



SCIENCE RESEARCH CENTER

# FLAMMABILITY AND THERMAL STABILITY OF COTTON FABRICS TREATED WITH MICROENCAPSULATED TRIPHENYL PHOSPHATE

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# PROBLEM

- Commercially available non-durable and semi-durable flame retardants (FR) for cellulose fibers continue to base on phosphate or phosphonate salts as well as phosphonic acid.
- All commercial organophosphorus flame retardants are both water-soluble and in spite of being permanently fixed there is a slow decrease of flame resistance after several cycles of laundering



# POSSIBLE SOLUTION

- Microencapsulation of FR agent
- Microencapsulation is defined as a technology of packaging solids, liquids or gaseous materials in miniature, sealed capsules that can release (or not) their contents at controlled rates under the influence of specific conditions.
- This core/shell structure allows isolation of the encapsulated FR agent from the surroundings and thus protects it from any degrading factors such as water.



# WHY HAVE WE CHOSEN TRIPHENYL PHOSPHATE FOR CORE MATERIAL AND MELAMINE FORMALDEHYDE FOR SHELL MATERIAL

- TPP is cheap
- Solid TPP as FR core agent is simple to microencapsulate
- TPP is widely used as a non-solvent plasticizer for cellulose acetate films giving flexibility and toughness to the films
- TPP is excellent FR agent and plasticizer for synthetic resins based on phenolics- and phenylene oxide, as well as formaldehyde in production of stencil blanks, dopes films, varnishes, plastics, lacquers etc .
- Melamine formaldehyde is mechanically the strongest and the most durable material for



# EXPERIMENT

- We have examined the possible flame retarding effect of triphenyl phosphate melamine formaldehyde microcapsules (mTPP MF) loaded by screen printing on cotton fabrics .
- For comparison a commercial organophosphite flame-retarding agent was used and applied onto cotton fabric by impregnation.
- The flame retarding behavior as well as thermal stability of printed fabrics were valued with the LOI and the TGA analyses before and after one laundering cycle. The morphology of fabric surfaces was observed using the SEM.



# FR MICROCAPSULES SPECIFICATION

- FR microcapsules were obtained by in situ polymerization (Aero d.d.)
- Core: 100% solid triphenyl phosphate
- Shell: melamine formaldehyde
- Weight percent of shell: 25%
- Weight percent of core: 75%
- Percent of microcapsules in suspension: 35-40%
- Diameter: 4-8  $\mu\text{m}$
- 1 kg of suspension contains cca 26% of triphenyl phosphate



# PRINTING PASTE SPECIFICATION

- Synthetic thickener for pigment printing (Tubivist DRL 300, Bezema AG)
- Pigment printing binder based on acrylate styrene (Tubifast AS 30, Bezema AG)
- Distilled water
- Pigment dye (Bezaprint Braun RRT, Bezema)
- FR microcapsules, suspension (Aero d.d.)



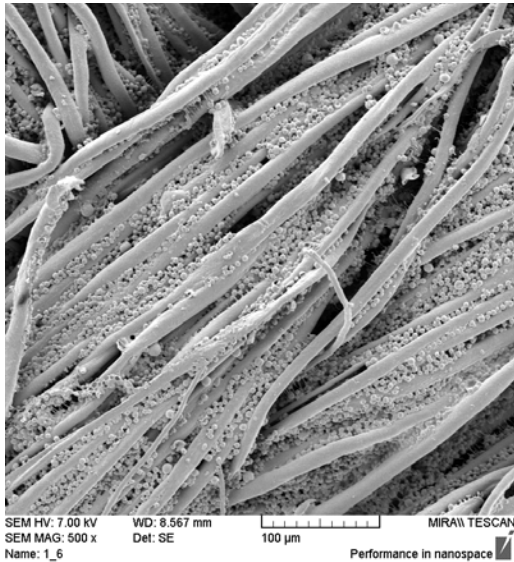
# IMPREGNATION SOLUTION SPECIFICATION

- Organophosphite flame-retardant finishing (Apyrol CEP, Bezema AG)
- Cross linking agent based on low-formaldehyde melamine resin (Apyrol MH, Bezema AG)
- pH regulator phosphore acid 85%
- Distilled water

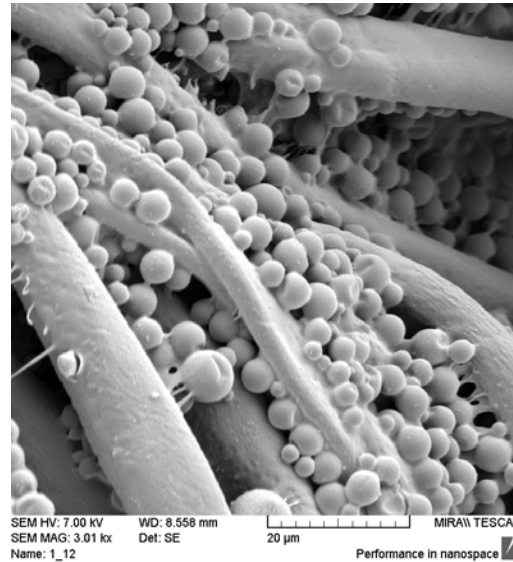




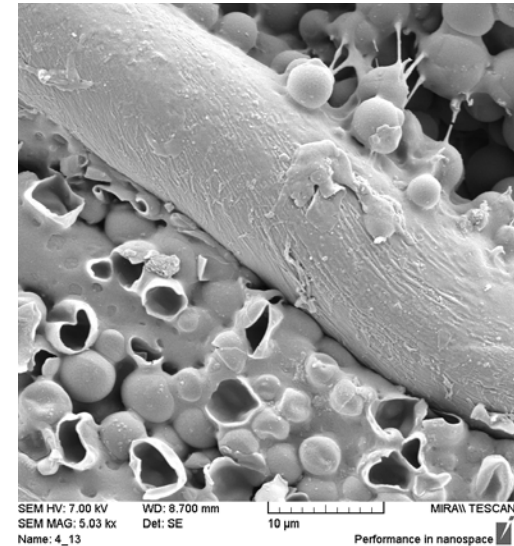
# RESULTS - SEM IMAGES OF PRINTED FABRICS



a)



b)

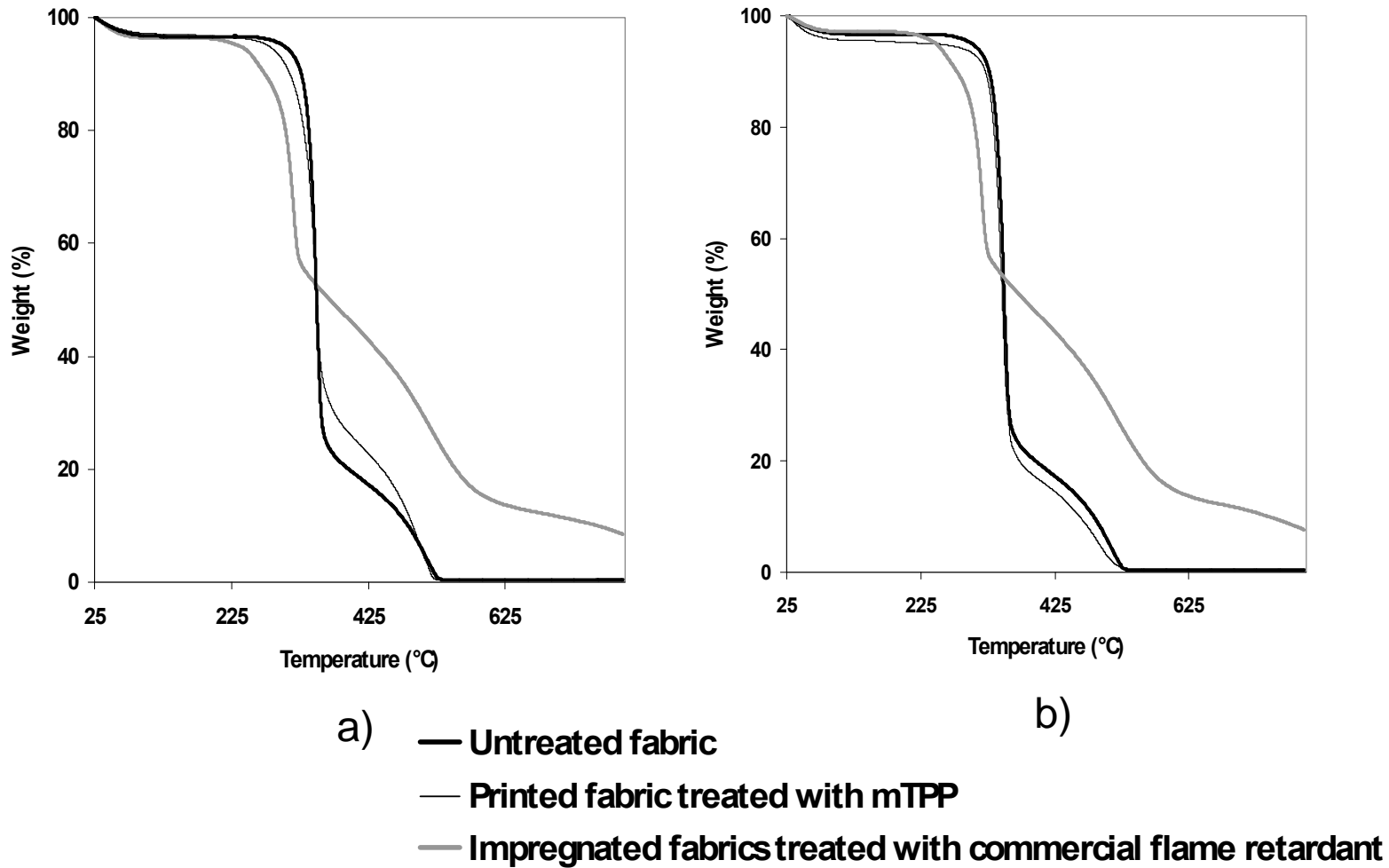


c)

**Figure 1:** SEM images of printed fabric treated with mTPP: a) unwashed MAG 500x and b) unwashed MAG 5000x c) washed MAG 5000x



# RESULTS – TGA CURVES



**Figure 2:** TGA curves of a) unwashed fabrics b) washed fabrics



# RESULTS – LOI VALUES

TYPE	LOI / %
Printed fabric treated with mTPP unwashed	22.00
Printed fabric treated with mTPP washed	21.00
Impregnated fabric treated with commercial FR unwashed	35.00
Impregnated fabric treated with commercial FR washed	34.00
Untreated fabric	20.00



# CONCLUSION

- TGA analysis have shown that mTPP has a very small influence on flame retardancy of cotton fabrics.
- The LOI values correspond to TGA analysis for printed fabrics treated with mTPP (22% before and 21% after washing).
- SEM images of mTPP treated fabric have shown that the amount of microcapsules adhered to textile surface remained after the washing, although their stability was apparently affected by the laundering process in sense of breakage of MF shell and leakage of TPP core.
- It has been proved that melamine formaldehyde shell of microcapsules is durable to washing, but due to external forces and pressure in the process of laundering, the microcapsules can deform and finally break.
- Efficiency of commercial flame retardant agents is incomparably better than that of mTPP. This is probably due to fact that TPP is not directly chemically bound to fibers.





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# THANK YOU...

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