“Synthesization, characterization, and in vitro evaluation of cytotoxicity of biomaterials based on halloysite nanotubes”

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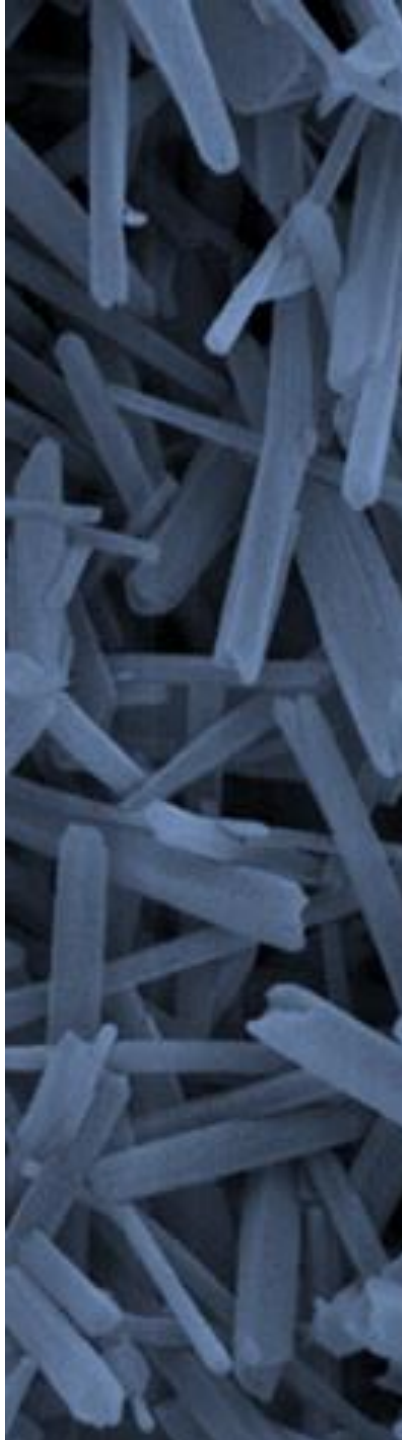
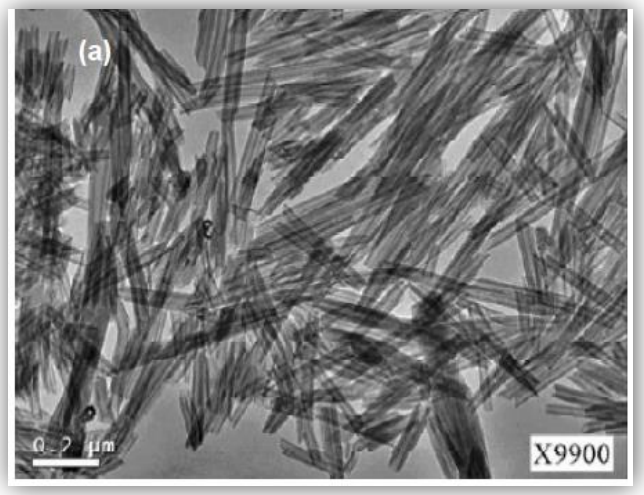


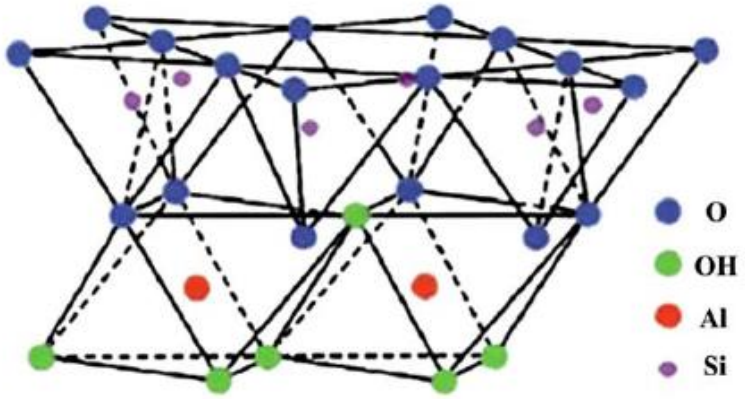
1st International Electronic Conference on Materials
26 May - 10 June 2014

BACKGROUND

- HNTs – two-layered aluminosilicate clay ($Al_2Si_2O_5(OH)_4 \cdot 2H_2O$)
- Multilayer walls with Al-OH (inner wall), Si-OH (outer wall)
- Nanosized lumen



Vergaro, et al. Biomacromolecules, 2010



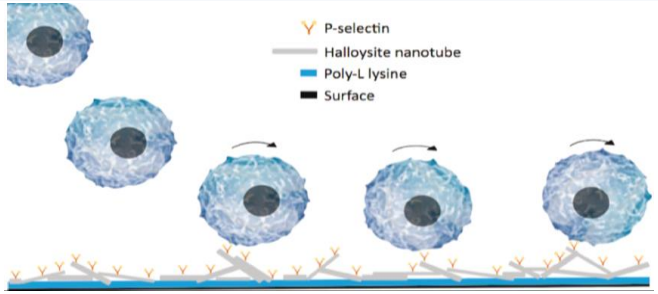
Moazeni, et al. Applied Polymer Science, 2013

BACKGROUND

Applications of HNTs

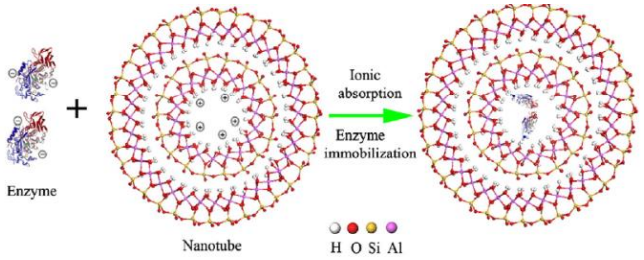
- Capture of tumoral cells

Hughes et al. Biomacromolecules 2010



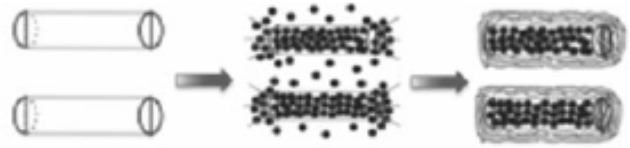
- Immobilize enzymes

Zhai et al. Catalysis Communications 2010



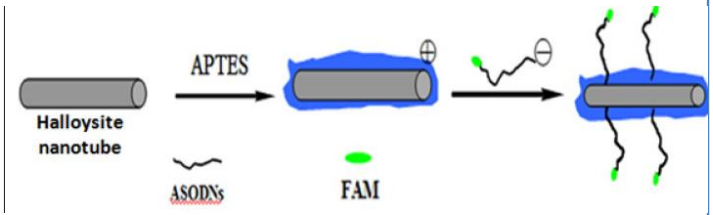
- Encapsulation and drug delivery

Vergaro et al. Macromolecular Biosciencie 2012



- APTES, therapeutic gene (ASODNs) and fluorescent

Shi et al. Nanoscale Research Letter 2011



MATERIALS

Material
HNTs
HNTs-TMPS
HNTs-TEOS

- Organosilane functionalization:
  - Trimethoxy(propyl)silane (TMPS)
  - Triethoxy(octyl)silane (TEOS)

HNTS FUNCTIONALIZATION

Add 10g halloysite nanotubes and 50 ml of acetone → Add 2 ml of TEOS/ TMPS → Stir manually → Heat to 50 °C for 48 hours → Leave in the refrigerator at 4-5°C

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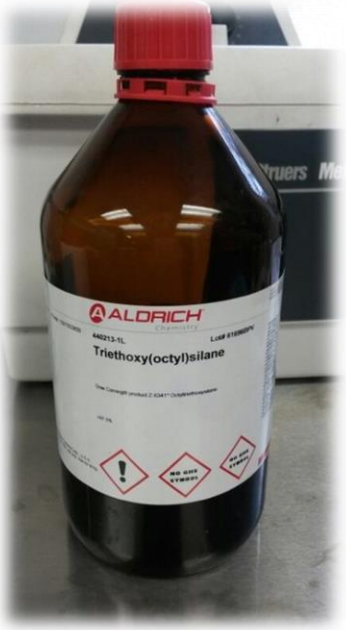

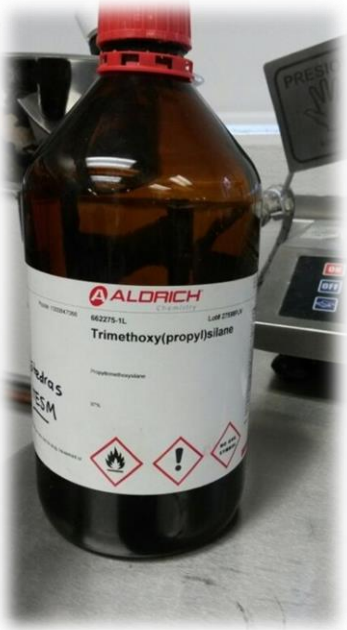

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FILTERING HNTS

Pour the reactions in the funnel → Add 10 ml of acetone 3 times → Obtain powder

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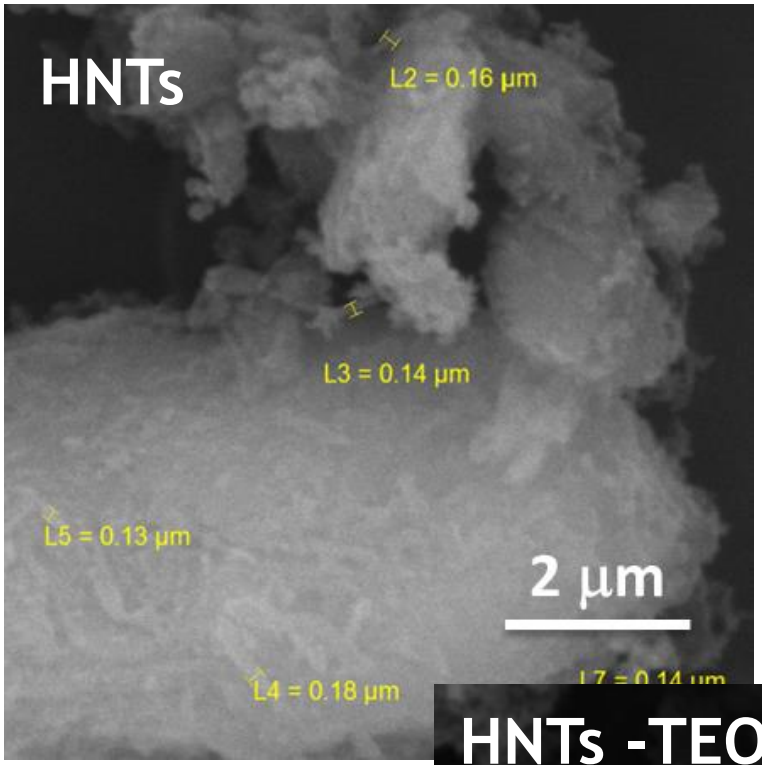
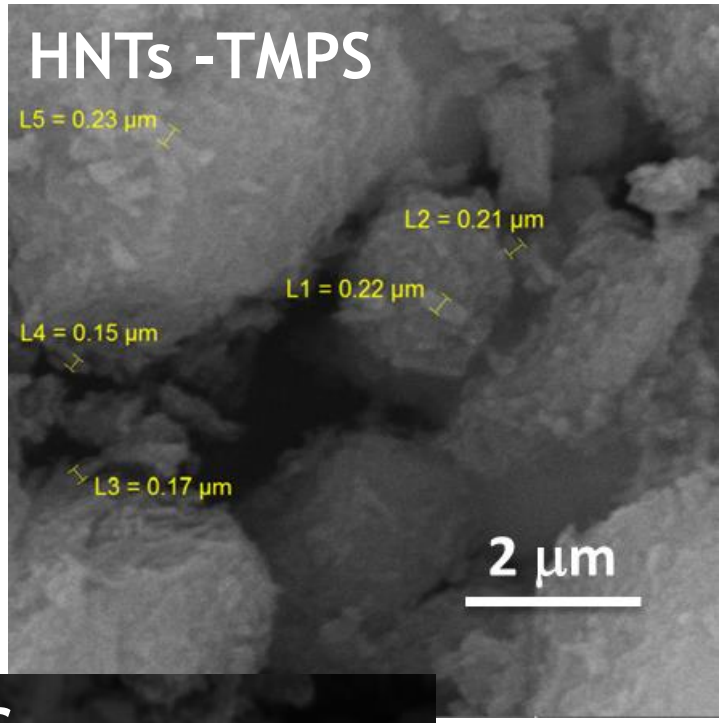
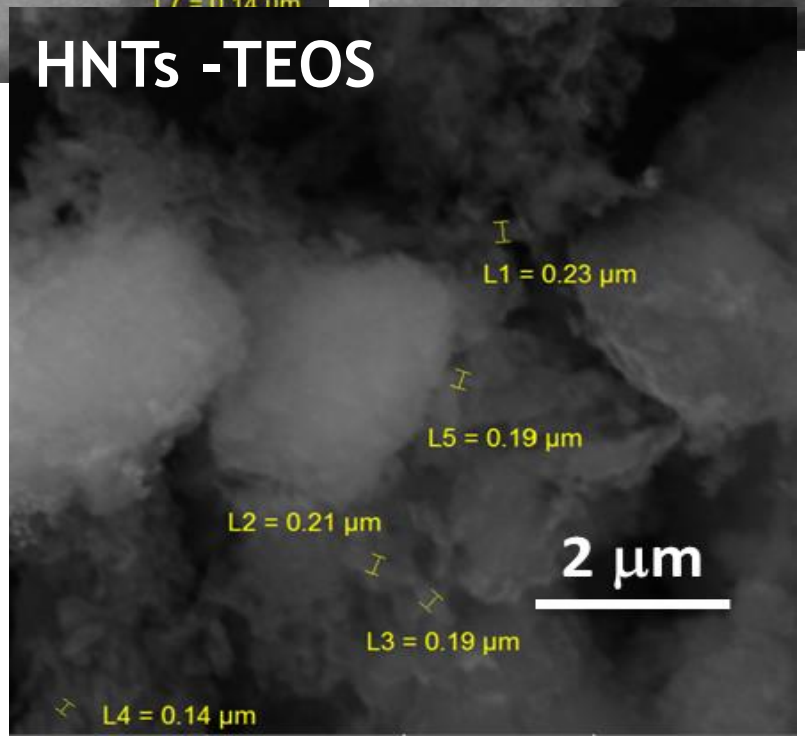
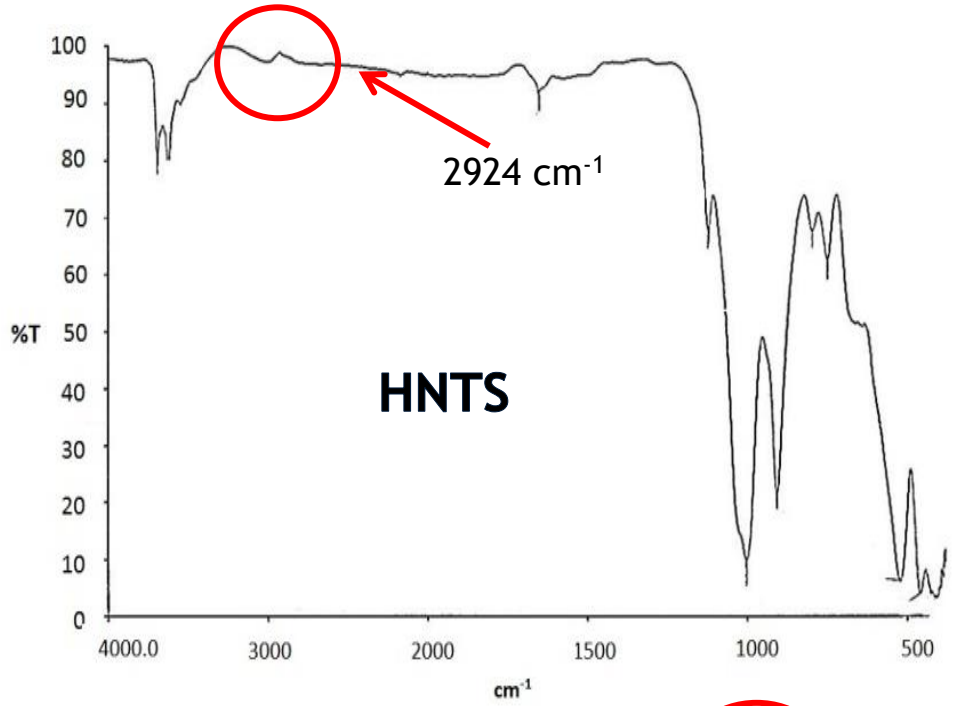
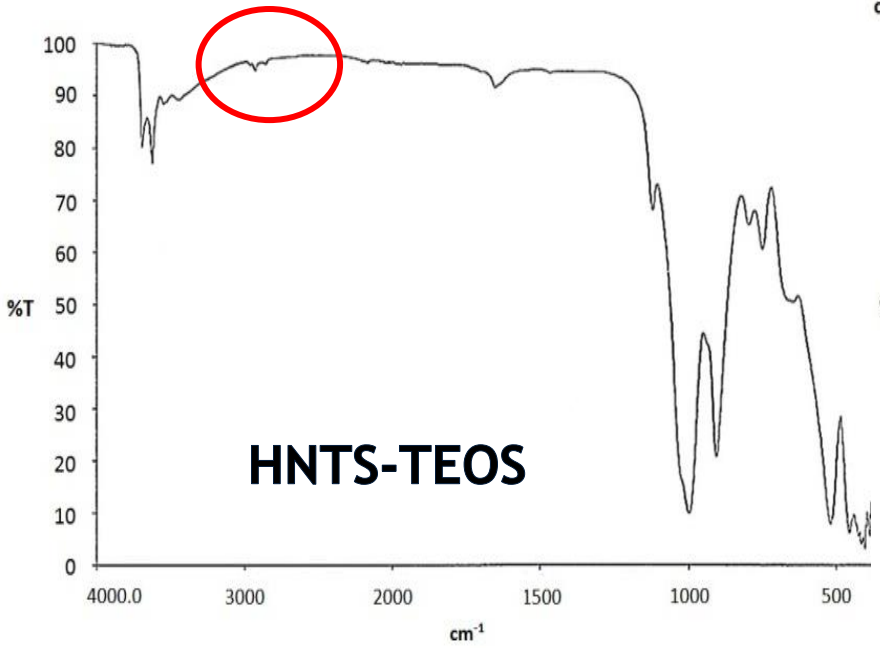
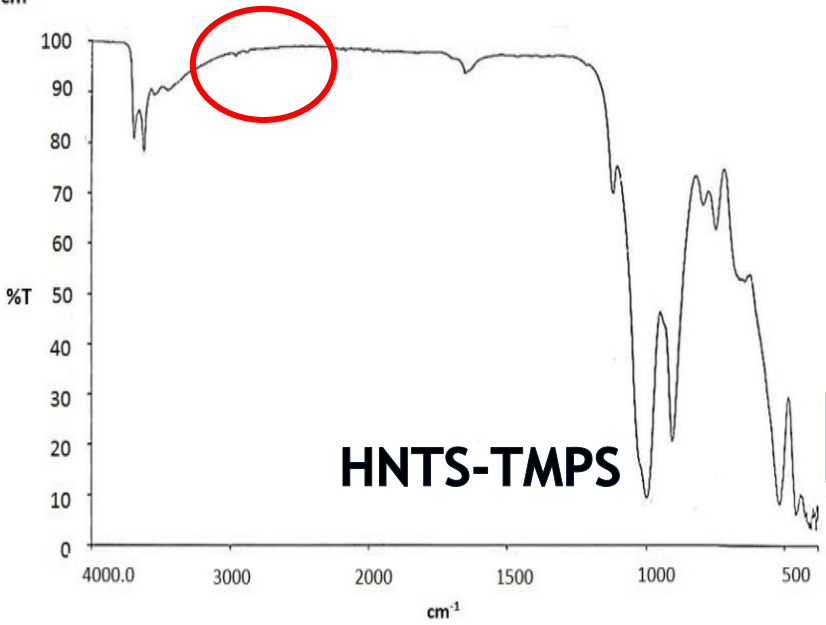

HNTs
L2 = 0.16 µm
L3 = 0.14 µm
L5 = 0.13 µm
2 µm
L4 = 0.18 µm


HNTs -TMPS
L5 = 0.23 µm
L2 = 0.21 µm
L1 = 0.22 µm
L4 = 0.15 µm
L3 = 0.17 µm
2 µm

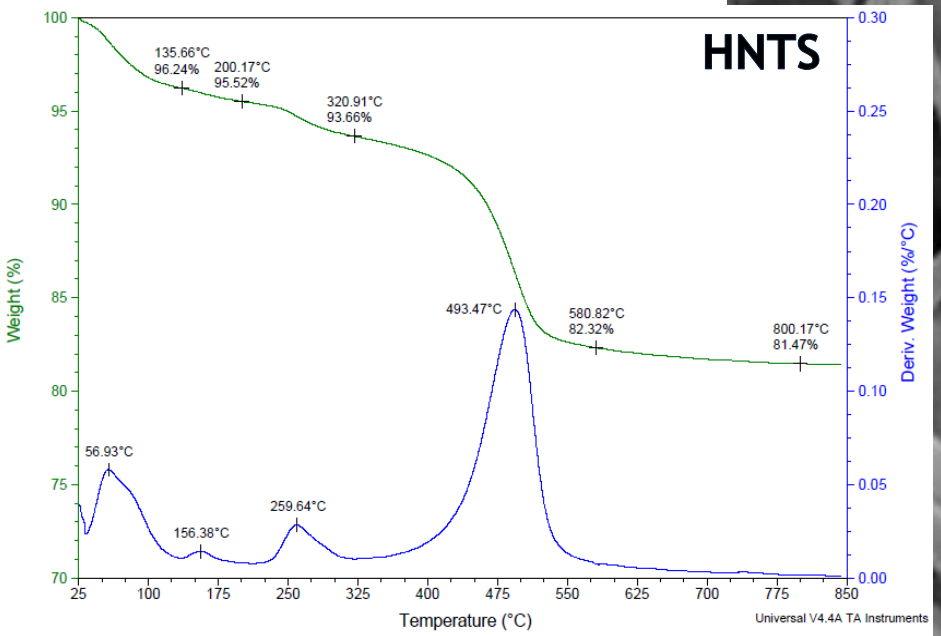

HNTs -TEOS
L1 = 0.23 µm
L5 = 0.19 µm
L2 = 0.21 µm
2 µm
L3 = 0.19 µm
L4 = 0.14 µm

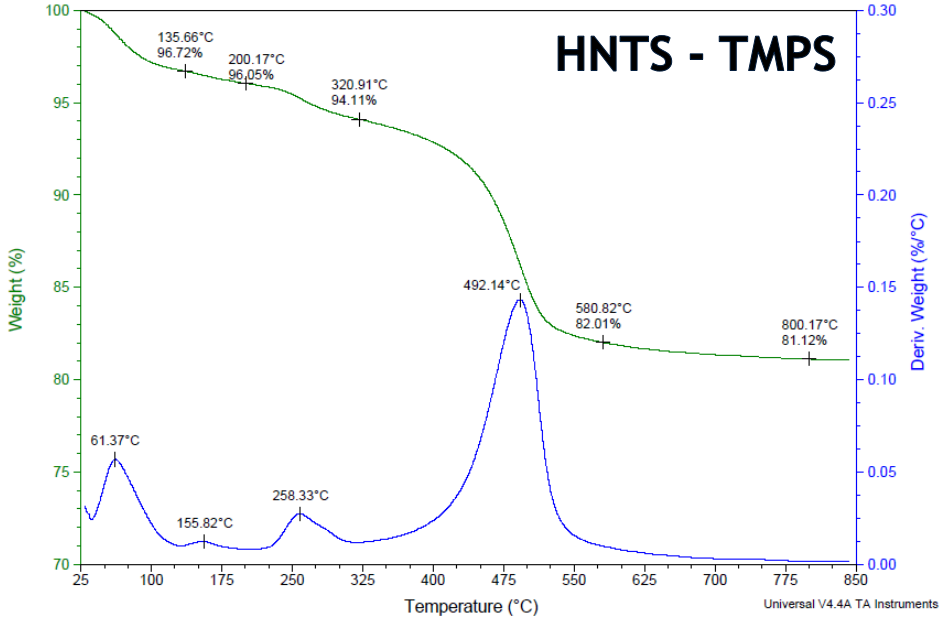

2924 cm-1
HNTS
%T
100
90
80
70
60
50
40
30
20
10
0
4000.0
3000
2000
1500
1000
500
cm-1

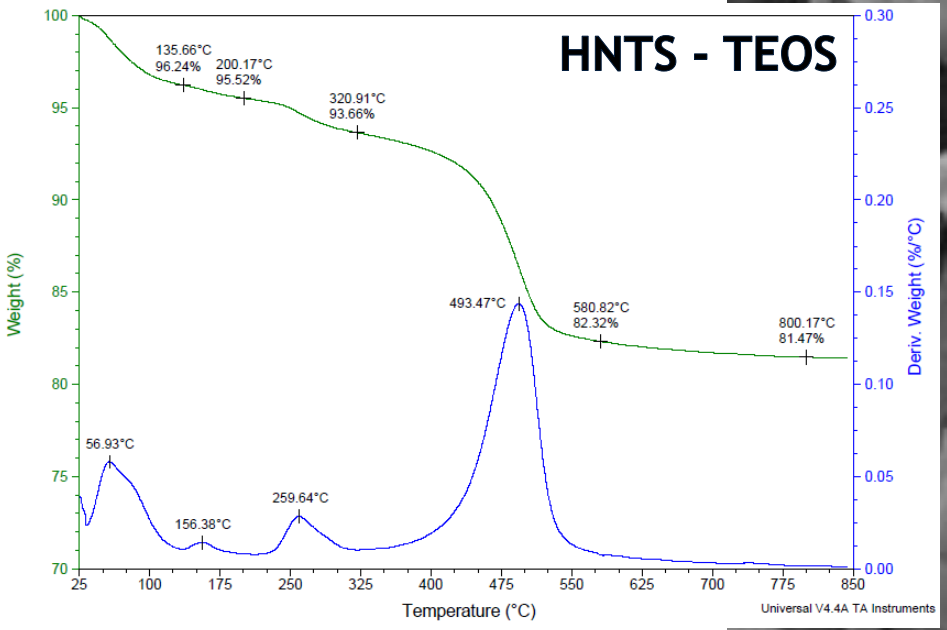

HNTS-TEOS
%T
100
90
80
70
60
50
40
30
20
10
0
4000.0
3000
2000
1500
1000
500
cm-1


HNTS-TMPS
%T
100
90
80
70
60
50
40
30
20
10
0
4000.0
3000
2000
1500
1000
500
cm-1

Sample	Weight loss in TGA, 200–320 °C (%)	Difference relative to HNTs (%)
HNT	1.86	-
HNTs-TMPS	1.94	0.08
HNTs-TEOS	2.04	0.18







Sample	Cytotoxicity	Apoptosis	Viability
HNTs	-	-	-
HNTs-TEOS	x	x	↑
HNTs-TMPS	x	x	-
Silica-chitosan	-	-	↓
Chitosan	-	-	↑
HNTs/Silica-chitosan	-	-	↓
HNTs-TEOS/Silica-chitosan	-	-	↓
HNTs-TMPS/Silica-chitosan	-	-	↓
HNTs/ Chitosan	-	x	-
HNTs-TEOS/ Chitosan	-	x	↑
HNTs-TMPS/ Chitosan	-	-	↑

CONCLUSIONS

- Characterization by FTIR and TGA showed the strong interaction of organosilanes with the chemical groups present in HNTs.
- This functionalization may be useful to improve the properties of HNTs for several applications, including:
  - Drug encapsulation and delivery
  - Biocatalysis
  - Nanocomposites
- HNTs showed to be a highly biocompatible material, however, functionalization by selected organosilanes exhibited high cytotoxicity, showing cell death by apoptosis.

ACKNOWLEDGEMENTS

- Dr. Laura Peña
- Dr. Antonio Sánchez
- Dr. Roman Vidal Tamayo
- Dr. Rodrigo Cue Sampedro
- Vanessa Pérez Silos.