IFATCC
INTERNATIONAL FEDERATION OF ASSOCIATIONS OF TEXTILE CHEMISTS AND COLORISTS

Rel. 2 — mar. 2009

XXII
INTERNATIONAL CONGRESS
ITALIA, LAGO MAGGIORE
STRESA, MAY 5—7, 2010

APPLICATION OF NANOPARTICLES AS PROMISING FLAME RETARDANT ADDITIVES FOR TEXTILE FABRICS

Jenny Alongi

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Outline

- FRONT Project

-*….against the fire….*

- *Cone calorimetry*

- Nanoparticles (NPs)

- Experimental part

- Results on ***PET***

- Results on ***COTTON***

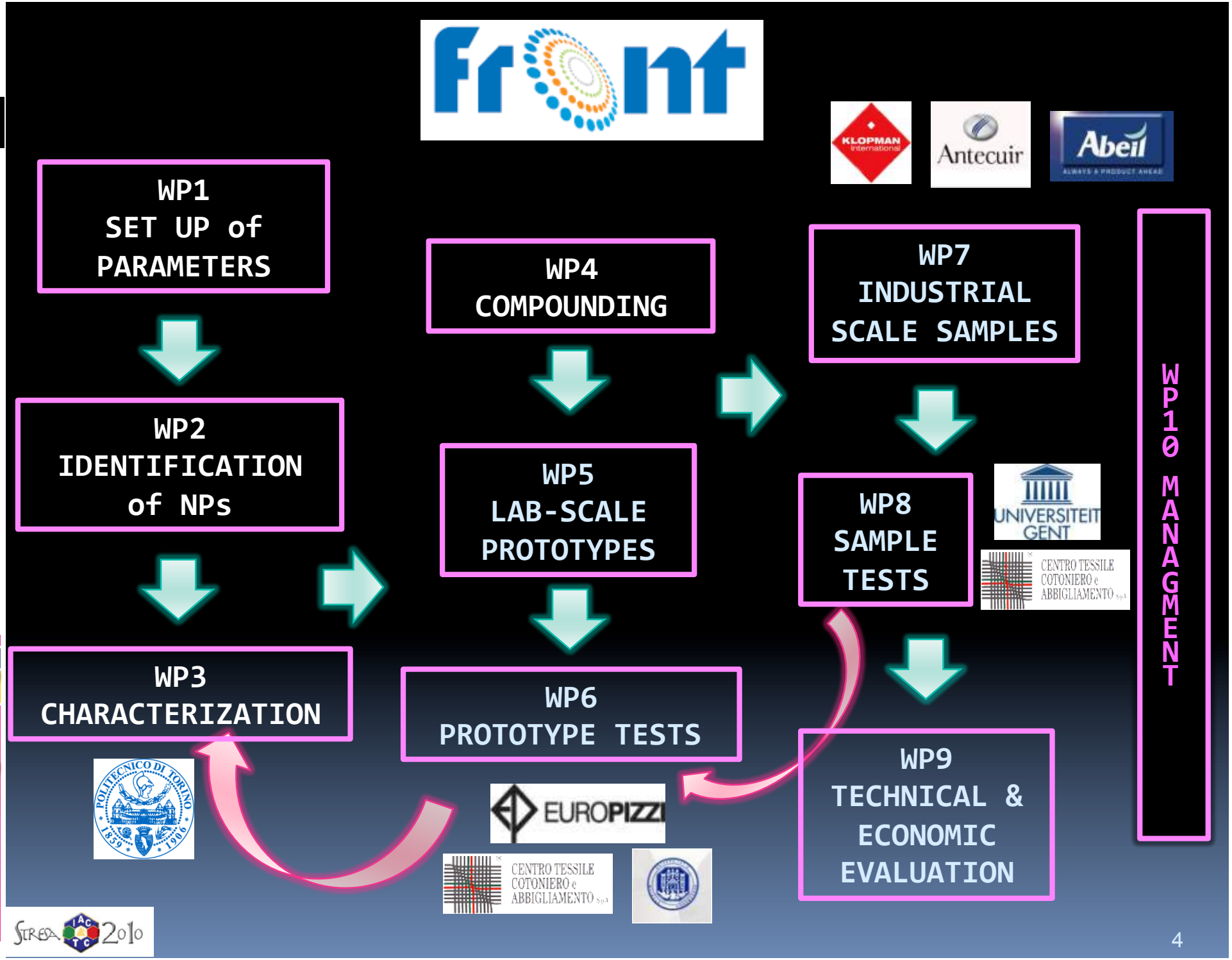
FRONT project: *Flame Retardant On Textile*

Collaborative Project of 2 years in 7°FP

Contract n° 222486

Members

	Beneficiary name	Country
SME and LE	Europizzi (coordinator)	IT
	Antecuir	ES
	Abeil	FR
	Klopman International srl	IT
RTD	Politecnico di Torino	IT
	Centro Tessile Cotoniero e Abbigliamento	IT
	Ghent University	BE


Front
WP1
SET UP of
PARAMETERS
WP2
IDENTIFICATION
of NPs
WP3
CHARACTERIZATION
WP4
COMPOUNDING
WP5
LAB-SCALE
PROTOTYPES
WP6
PROTOTYPE TESTS
WP7
INDUSTRIAL
SCALE SAMPLES
WP8
SAMPLE
TESTS
WP9
TECHNICAL &
ECONOMIC
EVALUATION
WP10 MANAGMENT
KLOPMAN International
Antecuir
Abeil
ALWAYS A PRODUCT AHEAD
UNIVERSITEIT GENT
CENTRO TESSILE COTONIERO e ABBIGLIAMENTO S.p.A.
POLITECNICO DI TORINO
1859
1906
EUROPIZZI
CENTRO TESSILE COTONIERO e ABBIGLIAMENTO S.p.A.
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STRESA 2010

…against the fire…


Ore 18: una strage tra gli spettat
64
A TORINO
NCENDIO NEL CI
fiamme si sprigionano in platea e il fumo invade la galleria trasformandola
a - Quando la nube si dirada appare uno spettacolo tremendo: corpi di sp
e - Tre ore dopo si scoprono 18 cadaveri nella toeletta e in un ripostiglio - I

..13TH FEBRUARY 1982
TORINO…..

From this fatal accident, Italian legislation obliged to use flame retardant materials in all the public locals (restaurants, cinemas, theatres…..)

64 DEATHES

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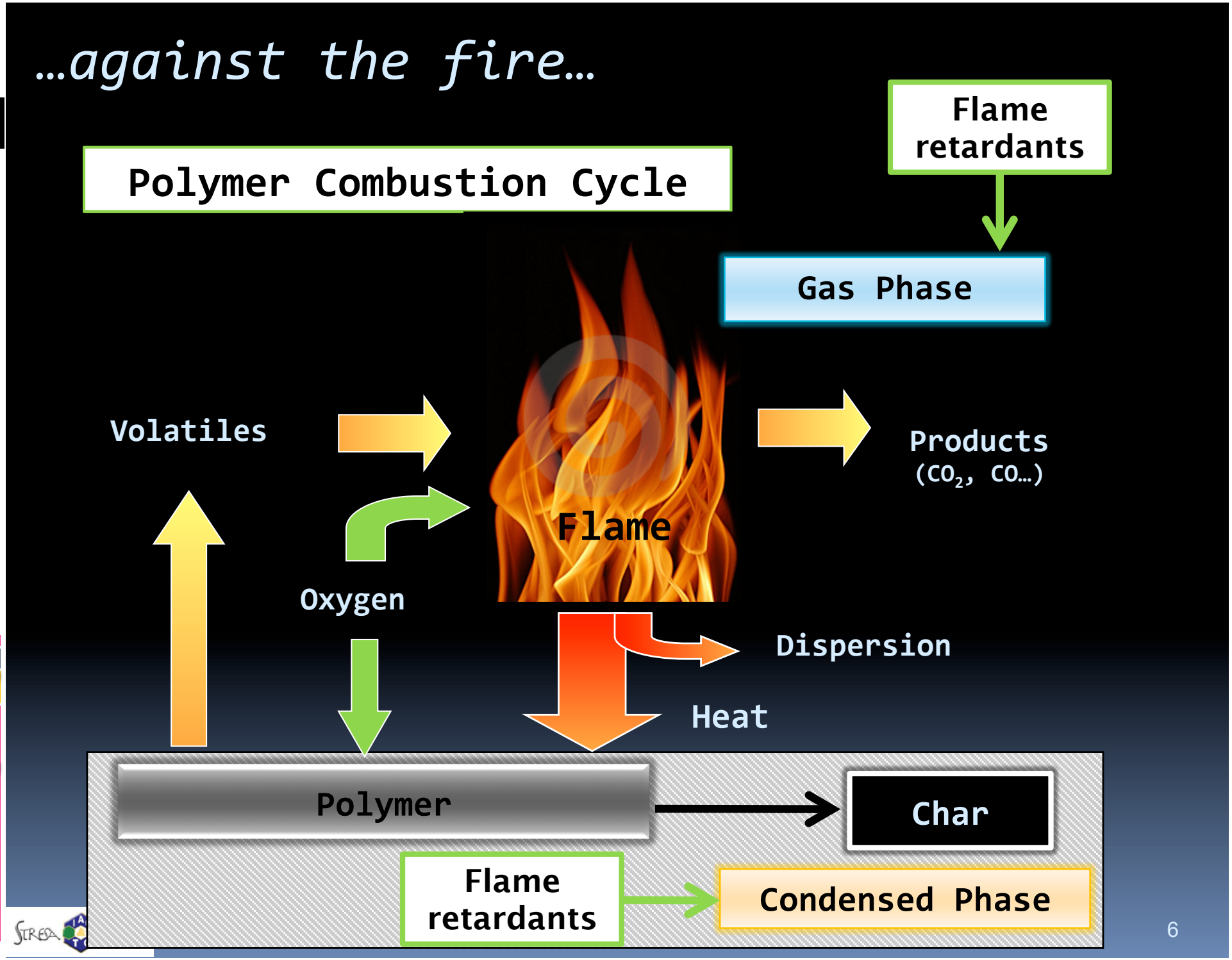
…against the fire…



… against the fire…

Flame retardants:

additives able ***to slow down and/or delay*** the combustion process before the fire is fully

- ✓Inorganic hydroxides
- ✓Halogen and metal-halogen derivates
- ✓Phosphorous compounds
- ✓Intumescent system
- ✓Polymer nanocomposites

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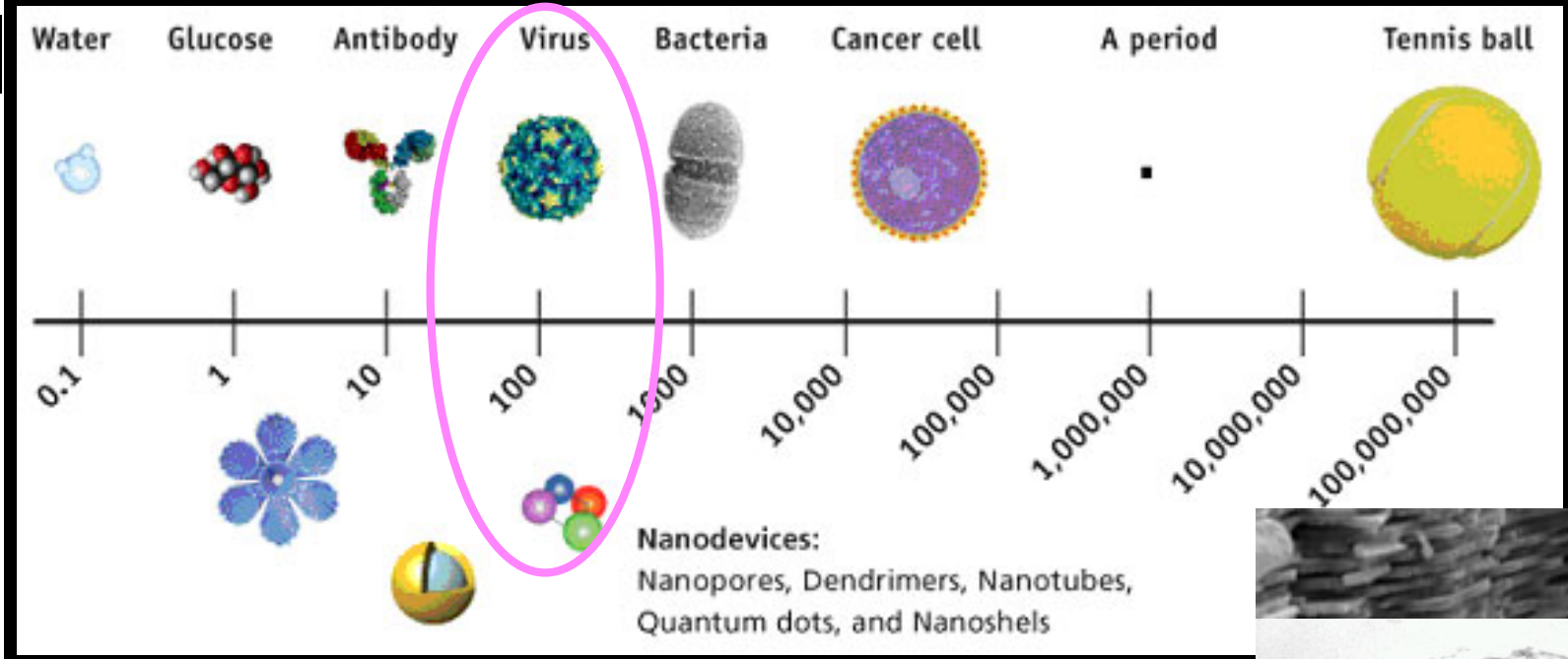
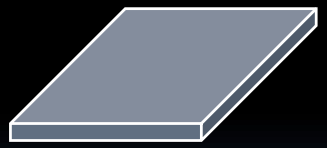
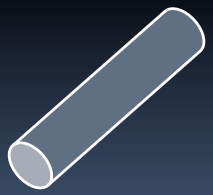
…Nanostructured material



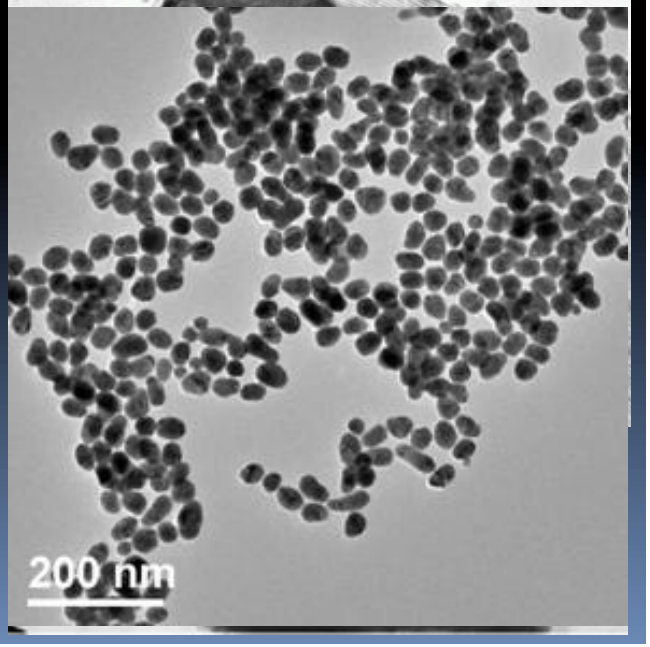
1 size <100 nm (lamellae)



2 sizes <100 nm (fibers, carbon nanotubes)



3 sizes <100 nm (silica, POSS)



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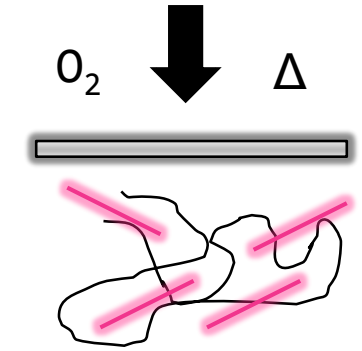
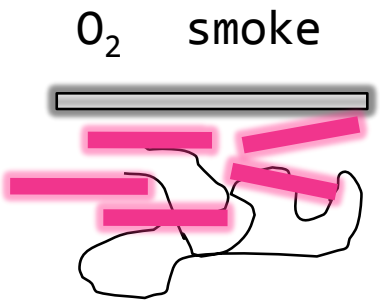
NANOCOMPOSITE PROPERTIES

- Increasing of the Modulus
- Decreasing of the Thermal Expansion Coefficient
- Reducing Gas Permeability
- Increasing Solvent Resistance
- Enhancing Ionic Conductivity
- Optical Transparency
- ***Modified Thermal Degradation***
- ***Lower Combustion Heat Release Rate***
- Easy Recyclability

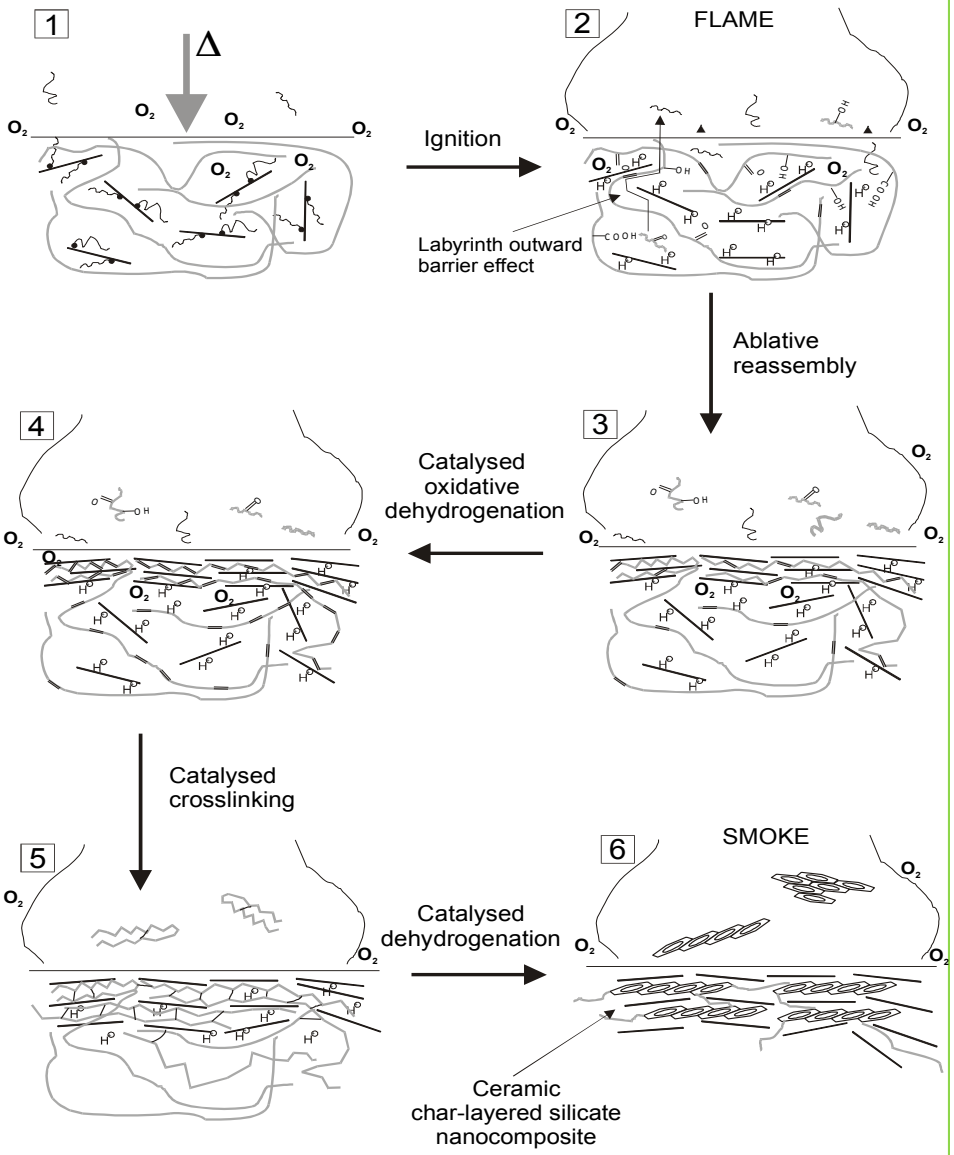
NANOCOMPOSITE COMBUSTION



1. Ignition
2. Ablative reassembly
3. Catalyzed oxidative dehydrogenation
4. Catalyzed cross-linking
5. Catalyzed dehydrogenation



PHYSICAL AND CHEMICAL BARRIER TO HEAT AND OXYGEN AND THUS TO FIRE

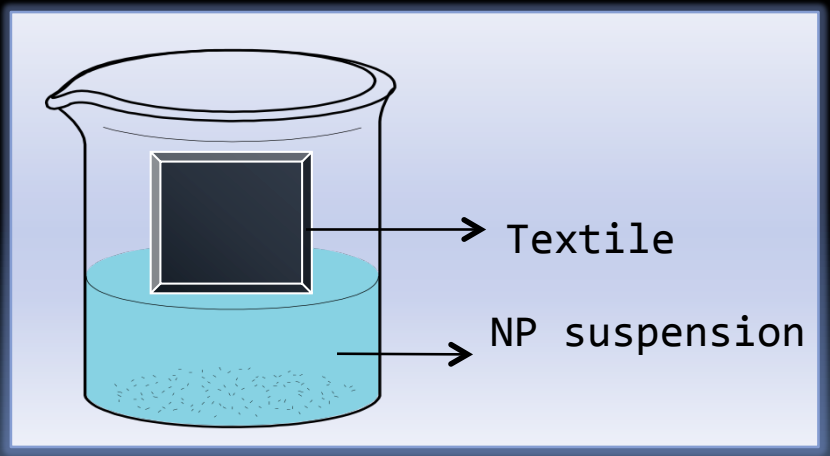


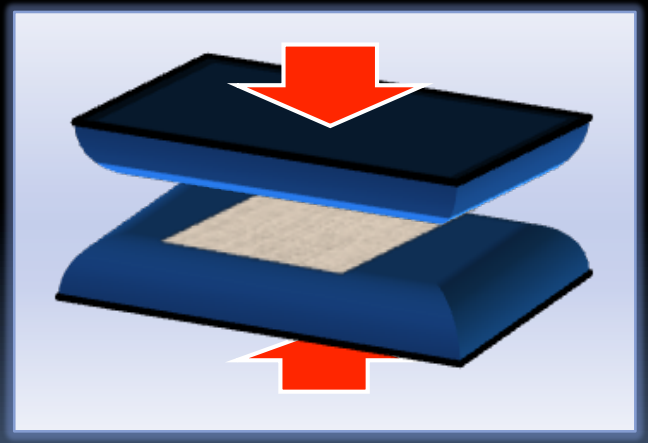
EXPERIMENTAL PART

- ## PREPARATION OF NP BASED TEXTILE FABRICS

1° step: immersion of textile into NP aqueous suspension

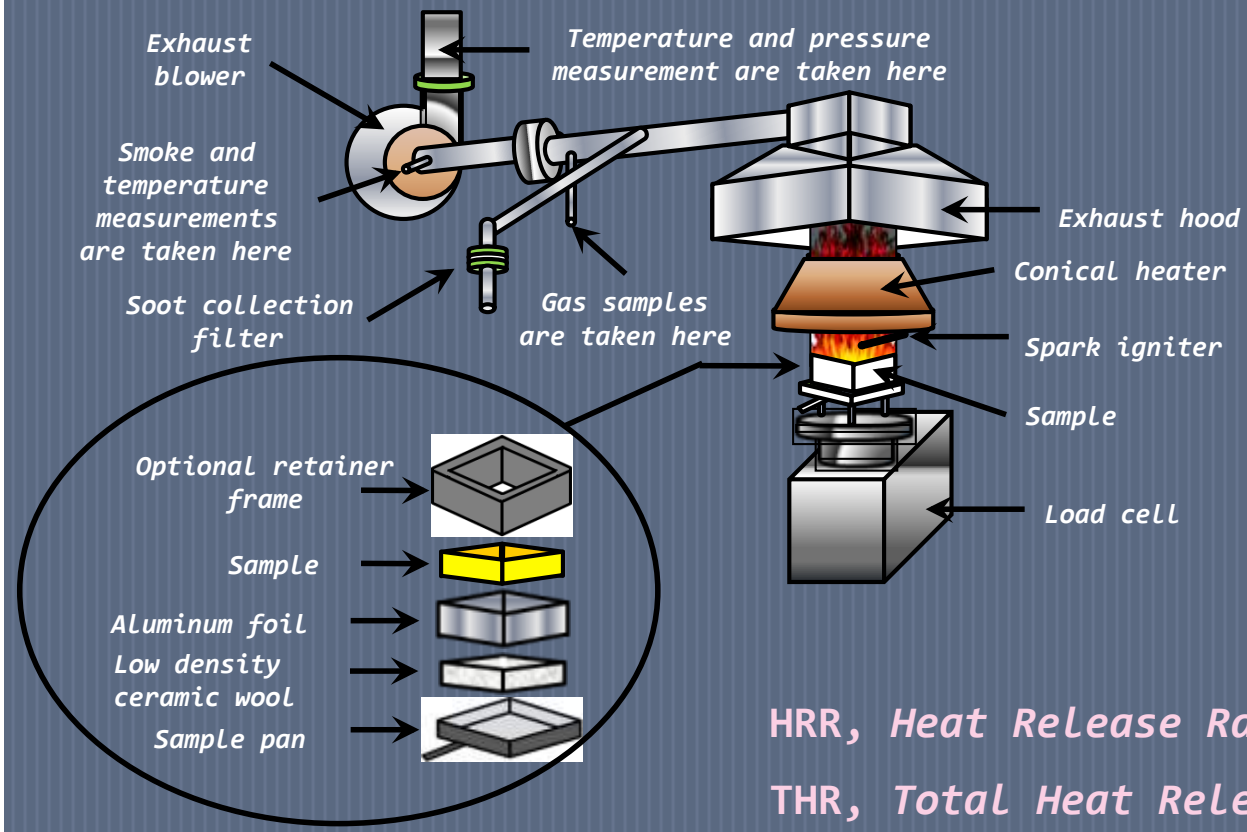
2° NP fixation by thermal treatment





Hot disks
@ T= 200 °C, p=2.5ton

CONE CALORIMETRY (ISO 5660)



Specimen size: 100x100x0.5mm
Heat Flux: 35 kW/m^2

HRR, *Heat Release Rate*

THR, *Total Heat Release*

TTI, *Time To Ignition*

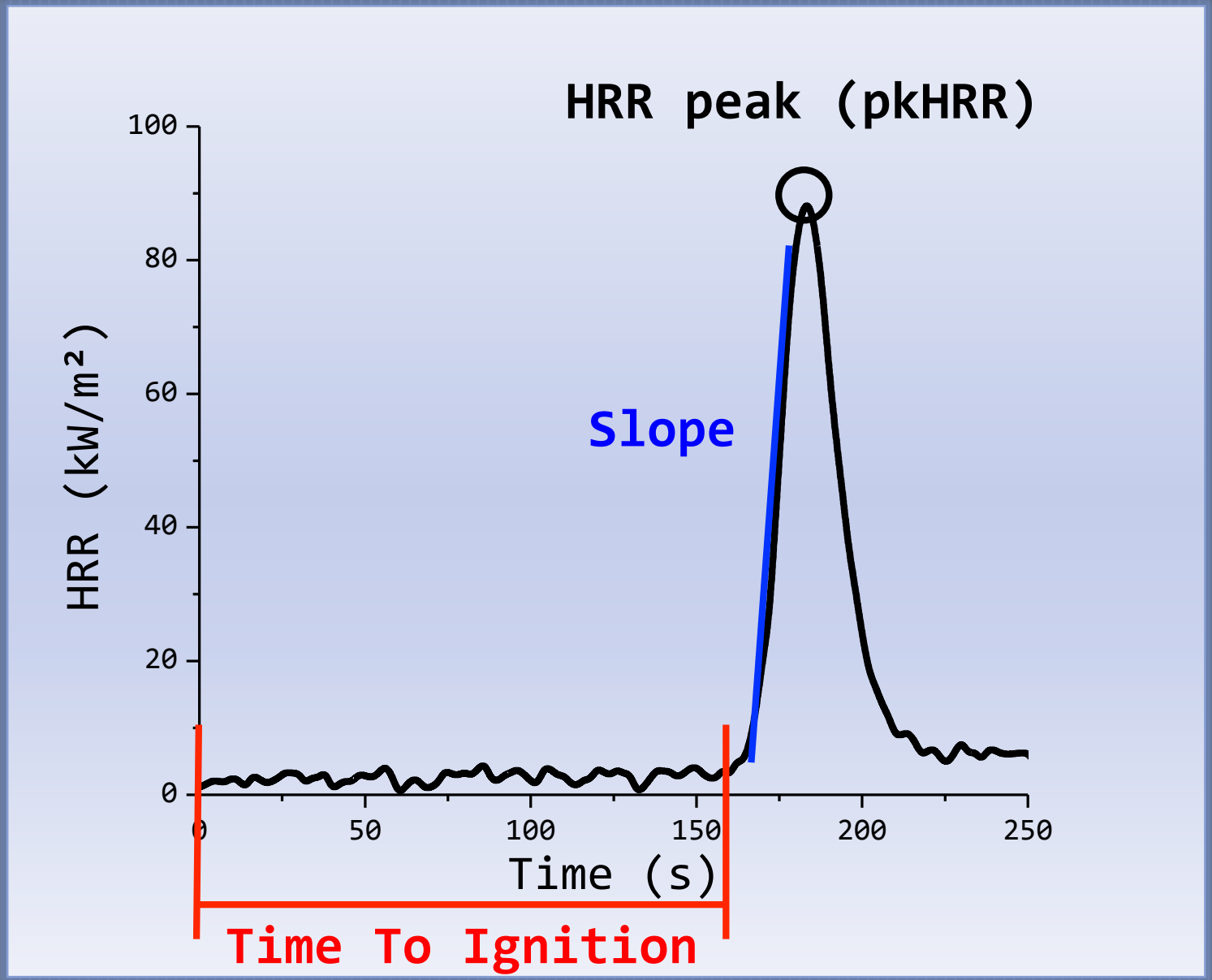
TSR, *Total Smoke Release*

OD, Optical Density

Mass or residue

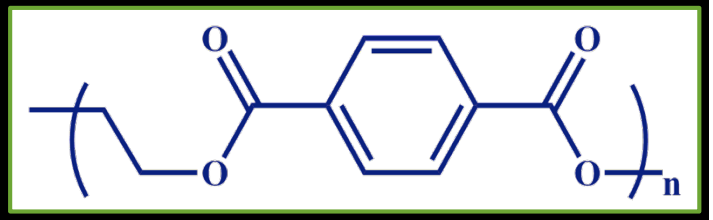
CO_2 and CO amount

HRR vs time

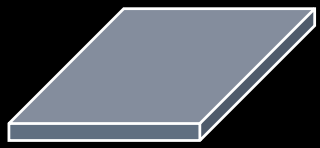


Optimization of the procedure to burn textile fabrics by cone calorimeter: part I. Combustion behavior of polyester
J. Tata, J. Alongi, F. Carosio, A. Frache *submitted to Fire and Materials*

1. PET+FILLER [1WT.-%]

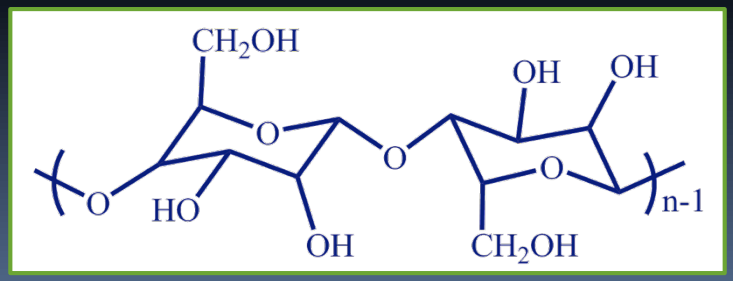


- ✓ MONTMORILLONITE= CNa
- ✓ BOHEMITE= OS1
- ✓ HYDROTALCITE= HT



- ✓ POLYHEDRAL OLIGOMERIC SILSESQUIOXANES= POSS

2. COTTON+CL+FILLER

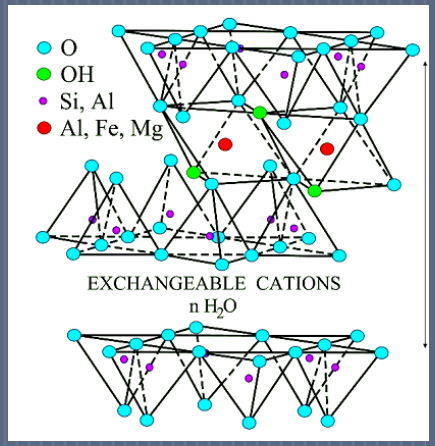


- ✓ CNa
- ✓ OS1
- ✓ POSS

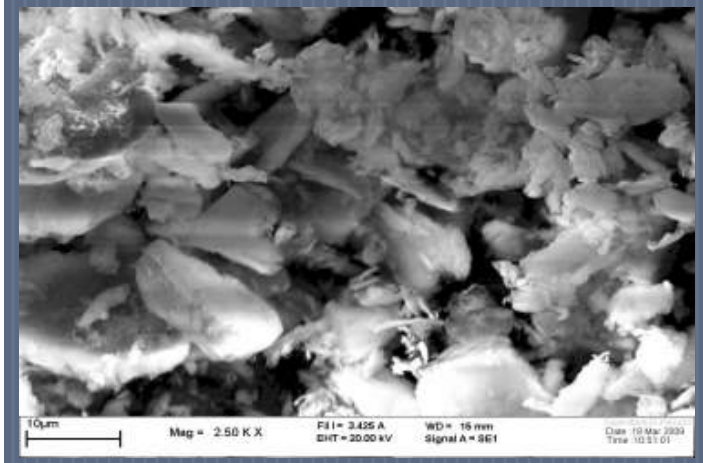
Jenny Alongi

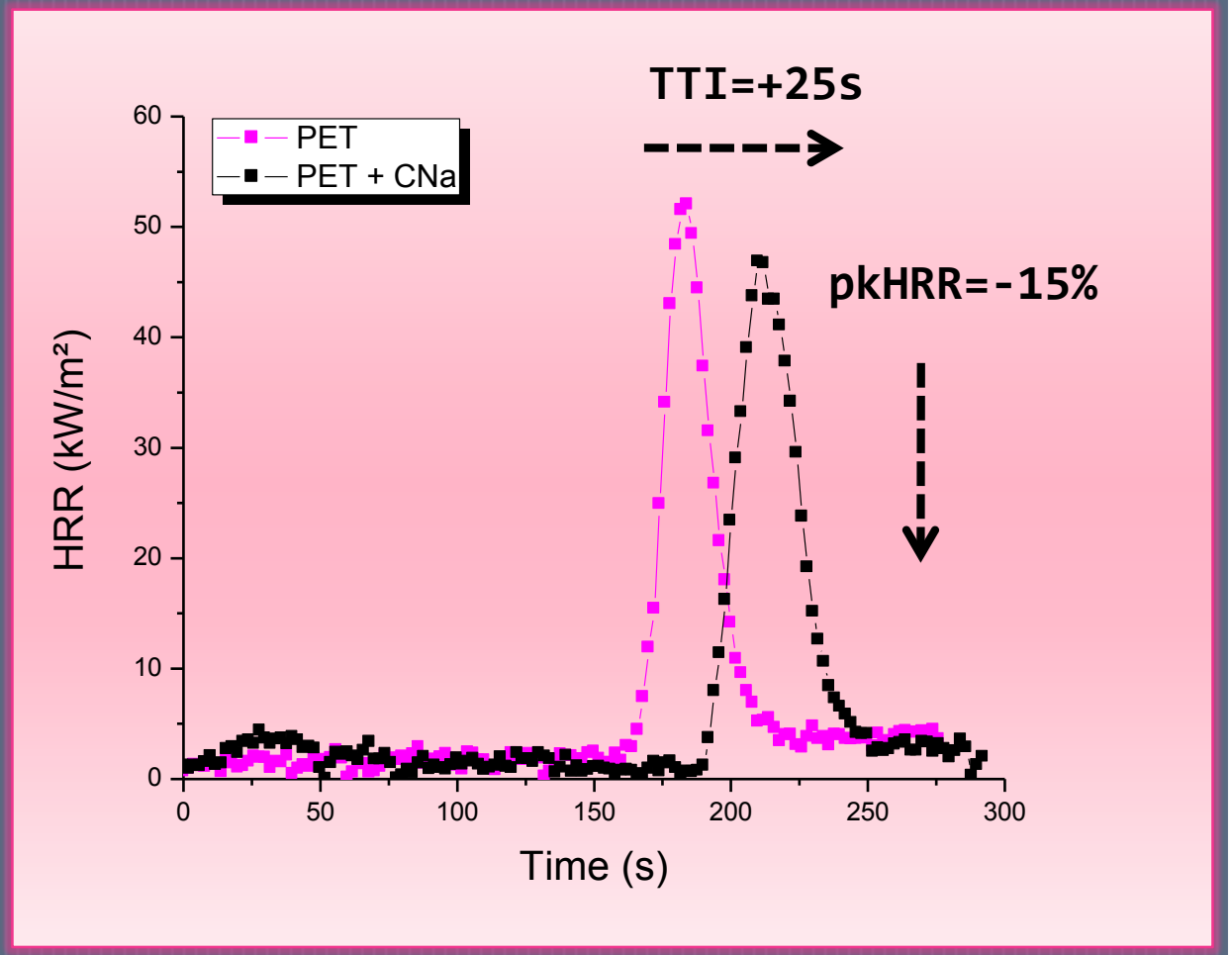
PET+CNa

WHAT IS CNa?
MONTMORILLONITE



$M_x[Al_{4-x}Mg_x](Si)_8O_{20}(OH)_4$





Combining immersion of CNa with a pre-treatment by cold plasma: TTI=+75s ☺☺

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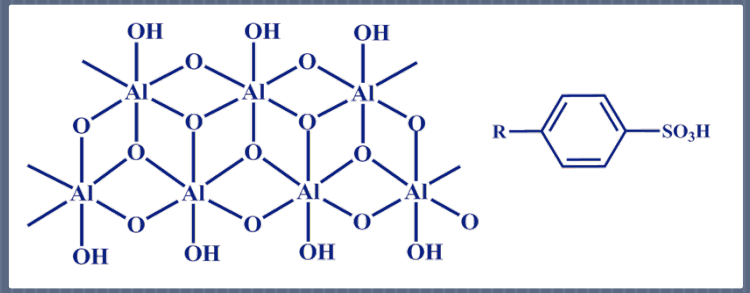
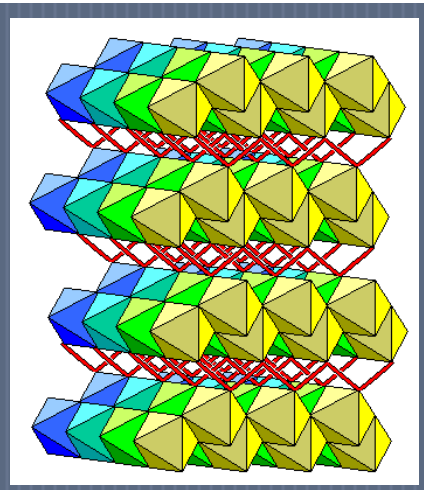
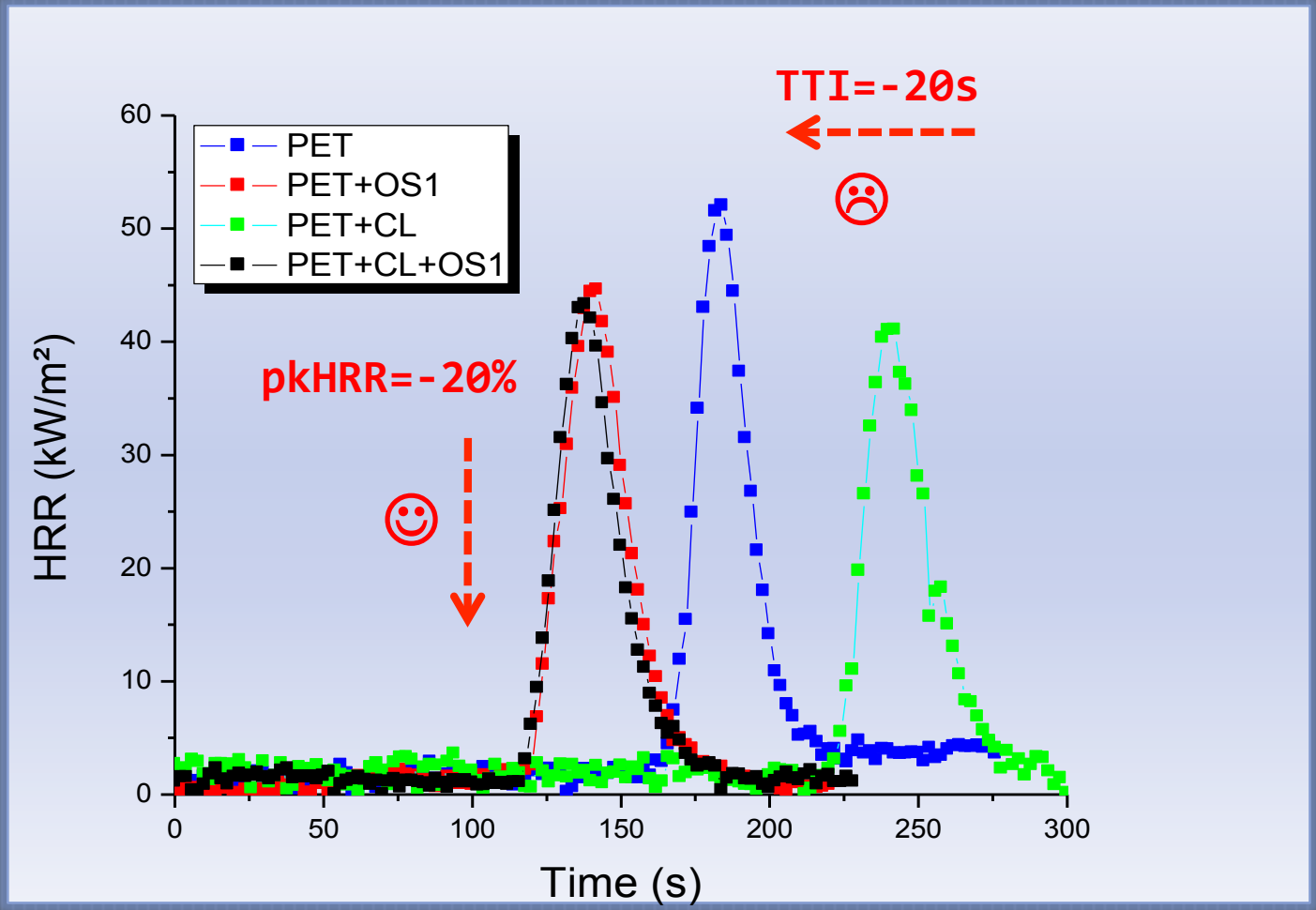
PET+OS1

WHAT IS OS1?
BOEHMITE AlO(OH)

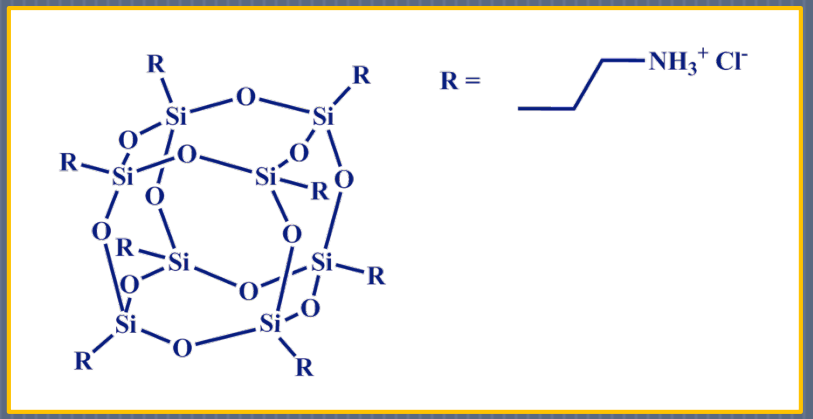


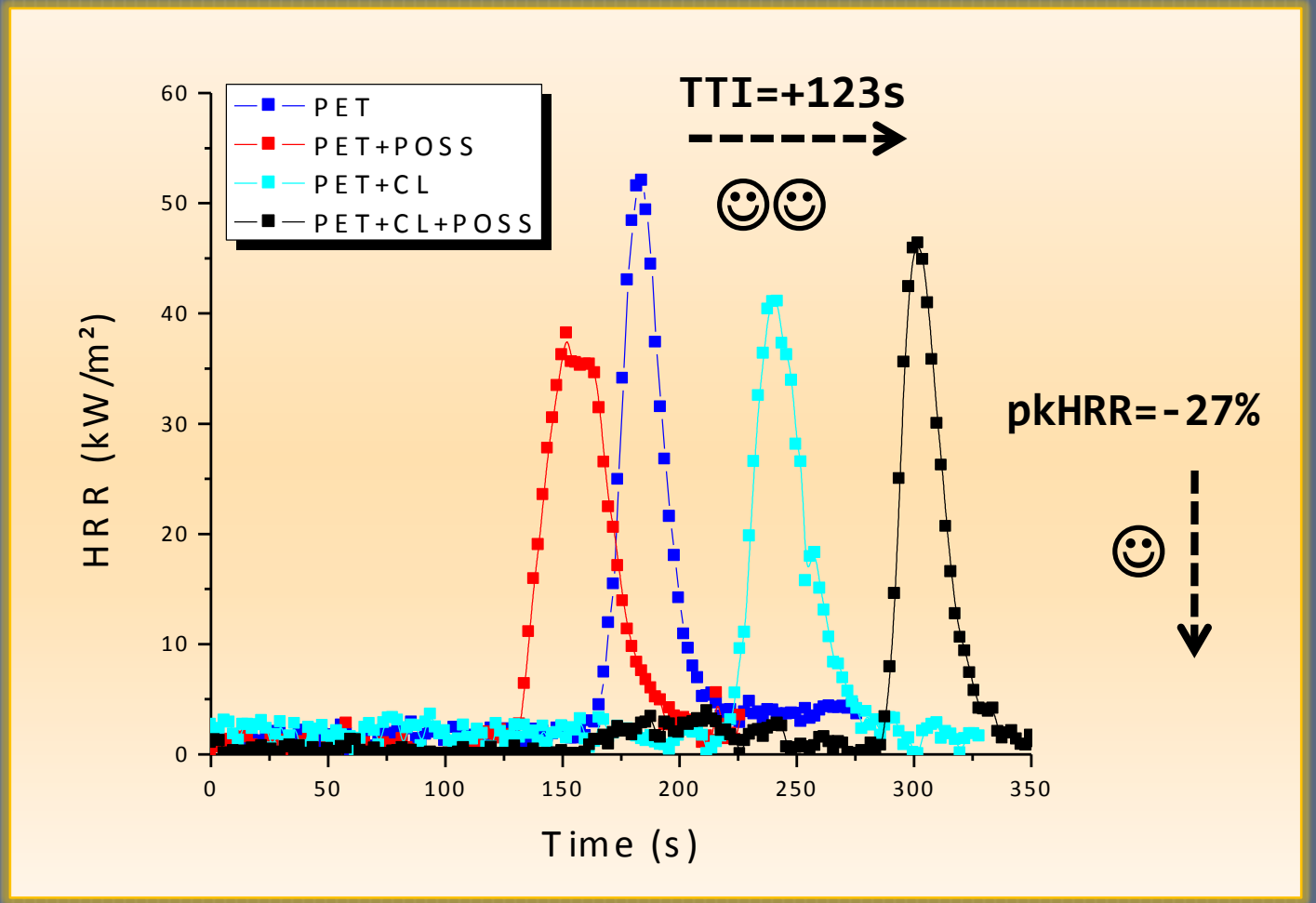




PET+POSS

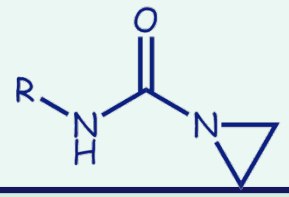
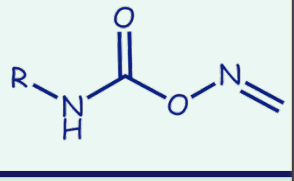
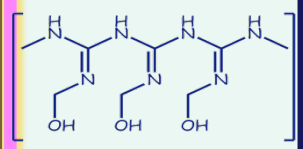
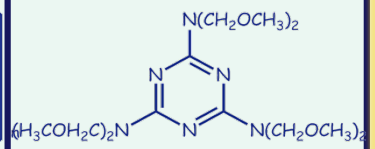
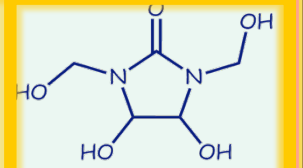
WHAT IS POSS? $RSIO_{15}$

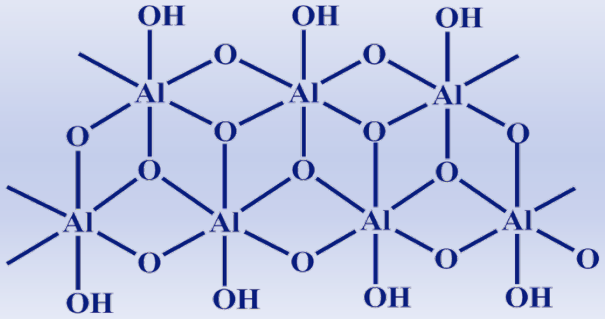


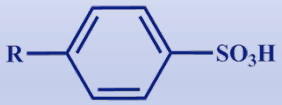


COTTON+CL+FILLER [1WT.-%]

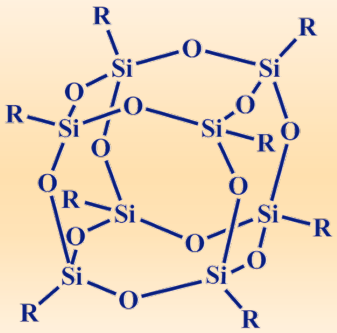
CROSS-LINKERS (CL)

FORMULA					
CODE	A	B	C	D	E



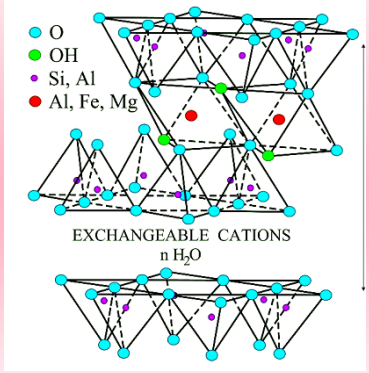


OS1



R = 

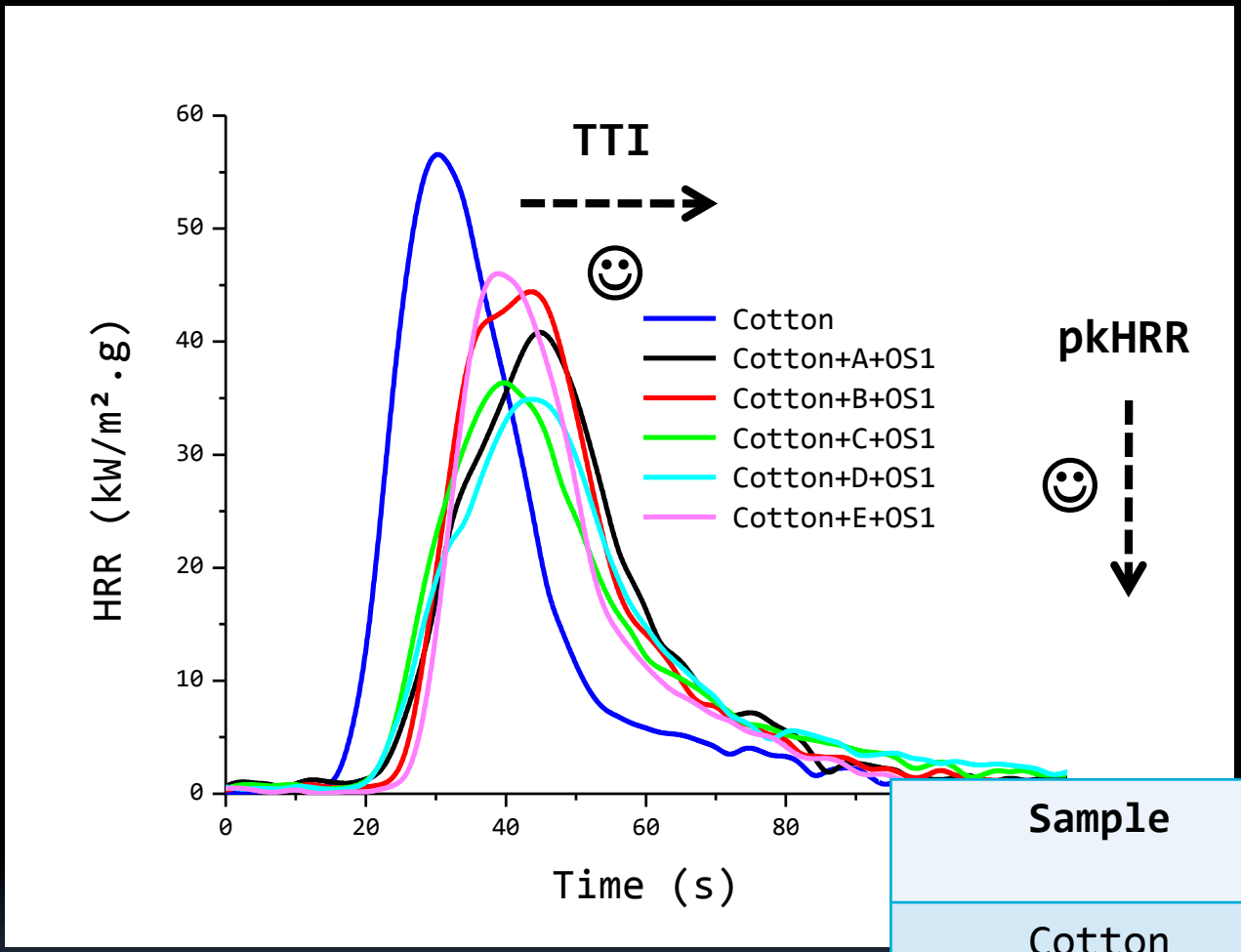
POSS



CNa

CNa [%]	POSS [%]	CNa:POSS [%]
1	1	-
2	2	1:1
5	5	2.5:2.5

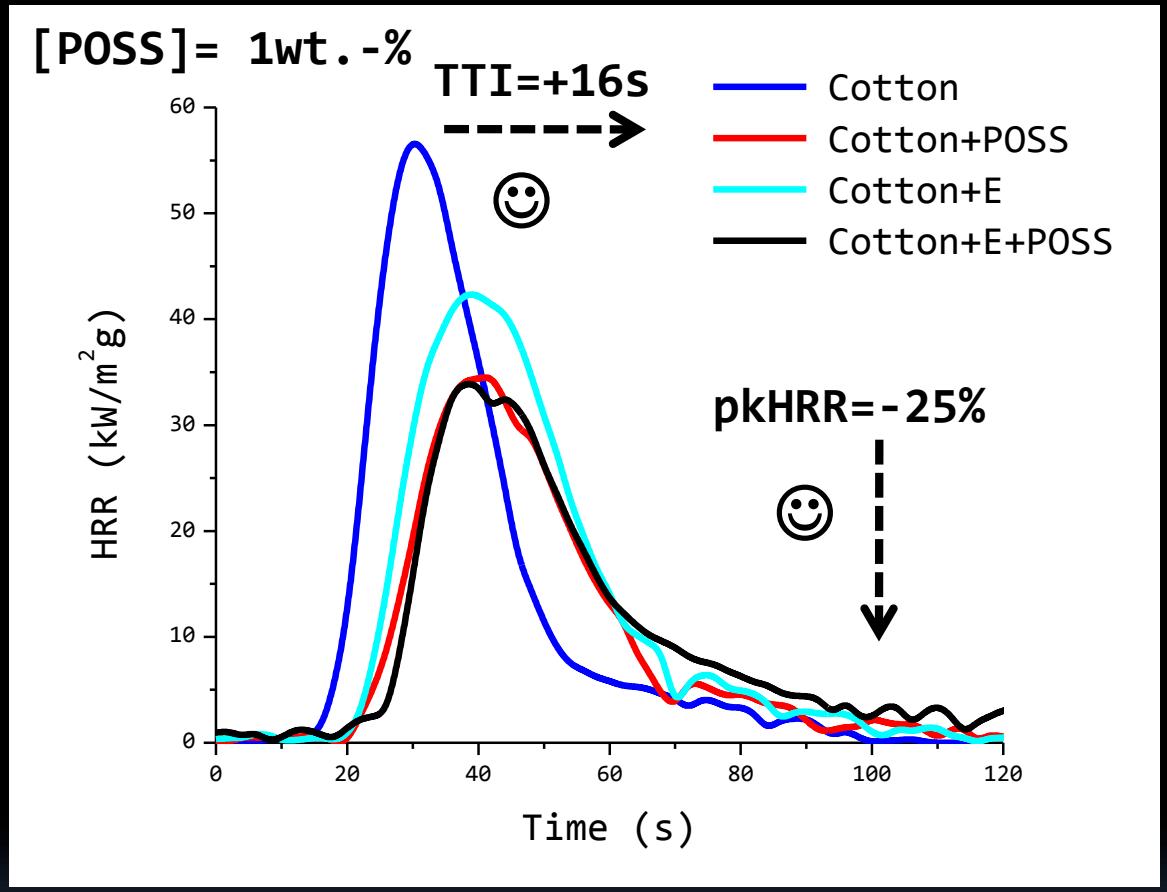
COTTON+OS1



Sample	TTI (s)	pkHRR (kW/m².g)
Cotton	17	57
Cotton+A+OS1	26	41
Cotton+B+OS1	23	45
Cotton+C+OS1	21	36
Cotton+D+OS1	21	35
Cotton+E+OS1	28	46

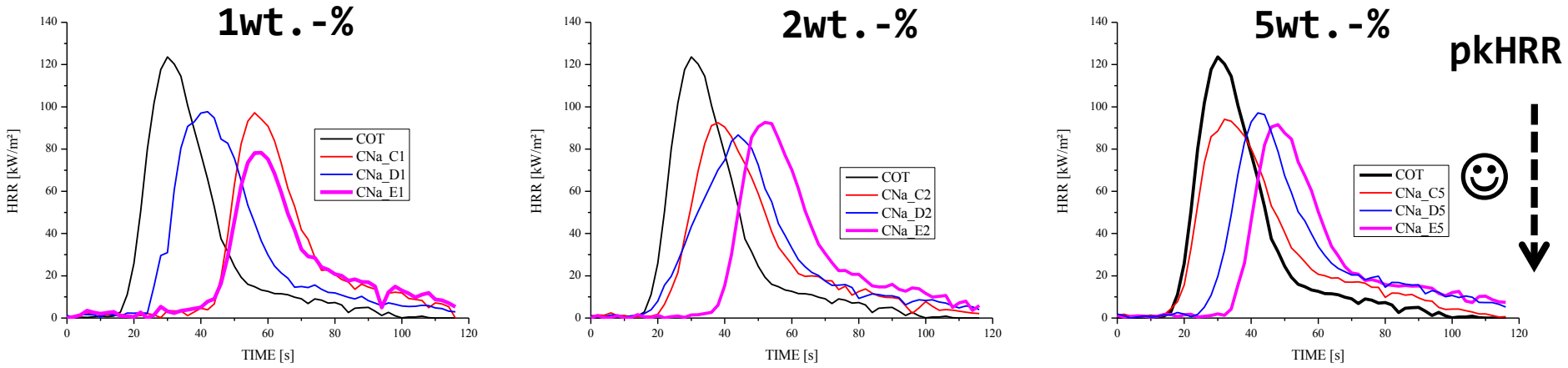
Use of cone calorimetry to measure the combustion behavior of POSS and boehmite finished cotton textile fabric
J. Alongi, J. Tata, G. Brancatelli, A. Frache, G. Rosace *submitted to Applied Surface Science*

COTTON+POSS



Sample	TTI(s)	pkHRR(kW/m²g)	Δ (%)
Cotton	14	57	-
Cotton+E+POSS 1%	30	42	-25
Cotton+E+POSS 2%	35	32	-44
Cotton+E+POSS 5%	27	33	-44

COTTON+CNa



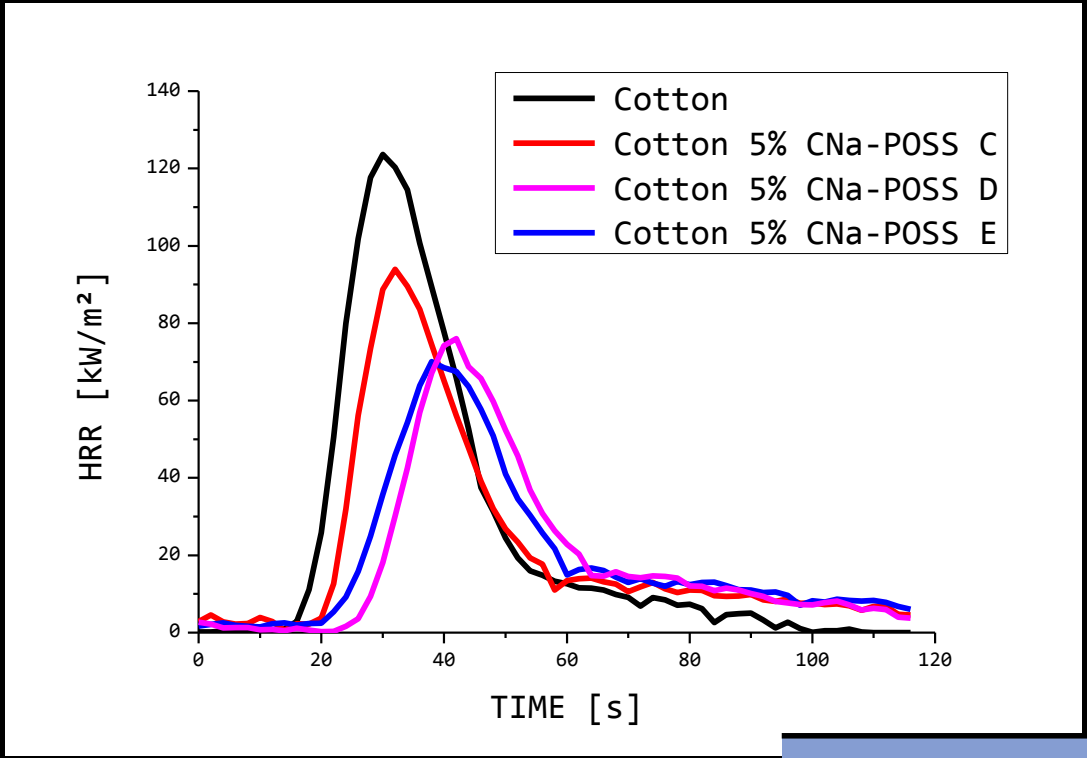
TTI increases of ca. 30s for each CL ☺

➢E cross-linker turns out the best cross-linker to link CNa

➢ The better performance is obtained with 1wt.-% of CNa

	TTI [s]	Δ [s]	pkHRR [kW/m²]	Δ [%]
Cotton	15	-	123	-
Cotton+E+CNa 1%	40	+25	77	-37
Cotton+E+CNa 2%	36	+19	92	-25
Cotton+E+CNa 5%	33	+18	91	-26

COTTON+CNa+POSS: synergism between two NPs????



$[filler]_{tot}$=5wt.-%

➢E cross-linker turns out the best cross-linker to link both CNa and POSS

➢ there is no a synergistic effect between CNa and POSS in terms of TTI increase and pkHRR decrease

	TTI [s]	Δ [s]	pkHRR [kW/m²]	Δ [%]
Cotton	15	-	123	-
Cotton+E+POSS 2%	40	+25	61	-51
Cotton+E+POSS 5%	28	+13	67	-45
Cotton+E+CNa 2%	36	+19	92	-25
Cotton+E+CNa 5%	33	+18	91	-26
Cotton+E+CNa+POSS 5%	26	+11	70	-43

POLITECNICO DI TORINO-ALESSANDRIA BRANCH

…thanks…

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