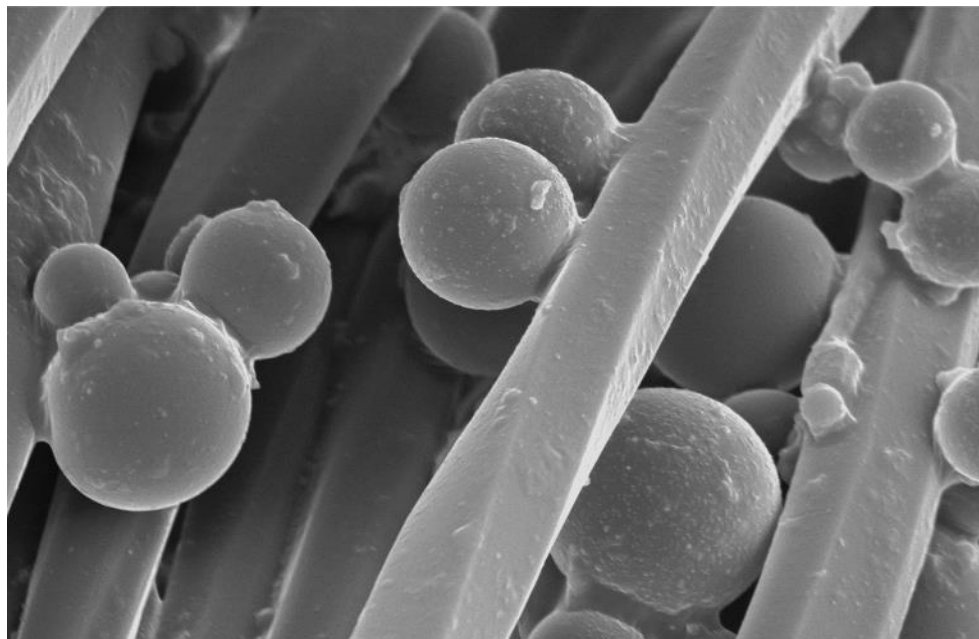


The logo for Devan Chemicals features a stylized green flask icon on the left. To its right, the word "devan" is written in a dark blue, lowercase, sans-serif font. Above the "van" portion of "devan", the word "chemicals" is written in a smaller, light green, lowercase, sans-serif font.



Bringing textiles to life 

# Development of microcapsules as additives for advanced composites



## *Innovations in Encapsulation*

**12 December 2014, London, UK**

Roberto Teixeira, Maxime Durka and Alexandre Beirão



# Core business

Bringing textiles **to life** 

**By creating innovative  
properties and  
functionality**

**Taking into  
consideration  
sustainability**



# Microencapsulation Platform

**Probiotex**<sup>®</sup>

Allergen Control by using *reactive* microencapsulated probiotic endospores on textiles

ALLERGEN CONTROL  
TECHNOLOGY



Sensorial Management Control by using *reactive* microencapsulated fragrances and body/skin care extracts on textiles

SENSORIAL MANAGEMENT  
TECHNOLOGY



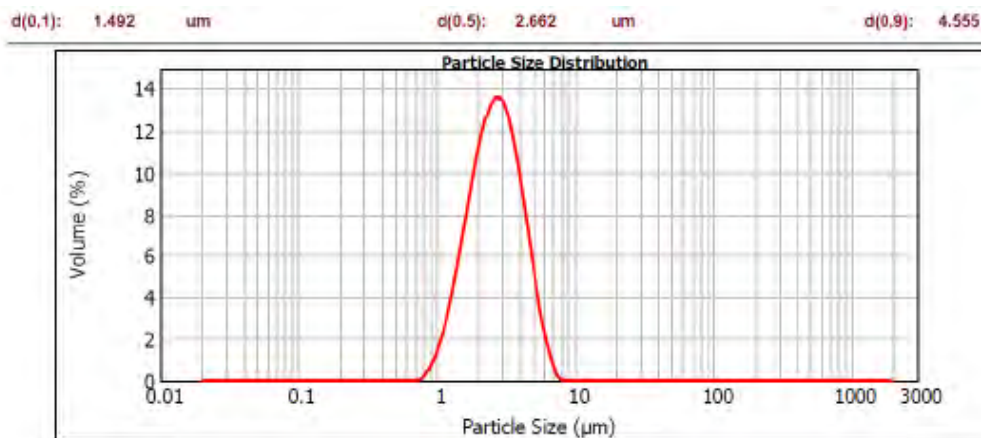
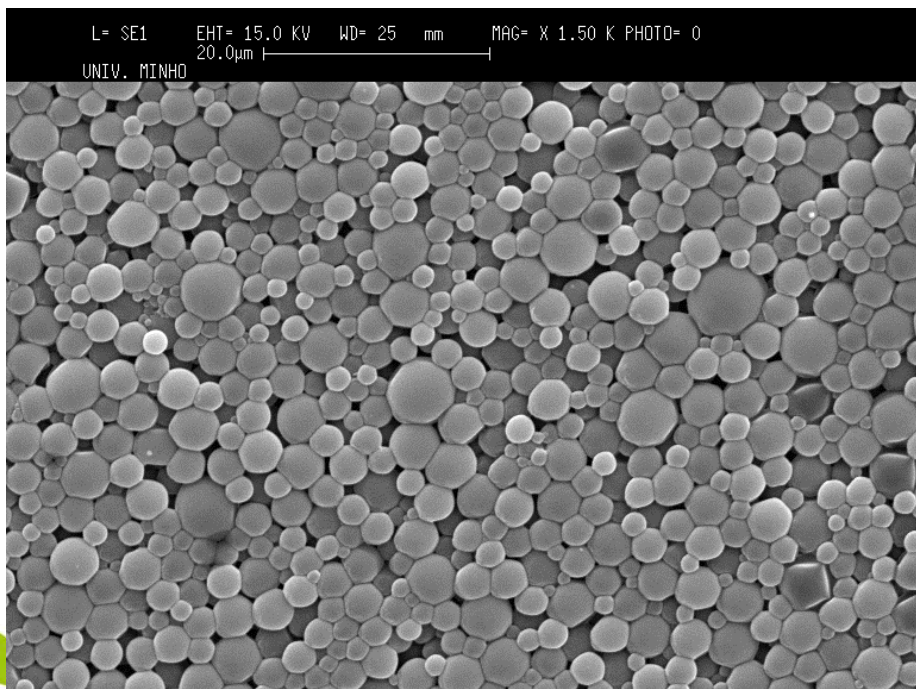
Thermoregulation Control by using *reactive* microencapsulated phase change materials on textiles

THERMOREGULATION  
TECHNOLOGY



Insect Control by using *reactive* microencapsulated natural & friendly repellents on textiles

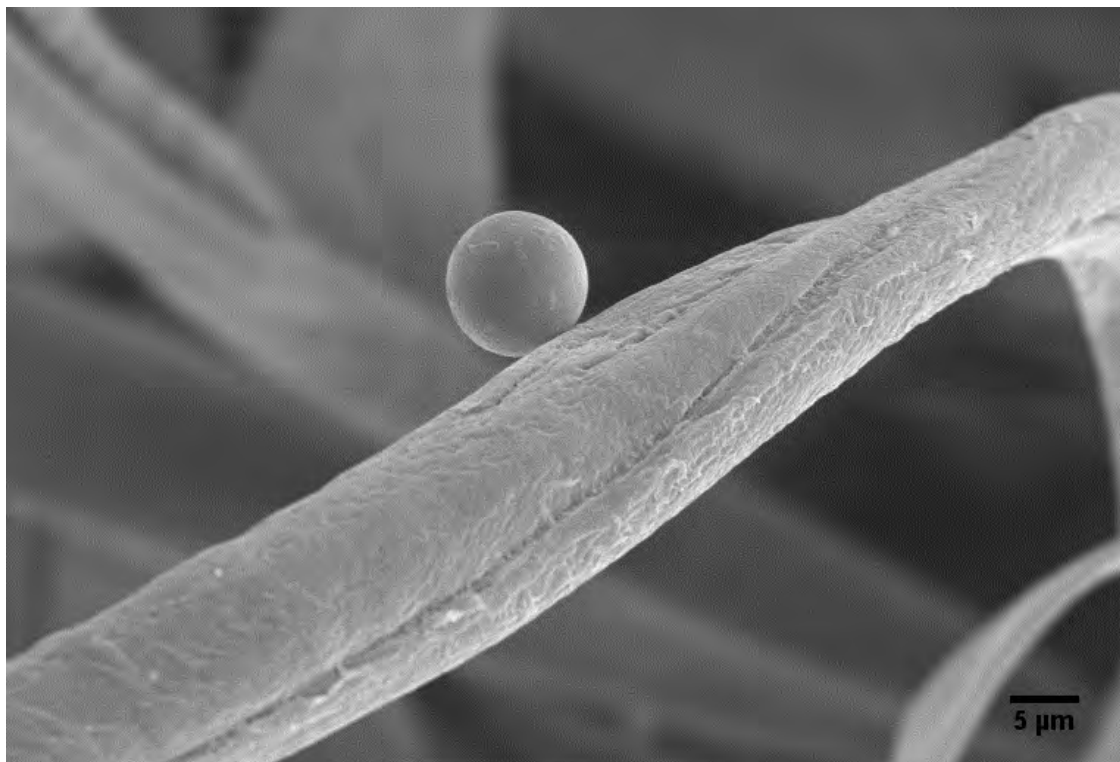
# Typical Microcapsules @ Devan



Small Size (d: 0.9 4.55µm) and monodisperse microcapsules

# Typical Microcapsules @ Devan

Work on the adhesion and wash durability



Controlled affinity and covalent reaction with fibers through available functional groups (shells to fibers).

Patented (WO/2006/117702).

# Self-Healing Concept

‘ Self healing material (SHM) is a material that has the built-in ability to fully or partially repair the damage occurring during its life time’

**Common goal: mimicking biological systems**



# Self-healing materials

**Intrinsic self-healing systems:**

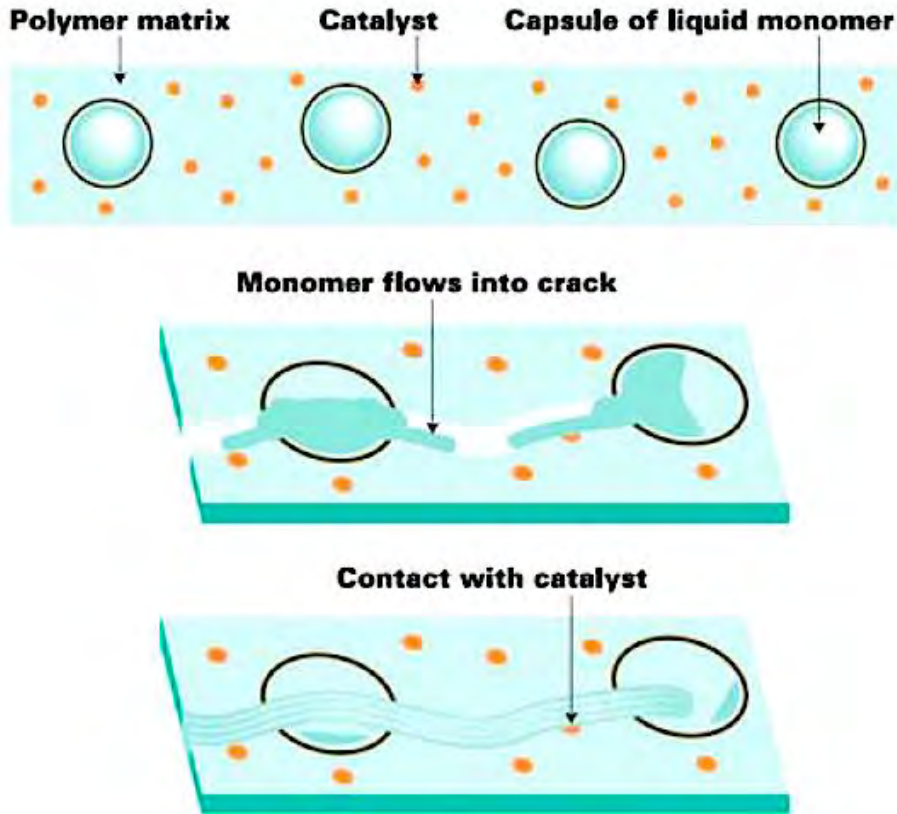
**Extrinsic self-healing systems:**

- **Microcapsules**
- Hollow fibers
- Microvascular systems
- Meltable particles





# Microcapsules in Self-Healing



## Self-healing concept:

**Autonomous:** no external stimulus needed

Thermoset materials with microcapsules containing healing agents

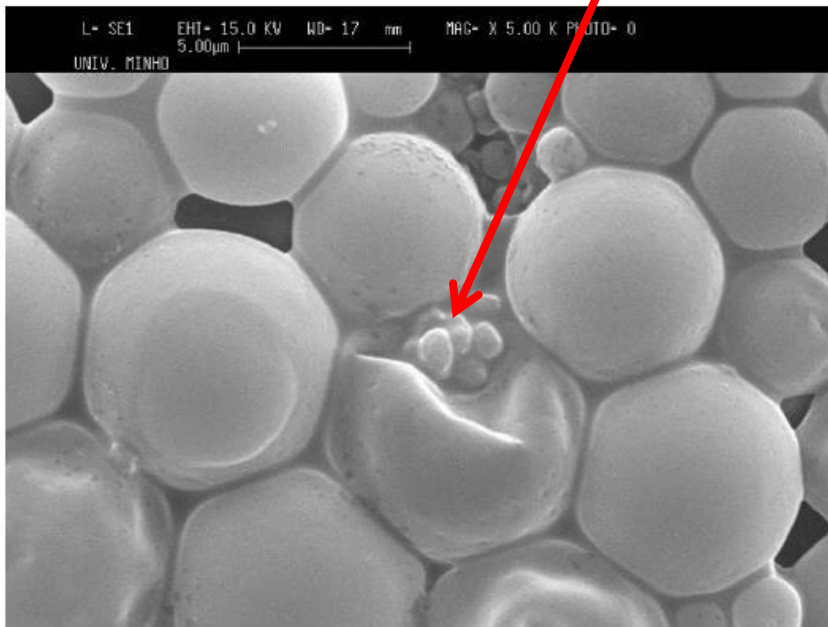
Different matrix materials: epoxy, polyurethanes, unsaturated polyesters

Self-healing concept using embedded microcapsules (adapted from Kessler, M. R. "Self-healing: A New Paradigm in Materials Design." P. I. Mech. Eng. G-J. Aer. 221 (2007) 479.)

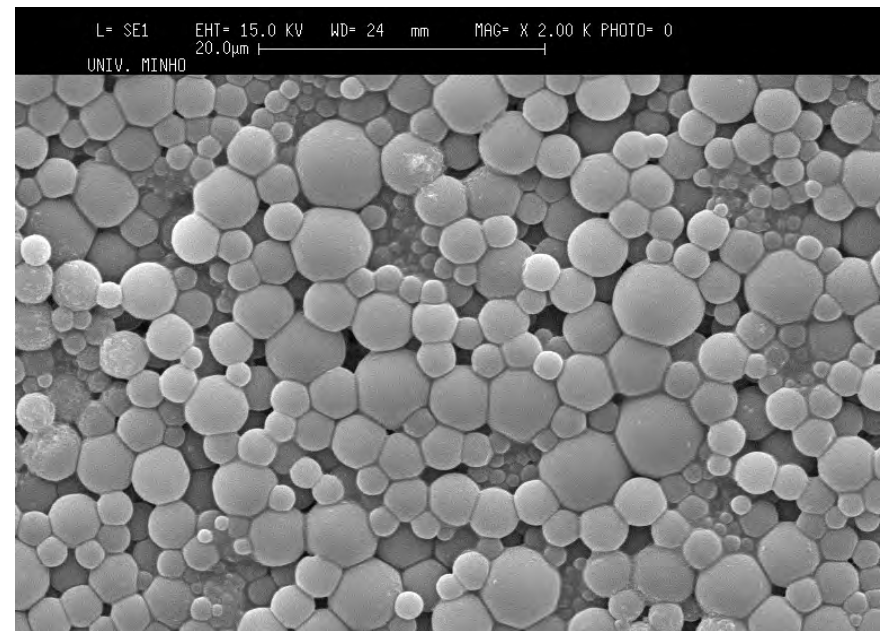
# Encapsulation of Biogenic Agents and Yeast extracts using MF Shell

1. Suspension in inert oil
2. Emulsion is formed with addition of water & shell precursors
3. Formation of the shell under temperature treatment

**Spores**



**FOOD SOURCE** in separated container  
**Microcapsules containing Yeast extracts**

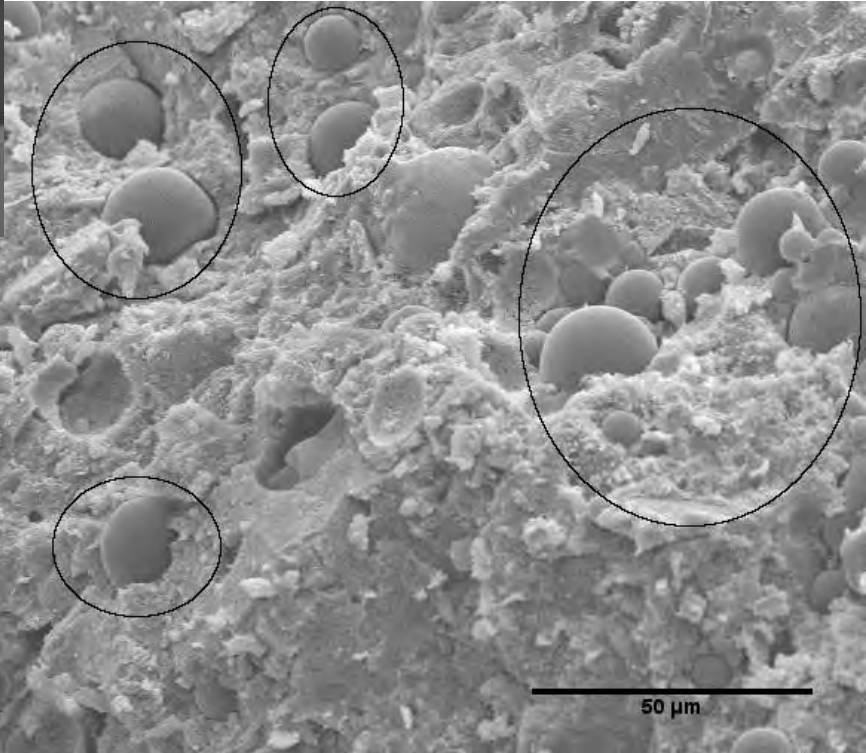
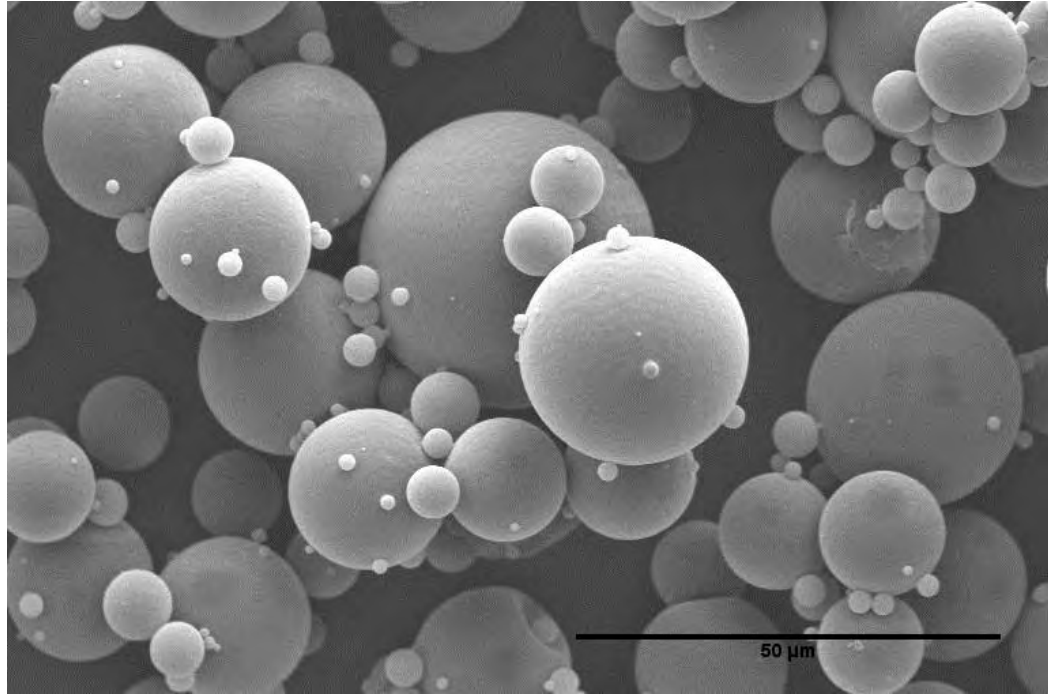


# MF Microcapsules dispersed in concrete

*MF microcapsules before mixing with Cement*



**Pictures from "The Magnel laboratory", UGent**



*MF microcapsules x 150*



**healCON**  
concrete which repairs itself

BRINGING TEXTILES TO LIFE

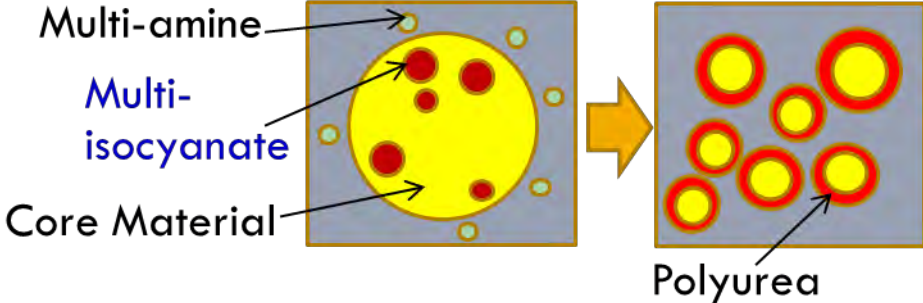
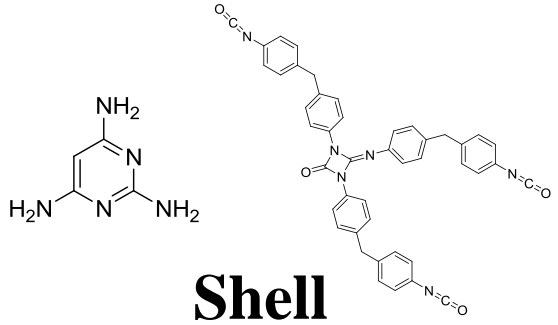
# Encapsulation of Isocyanates by Polyurea Shell



## Polyurea shell

Isocyanate component

Amine component

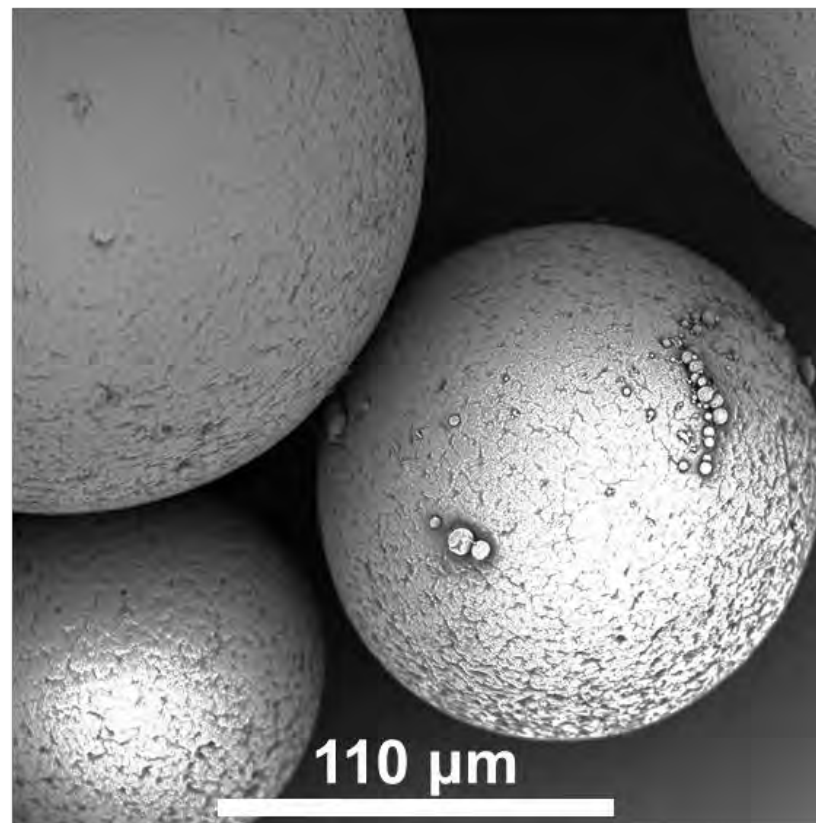
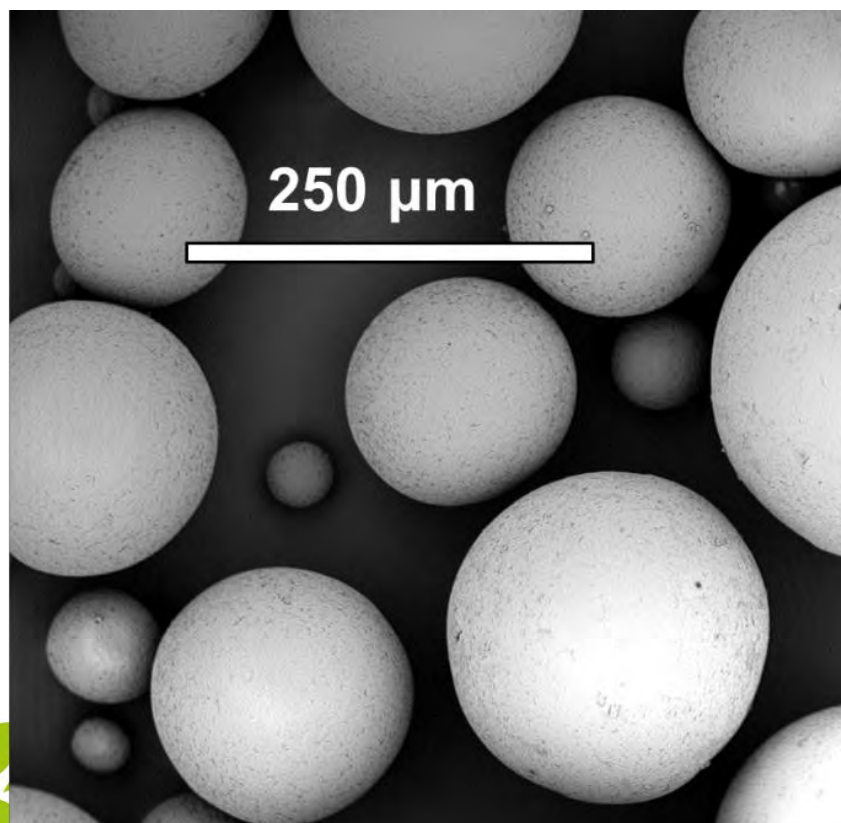


## Successful Microencapsulation of Isocyanates

### Tackled challenges:

- ✓ Functionalisation of capsule shell with different hydrophobic agents to improve the shelf-life of capsules
- ✓ Low core content (60%, in the literature) and short shelf-life

# Capsules with non-functionalised shell

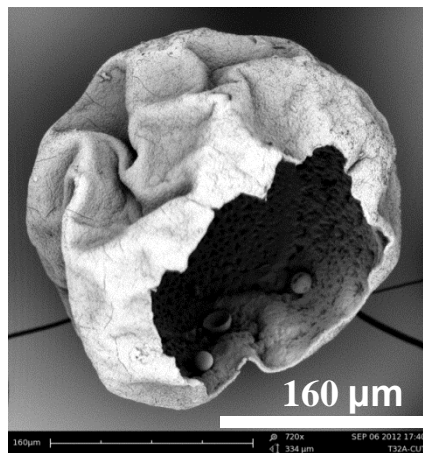
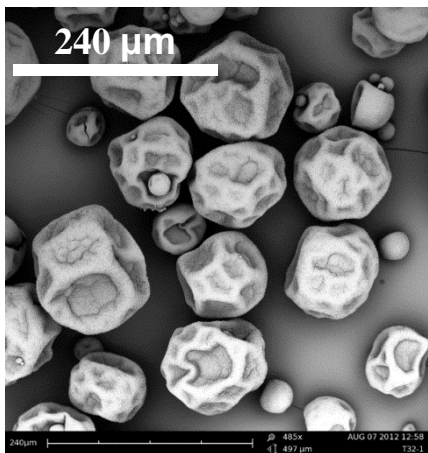


Isocyanate core content 52%  
Smooth microcapsules

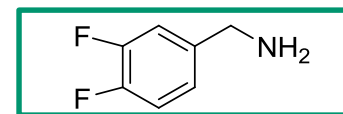
L. T. T. Nguyen, X. K. D. Hillewaere, R. F. A. Teixeira, O. Berg, F. E. Du Prez, Polymer Chemistry, Article ASAP

# Capsules with functionalised shell

## Encapsulation of Isocyanates

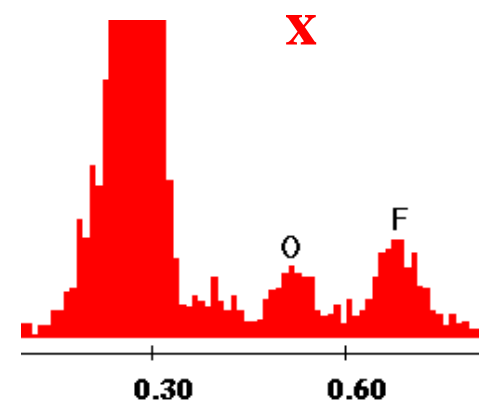
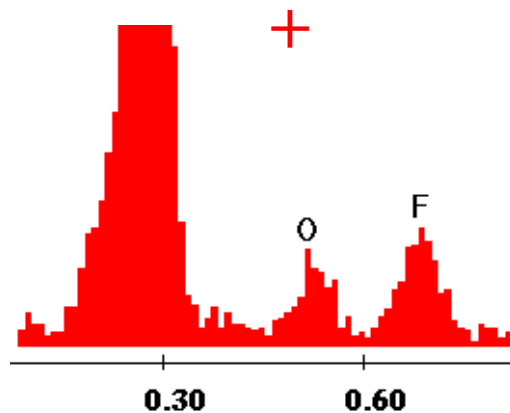
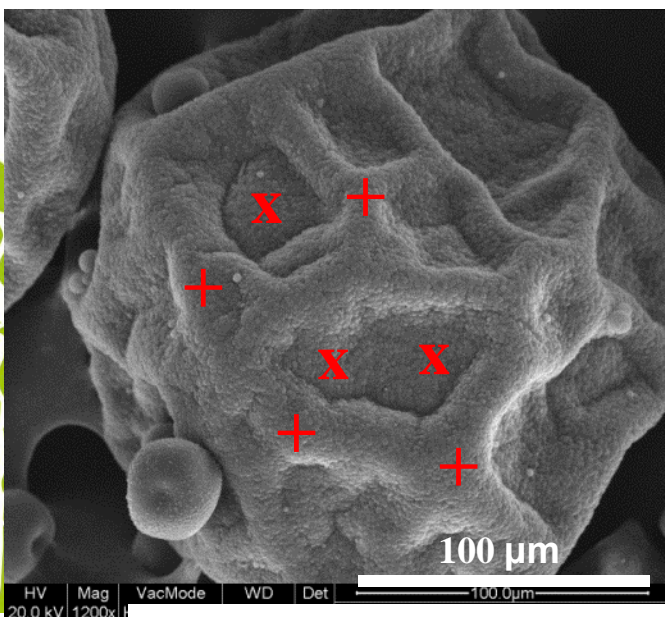


Cryo-Cut +  
core wash

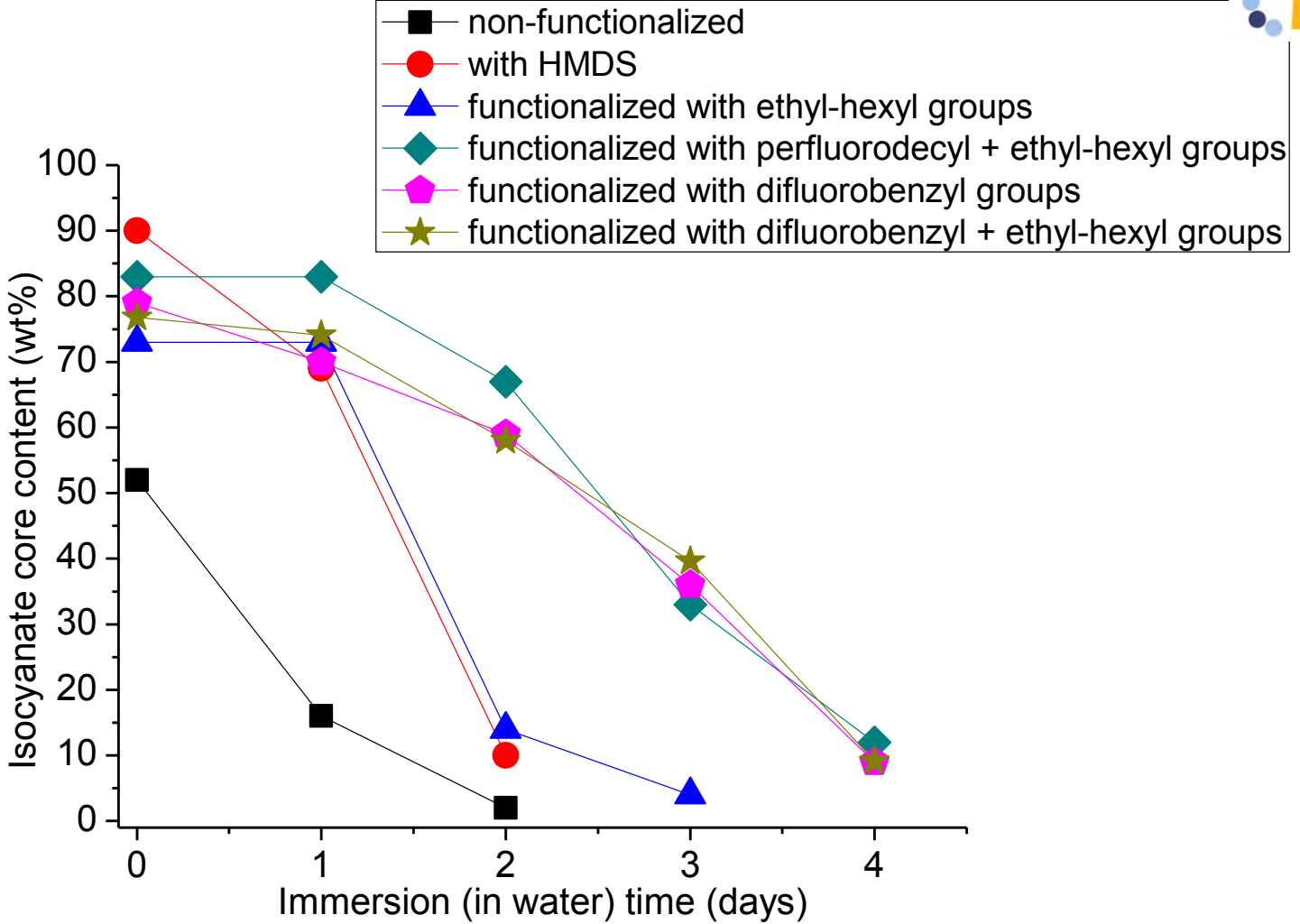


**Isocyanate  
core content  
79 wt%**

**Uniform distribution of F**



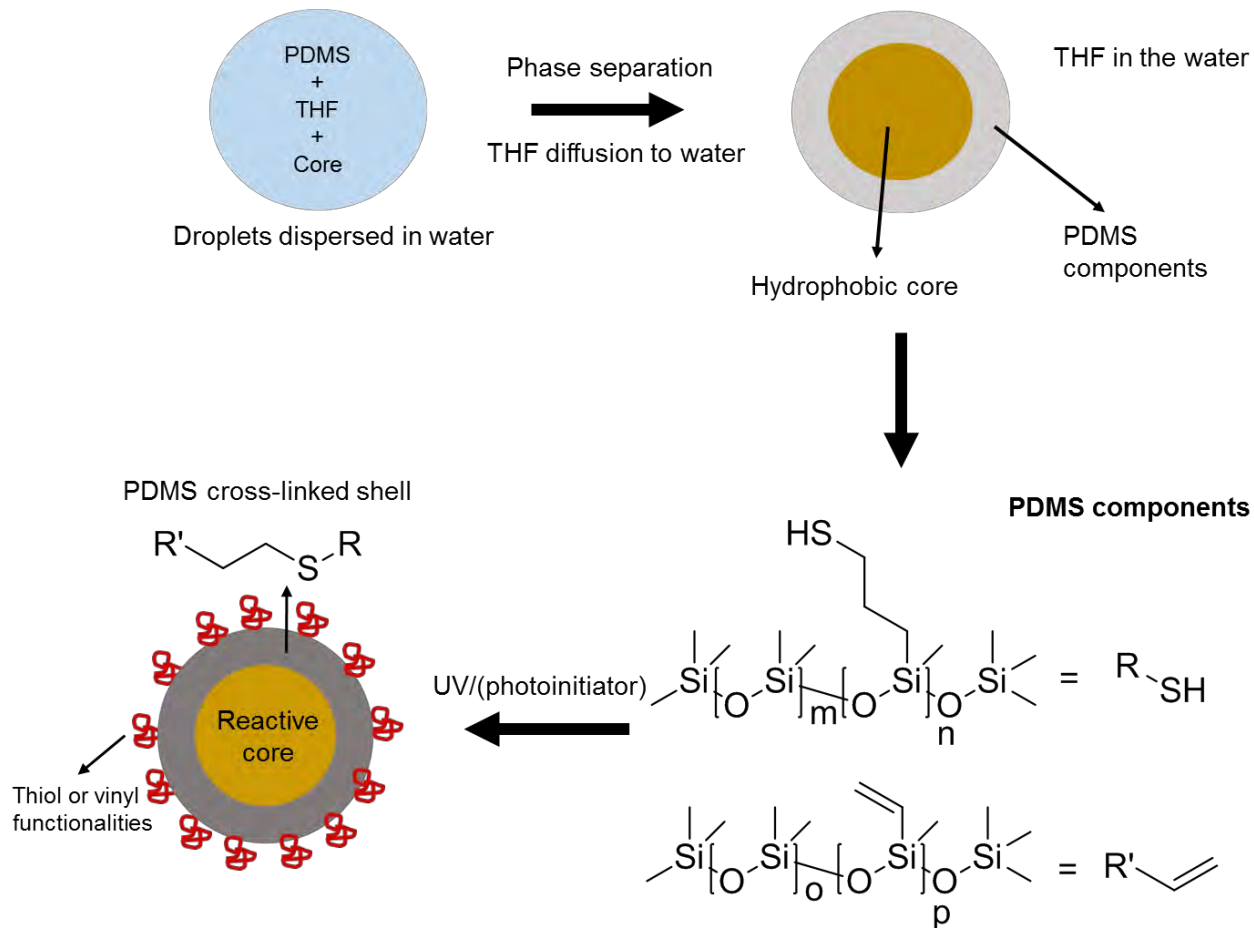
# Shelf-life of Isocyanate-containing microcapsules



L. T. T. Nguyen, X. K. D. Hillewaere, R. F. A. Teixeira, O. Berg, F. E. Du Prez, Polymer Chemistry, Article ASAP



# Microencapsulation of Active Ingredients Using PDMS as Shell Material – Encapsulation of multi-thiols

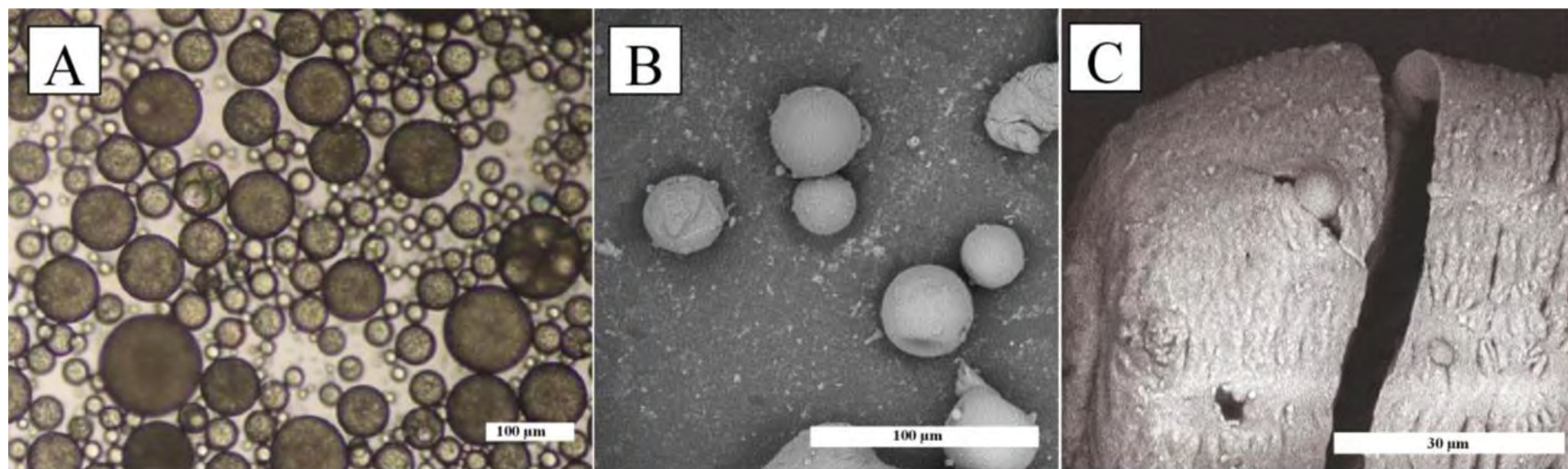


R. F. A. Teixeira, O. Berg, L. T. Nguyen, K. Feher, F. E. Du Prez, *Macromolecules*, Article ASAP.





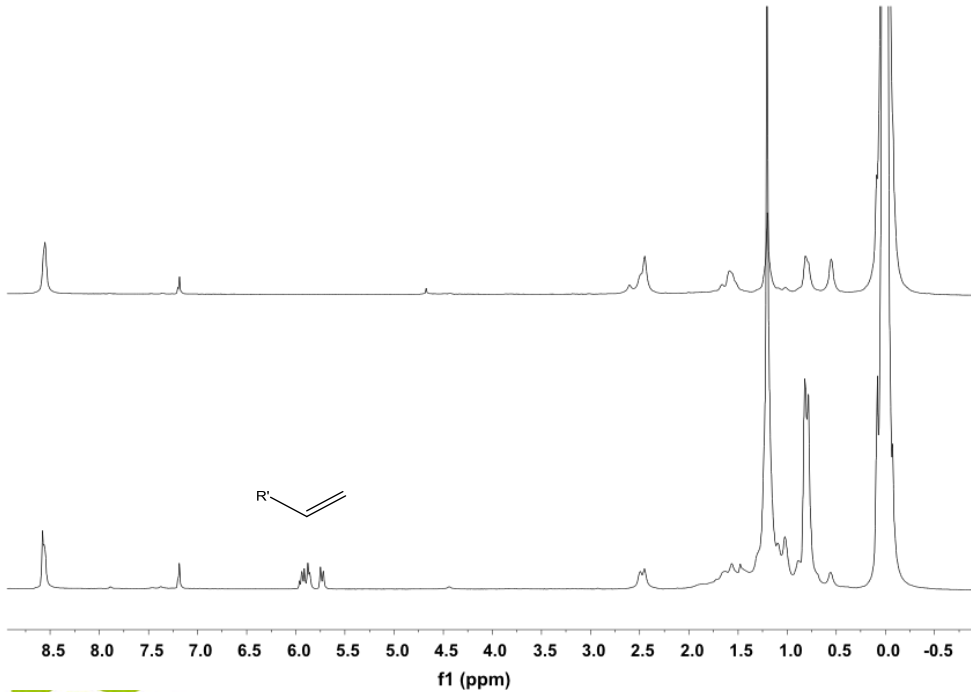
# PDMS Shell Microcapsules - Encapsulation of multi-thiols



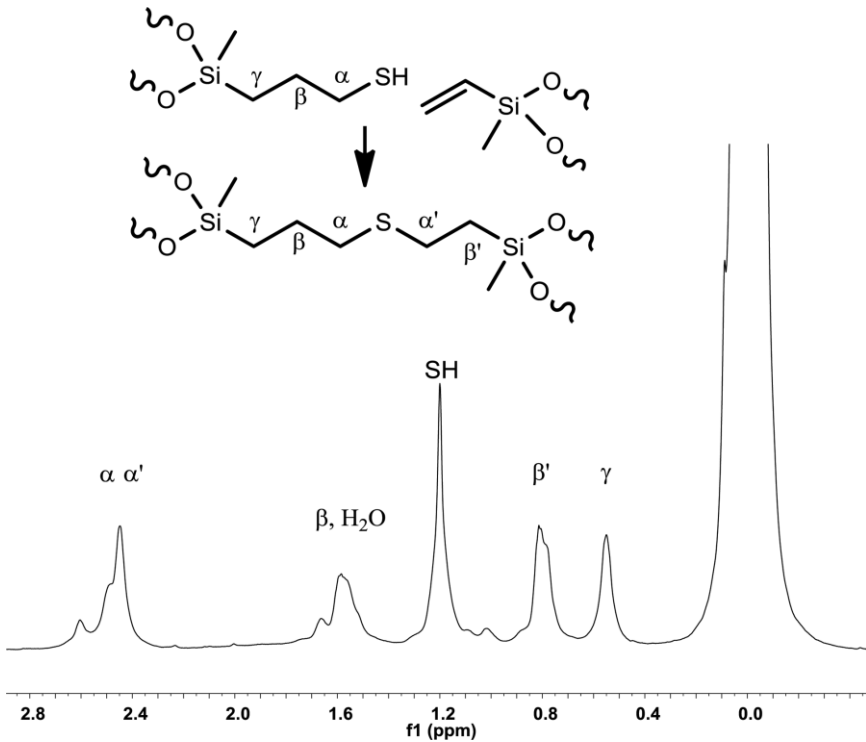
R. F. A. Teixeira, O. Berg, L. T. Nguyen, K. Feher, F. E. Du Prez, *Macromolecules*, Article ASAP.



# HR-MAS Analysis - Encapsulation of multi-thiols



Top: MC with excess of “thiol PDMS”  
Bottom: MC with excess of “vinyl PDMS”.



HR-MAS 1H NMR of MC prepared with excess of “thiol PDMS”

R. F. A. Teixeira, O. Berg, L. T. Nguyen, K. Feher, F. E. Du Prez, Macromolecules, Article ASAP.



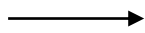
# Summary

## Out of the comfort zone

Comfort

Protection

Health



**Self-Healing**

## Microcapsules with highly reactive ingredients – Knowledge acquired

Isocyanates

Multi-thiols

## Self-healing opportunities – Market Exploration

Concrete ([www.healcon.ugent.be](http://www.healcon.ugent.be))

Elastomers (<http://www.sim-flanders.be/project/purepair>)

Epoxies



# Acknowledgments



*Thank you for your attention*

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