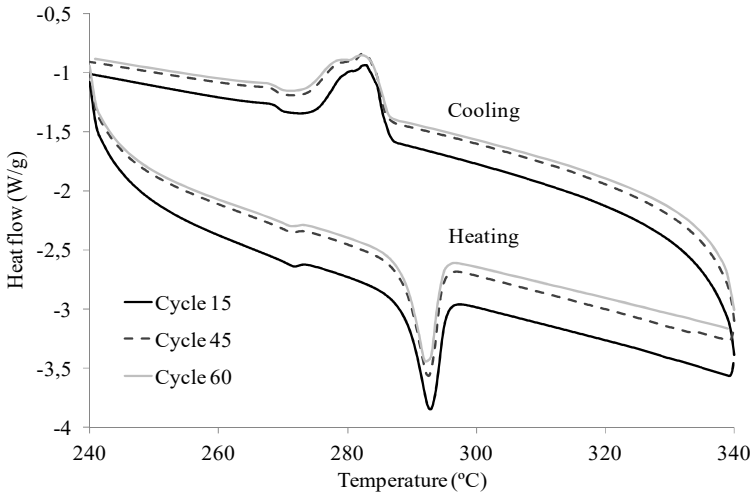


SOL-GEL MICROENCAPSULATION OF $NaNO_3$ AS PHASE CHANGE MATERIAL FOR THERMAL ENERGY STORAGE

RESULTS

240 to 340 ºC and 340 to 240 ºC for Na-0.25Si microparticles

Na-0.25Si	HEATING		COOLING	
	Tm (ºC)	ΔHm (J/g)	Tc (ºC)	ΔHc (J/g)
Cycle 1	294.0	28.3	283.6	20.3
Cycle 15	292.0	26.8	282.8	26.3
Cycle 30	291.8	26.2	283.1	25.7
Cycle 45	291.7	26.3	282.2	25.3
Cycle 60	291.6	26.2	283.0	25.3



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CONCLUSIONS

- Sol-gel has been demonstrated as a feasible technology for the microencapsulation of $NaNO_3$ using SiO_2 as shell material
- Effectiveness of microencapsulated $NaNO_3$ as thermal energy storage material greatly depends on the morphology of microparticles and therefore, on the $NaNO_3$:SiO_2 ratio
- Na-0.25Si microparticles have higher energy storage capacity even with a lower proportion of SiO_2. The SiO_2 shell may affect the $NaNO_3$ crystal growth
- Deeper work is being done to analyze the influence of the $NaNO_3$ crystal phase on its energy storage capacity when microencapsulated within SiO_2 shells
- Thermal energy storage stability of microencapsulated $NaNO_3$ with SiO_2 depends on the maximum temperature during use
- Temperatures higher than 400 ºC lead to the dissociation of NO_3^- to NO_2^- and therefore to a modification of the thermal energy storage properties of $NaNO_3$

ACKNOWLEDGEMENTS:

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THANK YOU VERY MUCH FOR YOUR ATTENTION