



POLITECNICO
MILANO 1863

I materiali avanzati per il packaging intelligente

Luigi De Nardo

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Materials for innovation lab

People



Luigi De Nardo, PhD MSc
Associate Professor

Materials science

Lina Altomare, PhD MSc
Assistant Professore

Bioengineering

Francesca Tana
PhD student
Chemistry

Margherita Basso
PhD student
Materials Eng.

Arash Galayanhesfasani
PhD student
Mechanical Eng.

Lorenzo Bonetti
PhD Student
Materials Eng.

MATERIALS
for
INNOVATION

Materials for Innovation Lab

Next Materials group

Permanent staff:

- ↘ Alberto Cigada
- ↘ Roberto Chiesa
- ↘ Maria Pia Pedferri
- ↘ Barbara Del Curto
- ↘ Gabriele Candiani
- ↘ Carmen Giordano
- ↘ Luigi De Nardo
- ↘ Lorenza Draghi
- ↘ Lina Altomare

Temporary staff:

- ↘ Marta Tunesi (Post Doc)
- ↘ 6+ PhD students
- ↘ 20 master students
- ↘ 5 Assistant researchers

Technical Staff:

- ↘ Dr. Monica Moscatelli

Materials Science

Biology

Industrial Design

The study of **functional materials for industrial applications**

- ↘ Study of **shape memory and smart materials** for the realization of new devices for **biomedical and packaging applications**
- ↘ Development of **surface modifications** based on chemical and electrochemical technologies
- ↘ Study of **hierarchical and meta-materials**

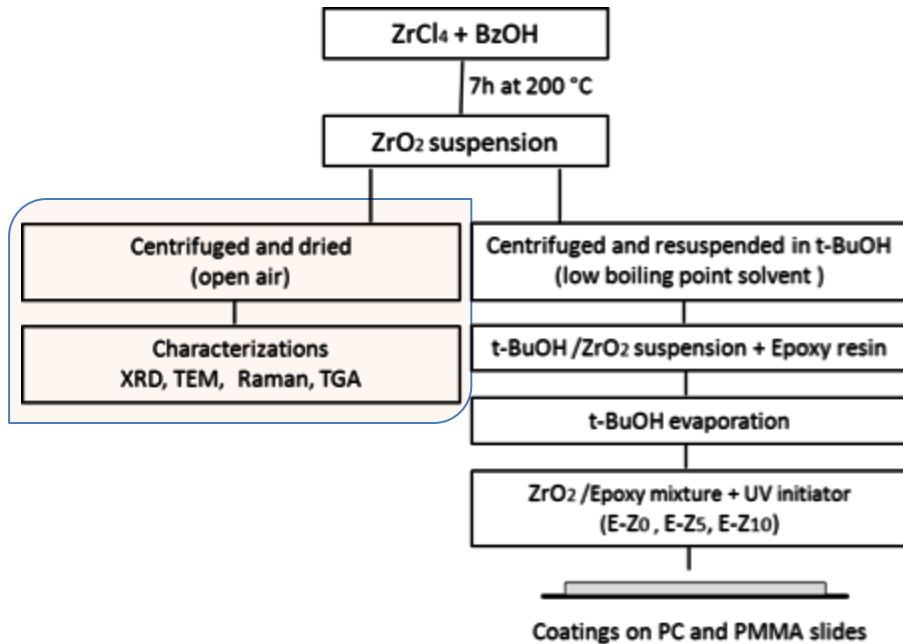
Develop knowledge and competencies in teaching, in order to provide the better training and education to high-grade students

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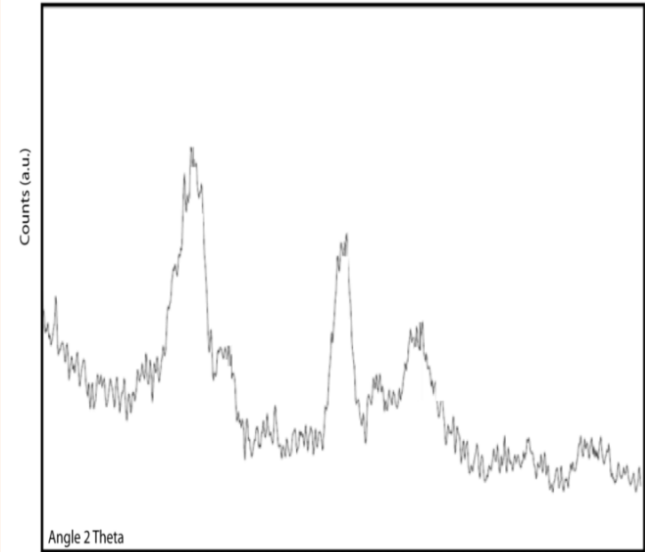
Develop knowledge and competencies in teaching, in order to provide the better training and education to high-grade students

ZrO₂ as nanofiller for antiscratch coatings

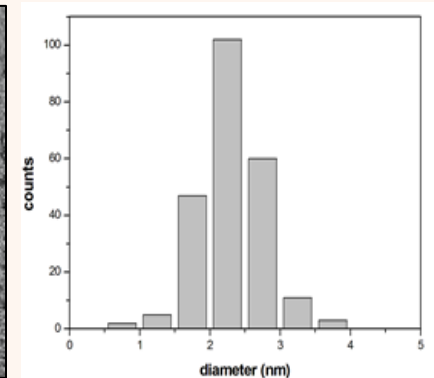
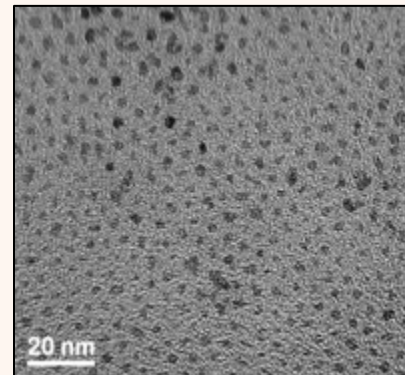


XRD: peak broadening, cubic and tetragonal peaks overlap in XRD → amorphous phase or nano-dimensions of analysed powders

TEM images: showed pseudo-spherical nanoparticles of around 2 nm and uniform size distribution

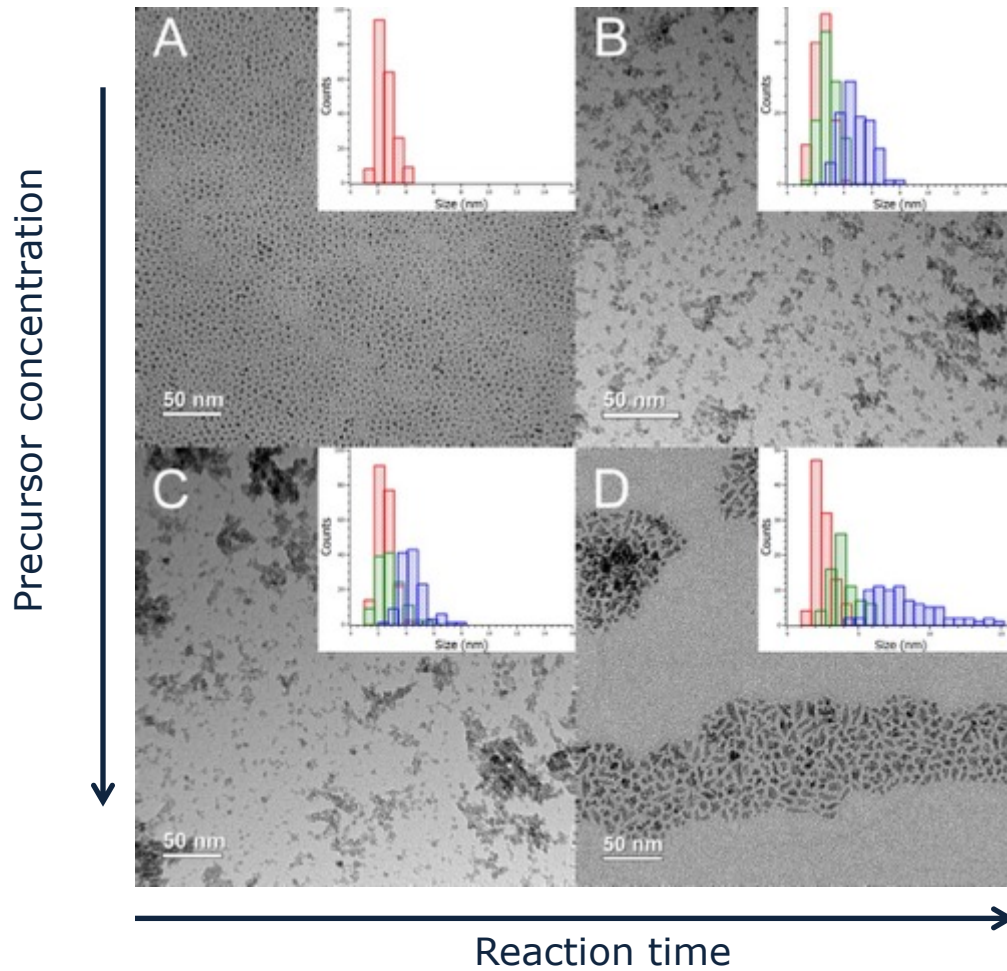


50-1089 Zirconium dioxide
27-0997 Zirconium dioxide



ZrO₂ modified synthesis

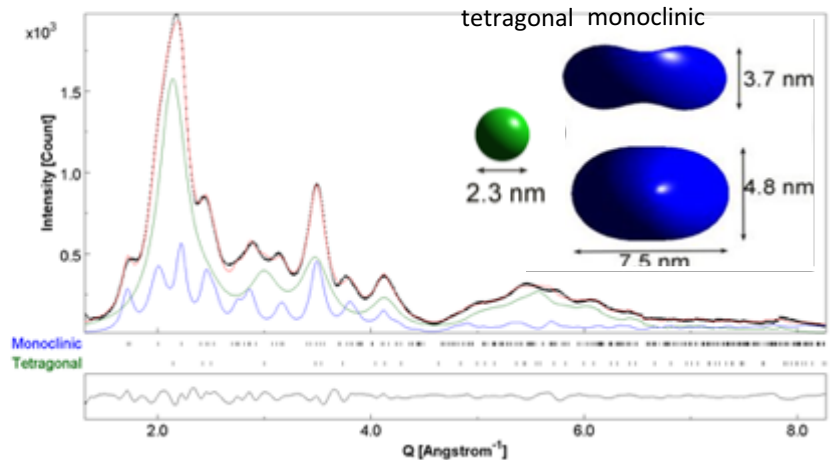
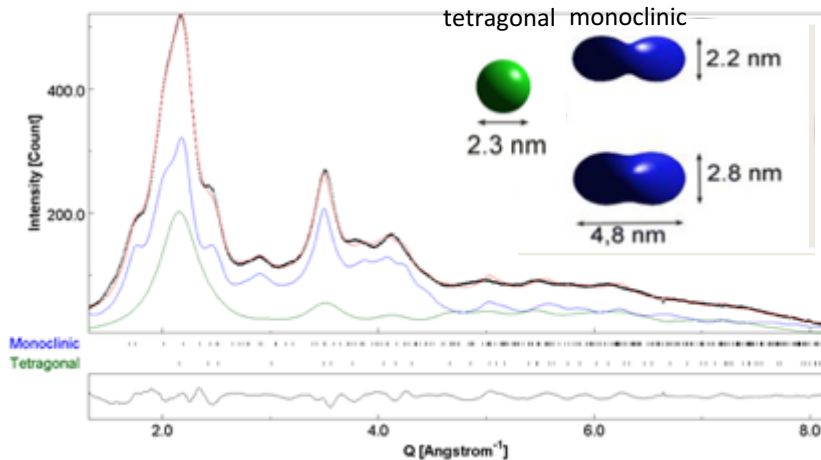
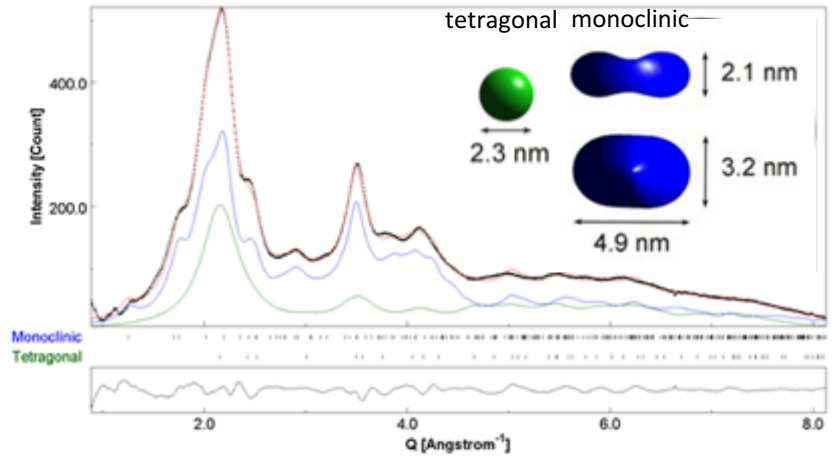
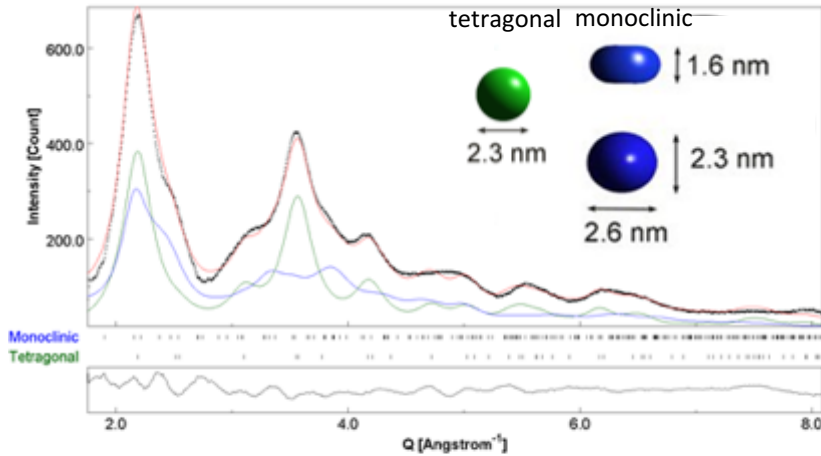
TEM characterization



ZrO₂ modified synthesis

TEM characterization

Rietveld refinement on electron powder diffraction were carried out in MAUD software (Material Analysis Using Diffraction) and allowed obtaining a model of zirconia particles shape

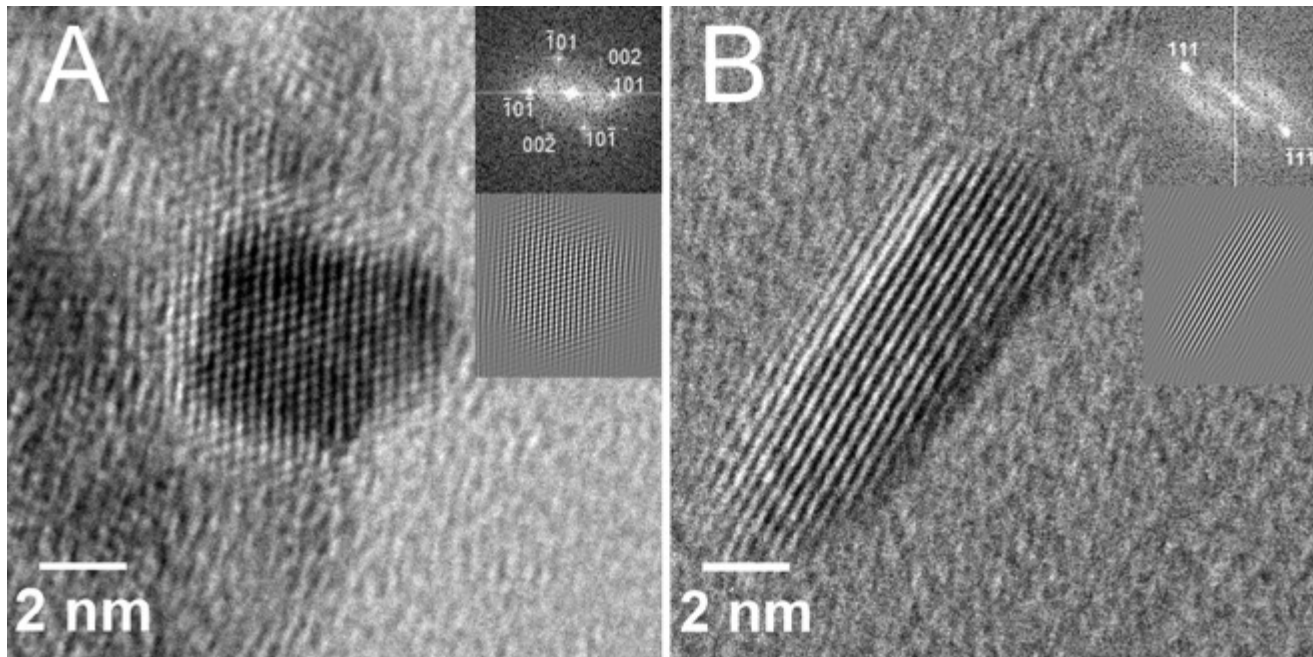


TEM analyses were performed by Andrea Serafini using MAUD software implemented by prof. Lutterotti (Università di Trento)

ZrO₂ modified synthesis

HRTEM characterization

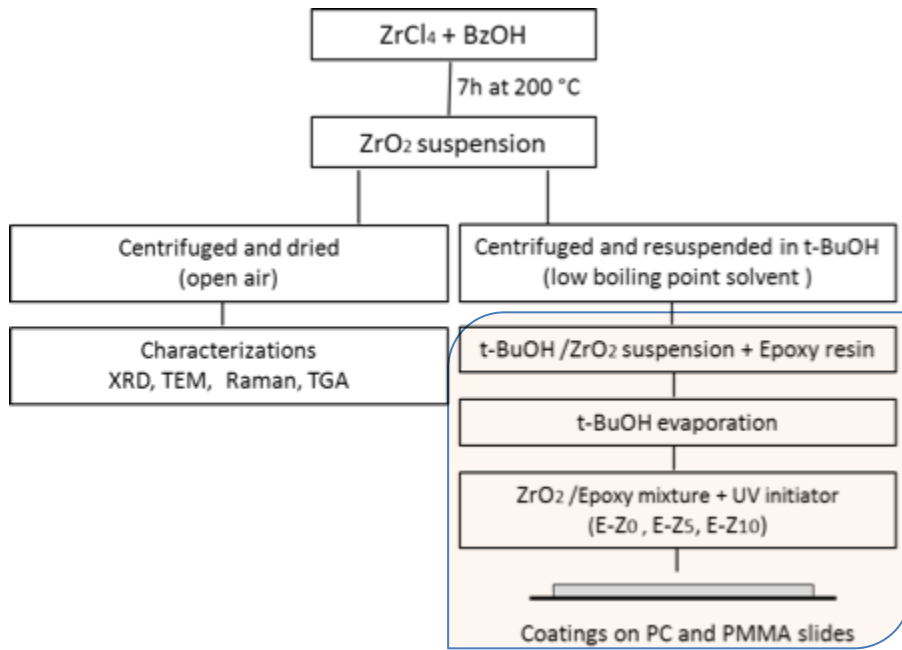
Correlation between particle crystalline phase and their morphological features confirmed that monoclinic particles possess mainly elongated shape in comparison with the tetragonal ones.



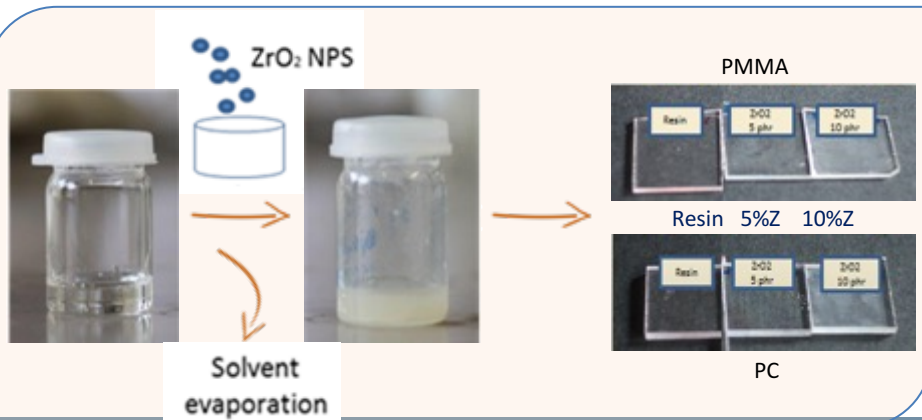
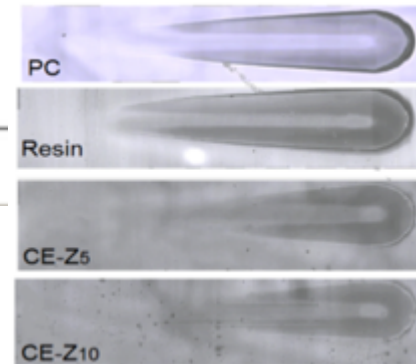
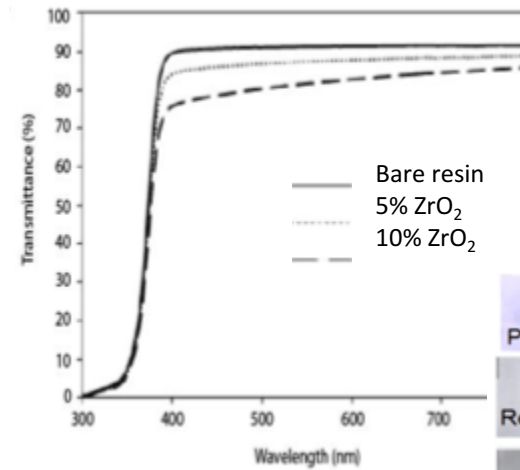
Tetragonal

Monoclinic

ZrO₂ as nanofiller for antiscratch coatings

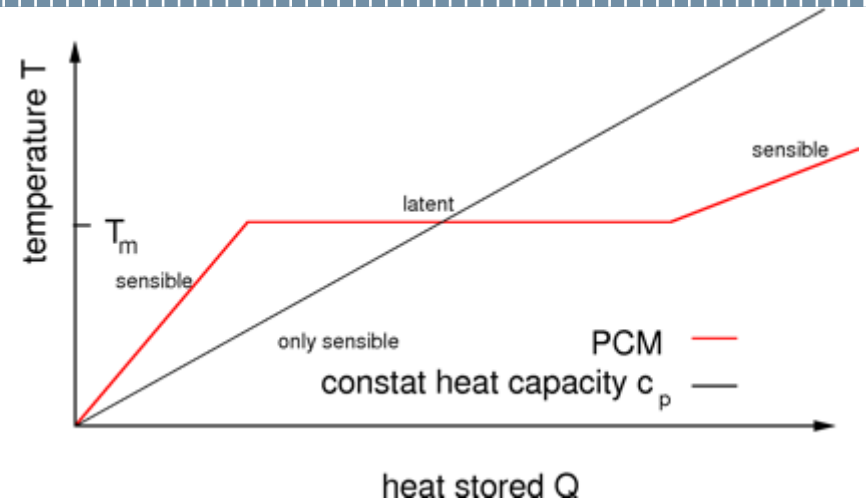
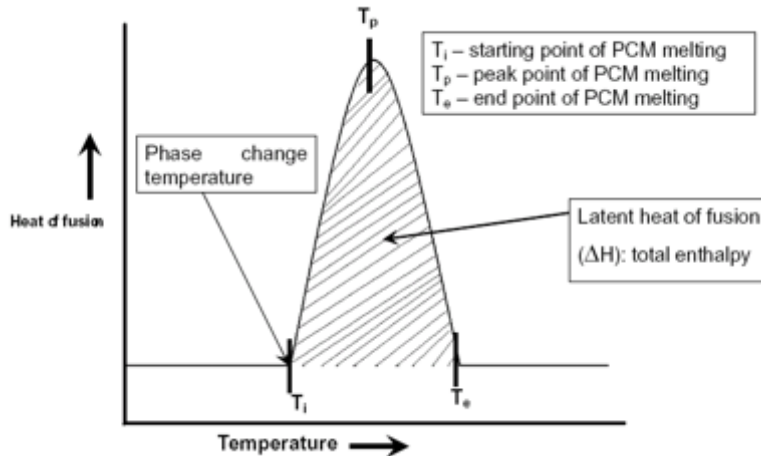


UV-visible and scratch measurements on coatings



Phase Change Materials

Theoretical principles



Applied Thermal Engineering 28 (2008) 1536–1550

Latent heat storage (LHS) is based on the heat absorption or release when a storage material undergoes a phase change

- ↳ from solid to liquid
- ↳ liquid to gas

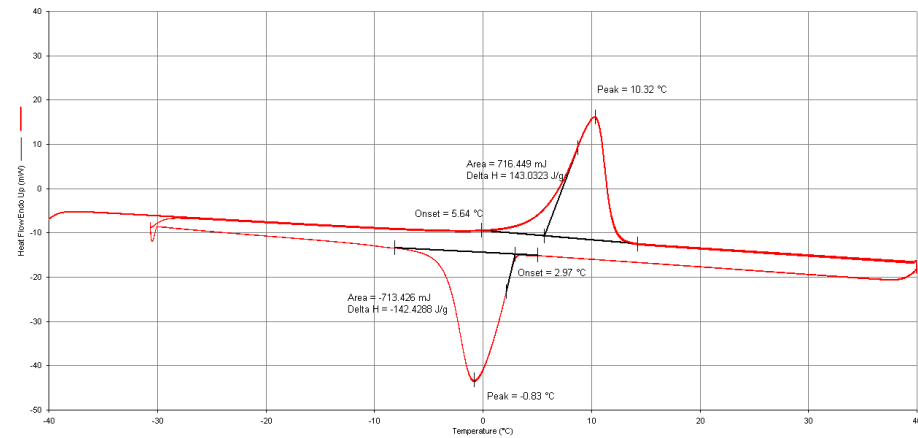
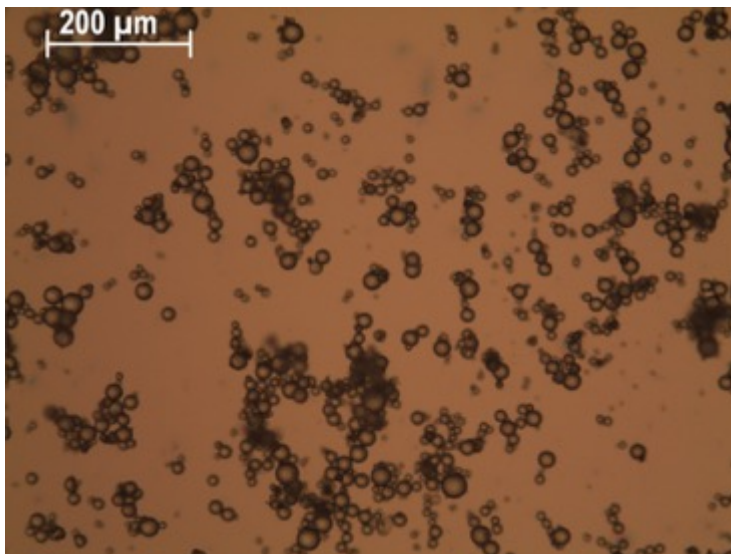
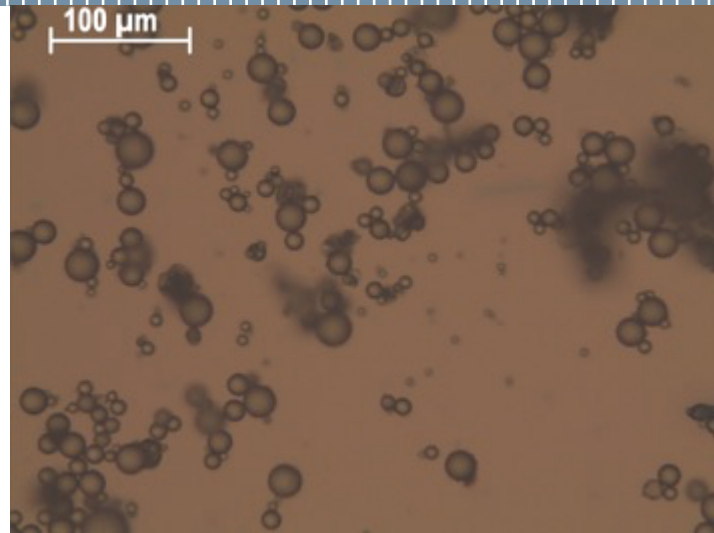
$$Q = \int_{T_i}^{T_m} mC_p dT + ma_m\Delta h_m + \int_{T_m}^{T_f} mC_p dT$$

$$Q = m[C_{sp}(T_m - T_i) + a_m\Delta h_m + C_{lp}(T_f - T_m)]$$

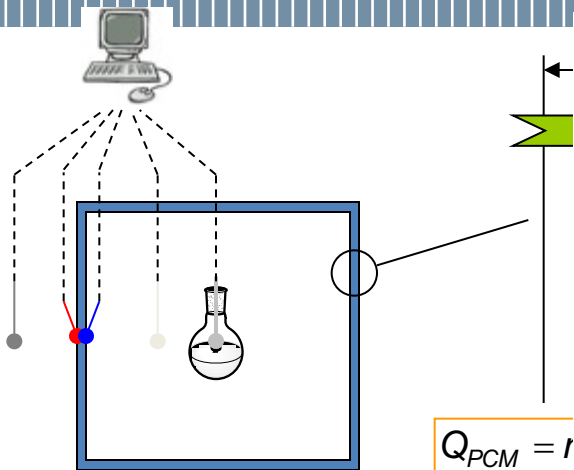
Phase Change Materials microparticles experimental

PCM μ particles:

- ↘ $T_m = 6-10\text{ }^\circ\text{C}$
- ↘ Easily suspended in common hydrophilic solvents
- ↘ Good dimension dispersion



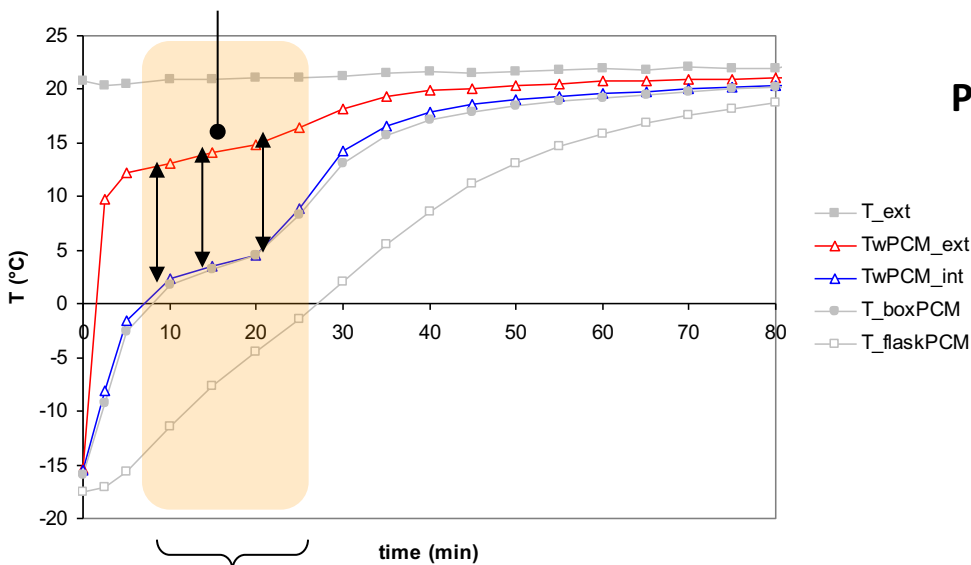
Phase Change Materials Towards practical applications



$$Q_{PCM} = I$$

$$Q_{PCM} = (0.:$$

$\Delta T \approx 10 \div 15^\circ\text{C}$



~20min

Applied Energy 89 (2012) 339–346

Contents lists available at SciVerse ScienceDirect

Applied Energy

journal homepage: www.elsevier.com/locate/apenergy

Phase change material cellulosic composites for the cold storage of perishable products: From material preparation to computational evaluation

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^b Istituti Nazionali di Ricerca e Tecnologia dei Materiali (INSTM), Aviano, Italy

PCM's really buffer the conductive heat flux

Prolonged buffering times can be obtained reducing the k/L ratio

- higher L
- lower k

1. **Materials**
2. **Packaging design**

Approccio proposto

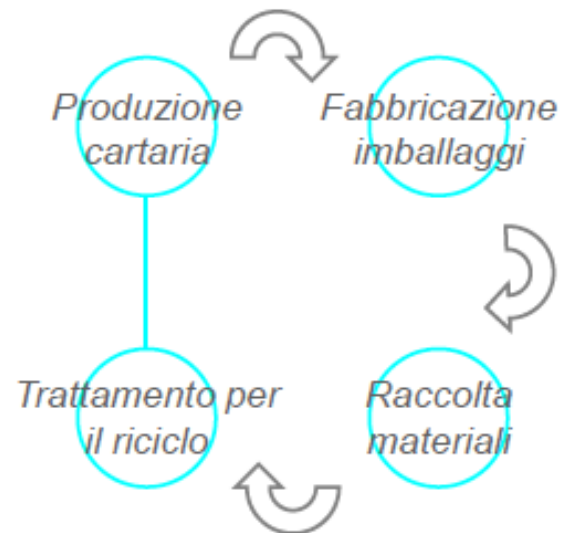
Compositi contenenti PCM

Imballaggi cellulósici immessi al consumo in Italia: oltre 4.000.000 t/anno

Tasso di riciclo: 78,7%

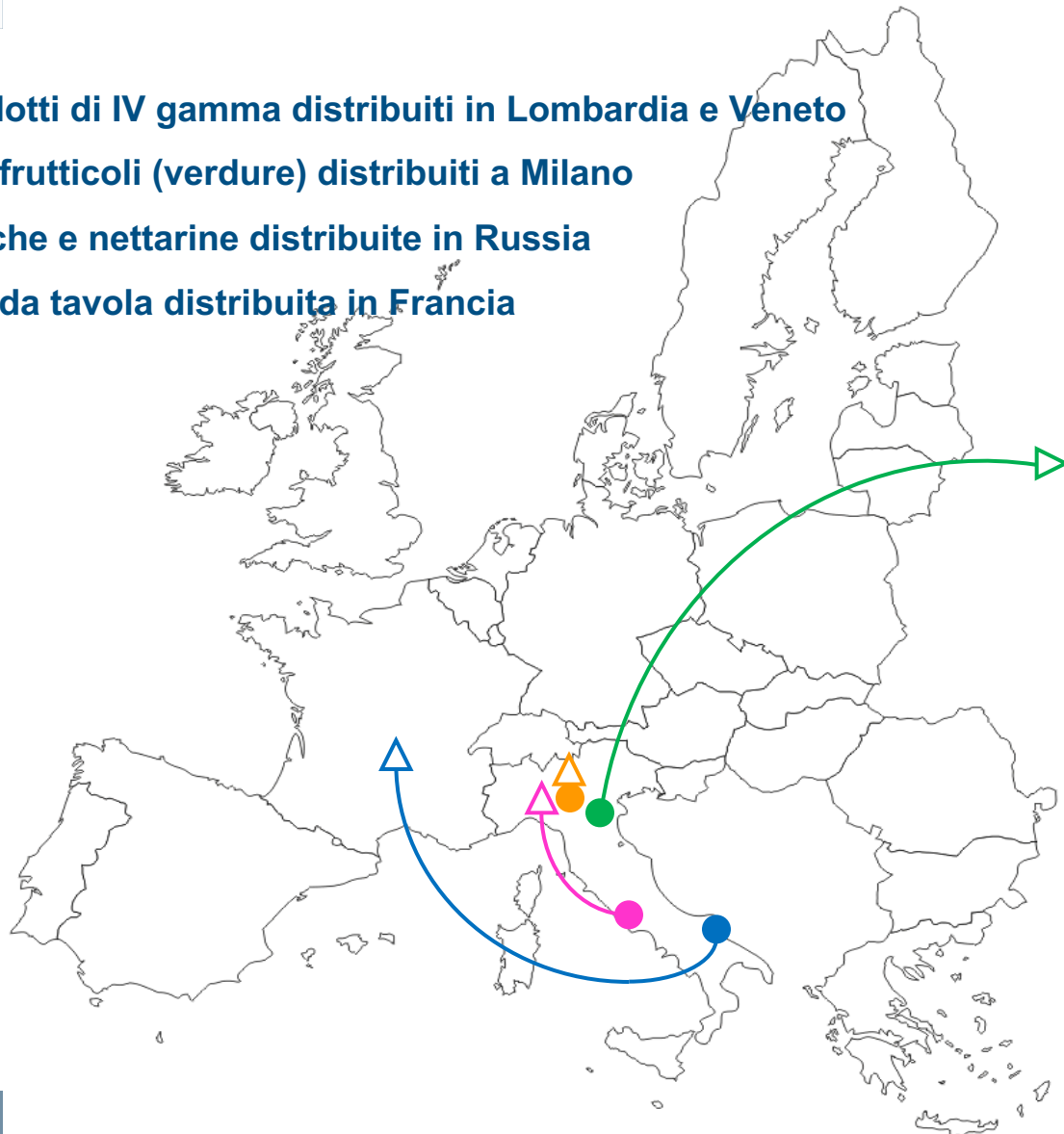
Recupero complessivo (compresa la quota di recupero energetico): 87,1%

(Comieco, 2011)



Sperimentazione Attività su campo

- **Prodotti di IV gamma distribuiti in Lombardia e Veneto**
- **Ortofrutticoli (verdure) distribuiti a Milano**
- **Pesche e nettarine distribuite in Russia**
- **Uva da tavola distribuita in Francia**



Sperimentazione su campo

Fasi del Progetto

Fase 1: Sviluppo di un processo di produzione industrializzabile per la realizzazione di imballaggi a mantenimento termico

Fase 2: Prove su campo

Fase 3: Prove sperimentali in laboratorio

Aziende che hanno collaborato allo sviluppo delle prime fasi del progetto:



Fase 2

Test su campo



26 Luglio
Bergamo
40 Vassoi



Verona
28 Vassoi:
- 7 PCM
- 7 TOP
- 14 STD



Como
12 Vassoi:
- 3 PCM
- 3 TOP
- 6 STD

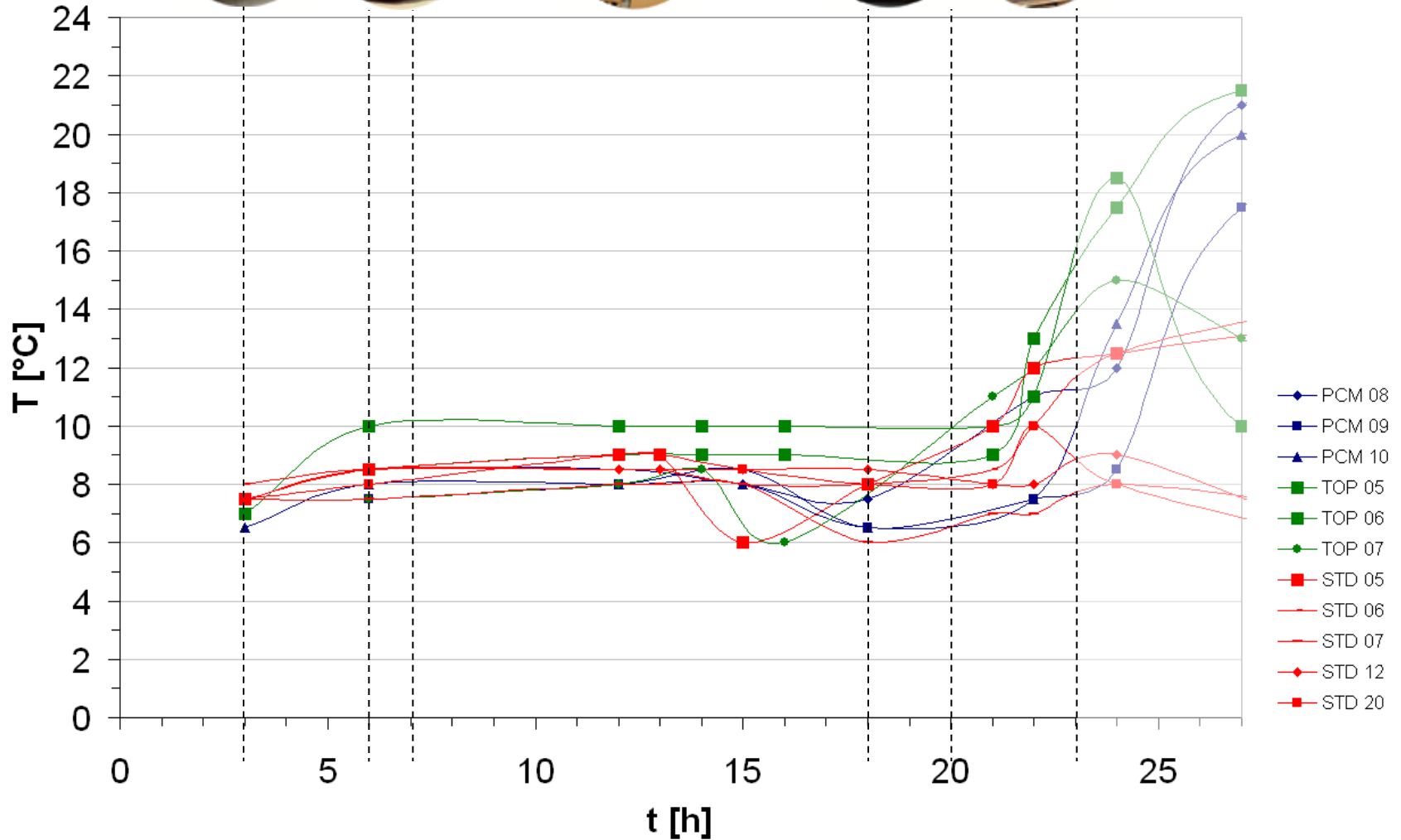
19 Punti Vendita

7 Punti Vendita

27 Luglio
Recupero Tracciatori di temperatura (39 di 40)



Fase 2 Risultati

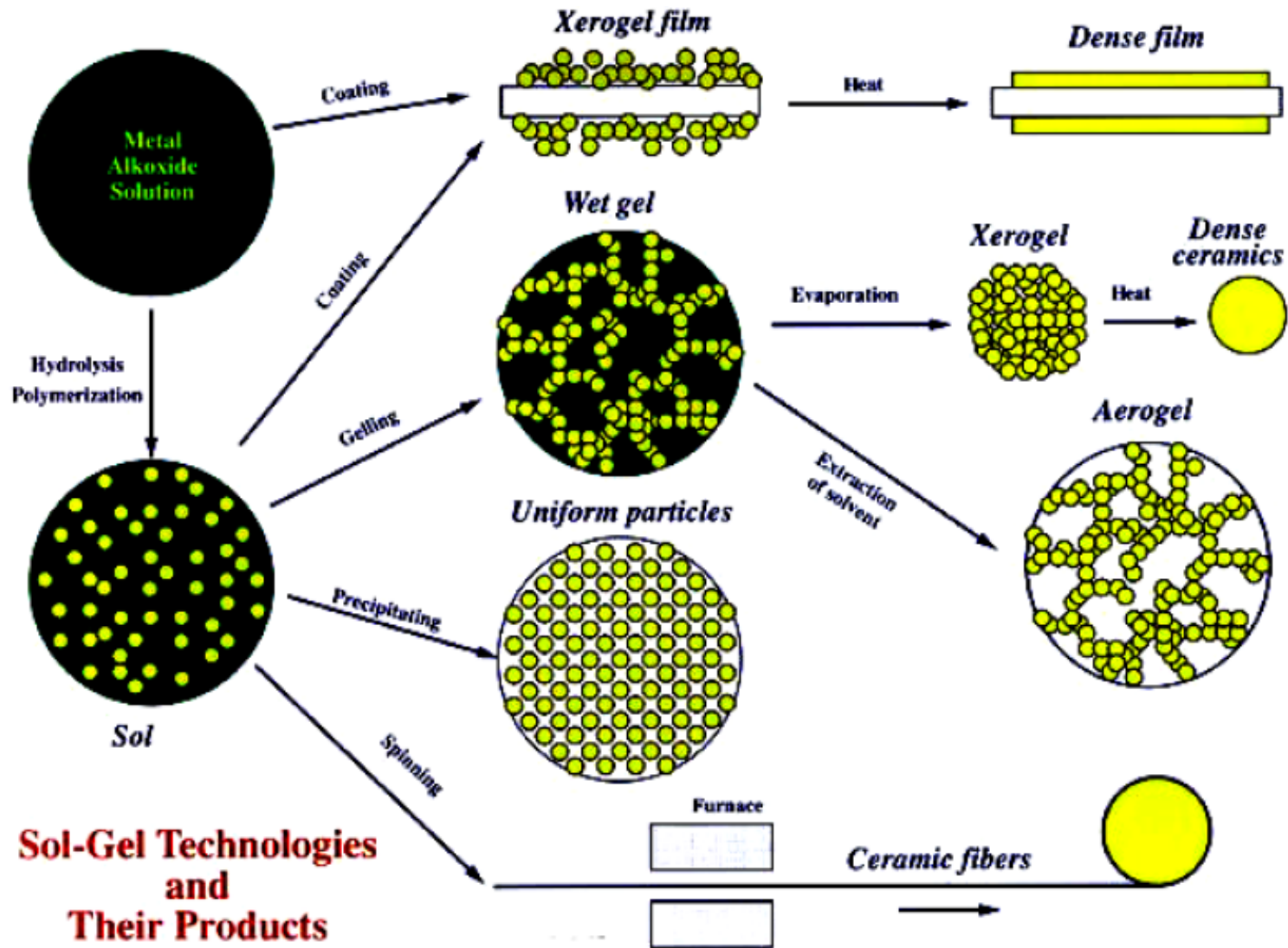


The study of **functional materials for industrial applications**

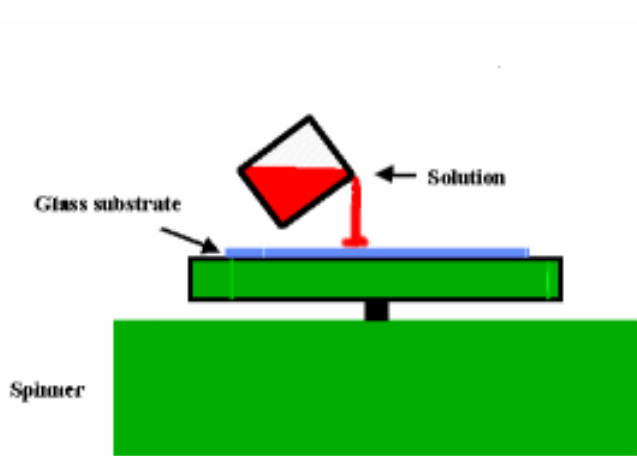
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Develop knowledge and competencies in teaching, in order to provide the better training and education to high-grade students

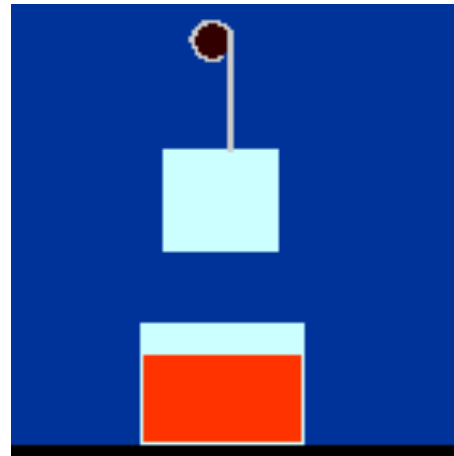
Lo schema del processo sol-gel



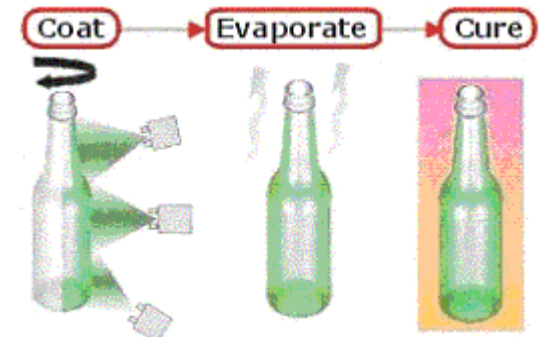
Tecniche di deposizione



Spin coating

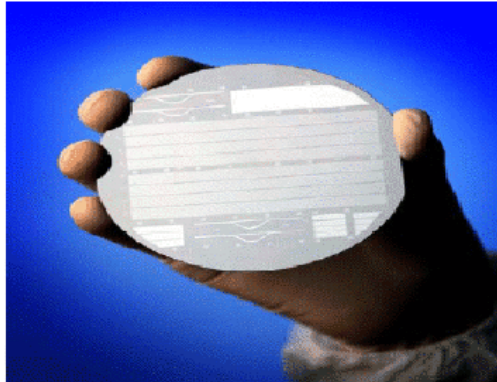


Dip coating



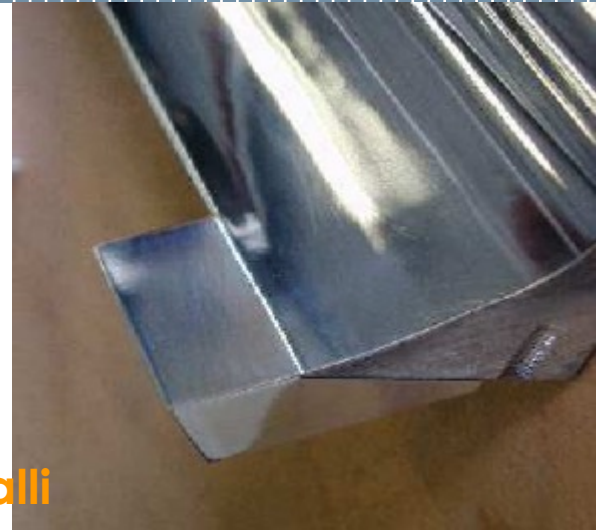
Spray coating

substrati trattabili

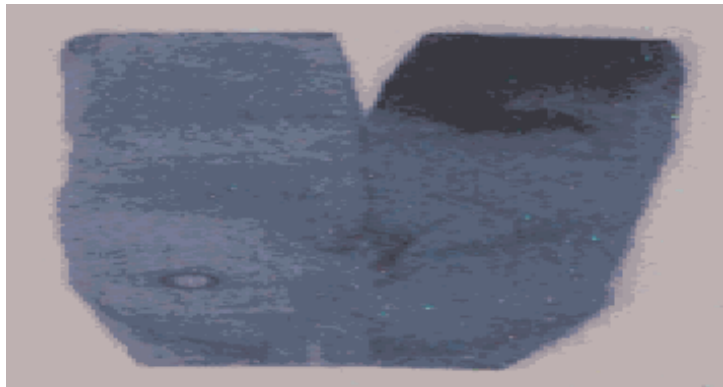


SOLICA™ PLC wafer with test structures

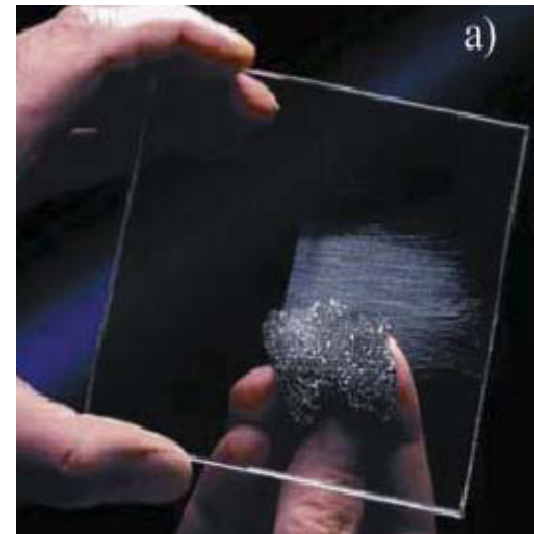
Ceramici



Metalli

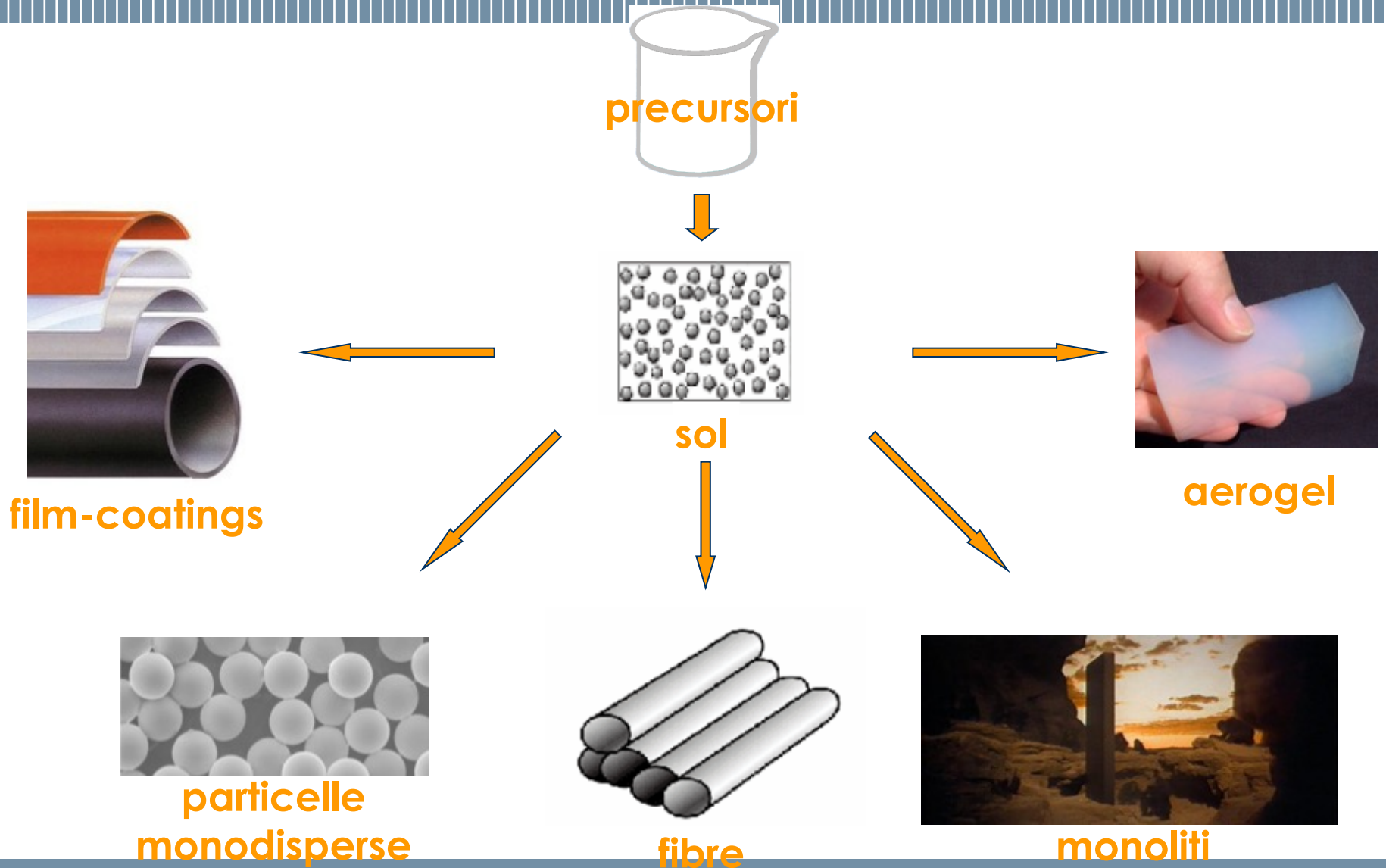


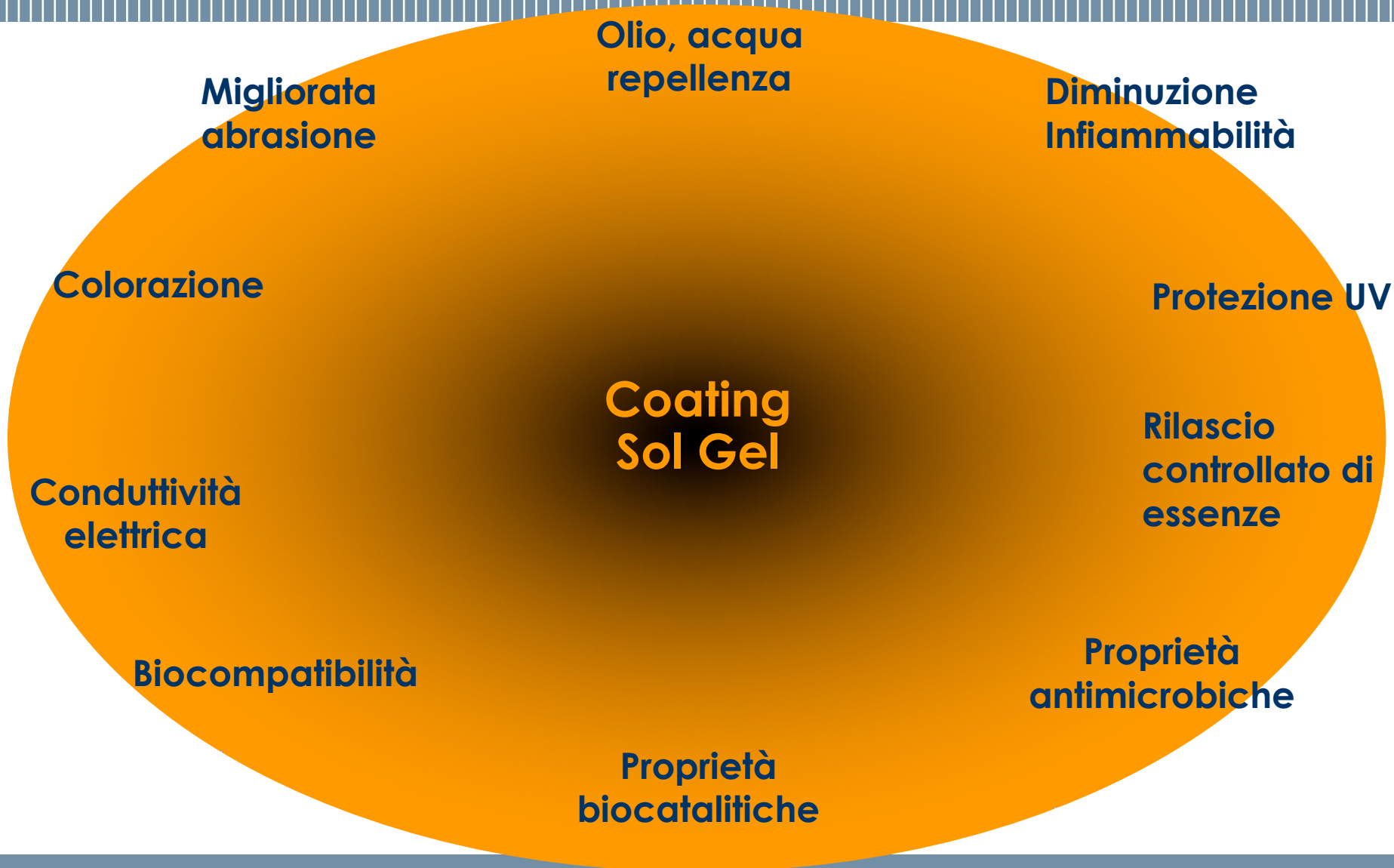
Tessuti naturali e artificiali



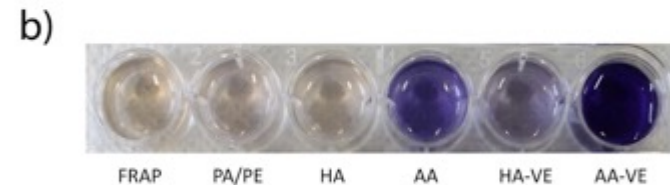
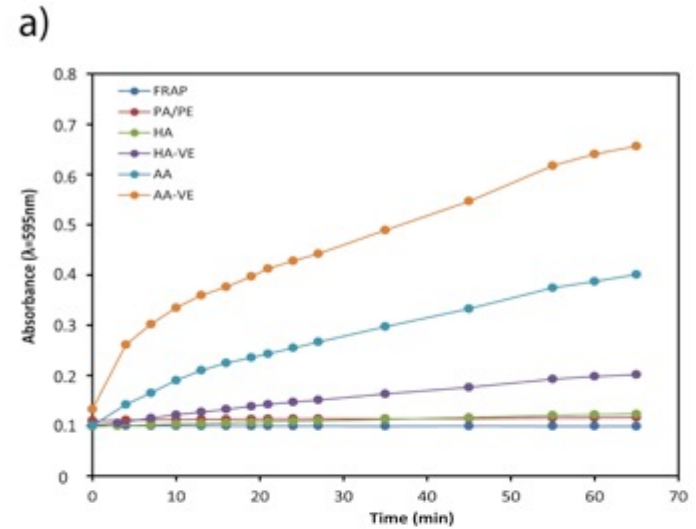
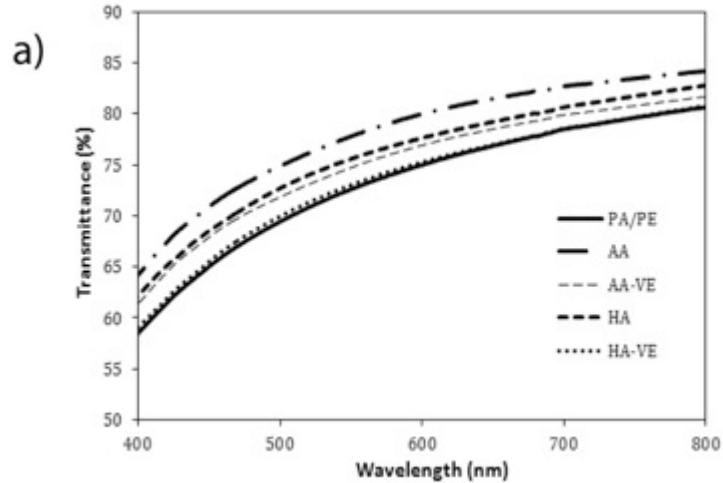
Polimeri

cosa si può fare...



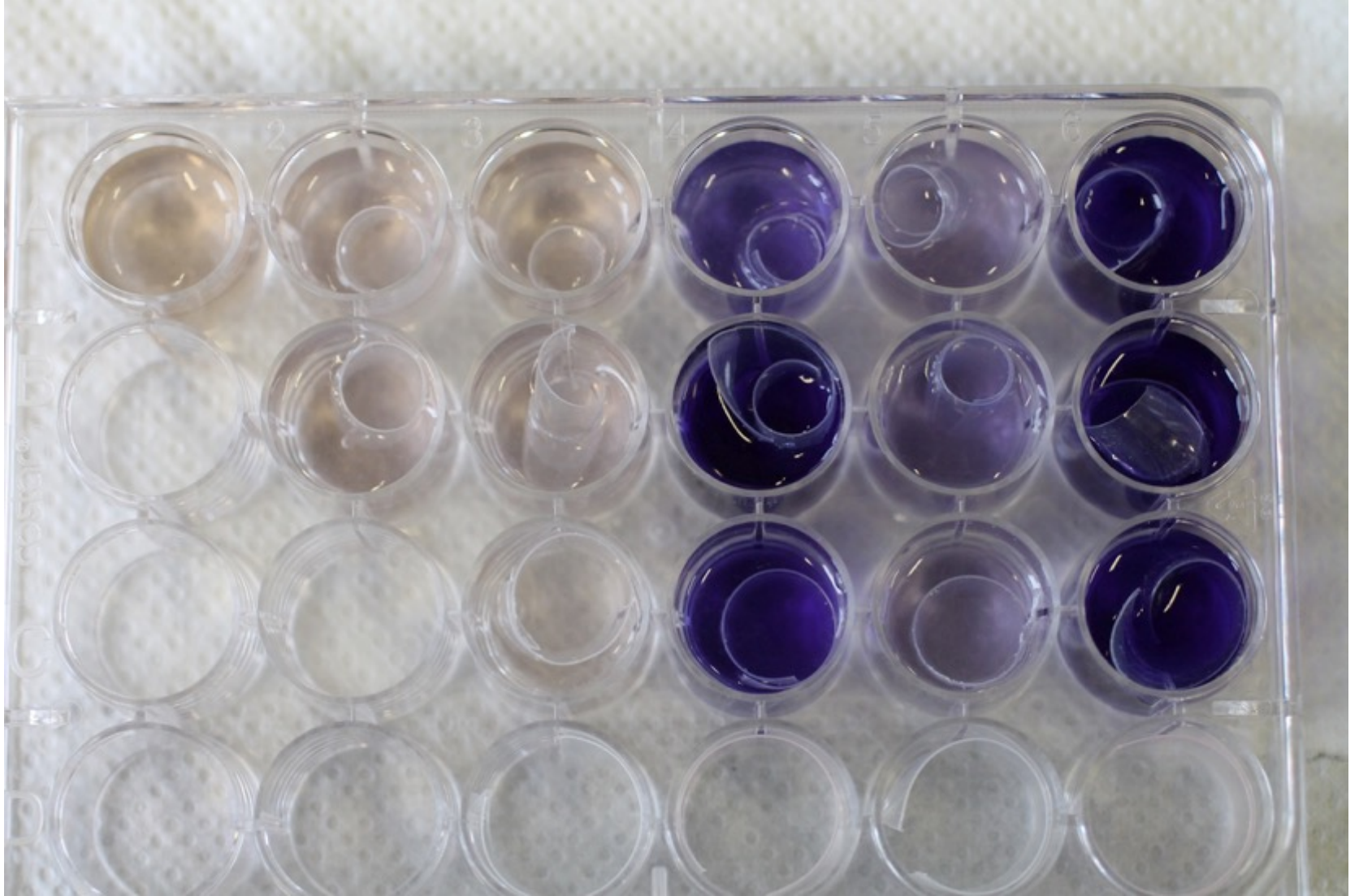


Films for active packaging Vitamin E



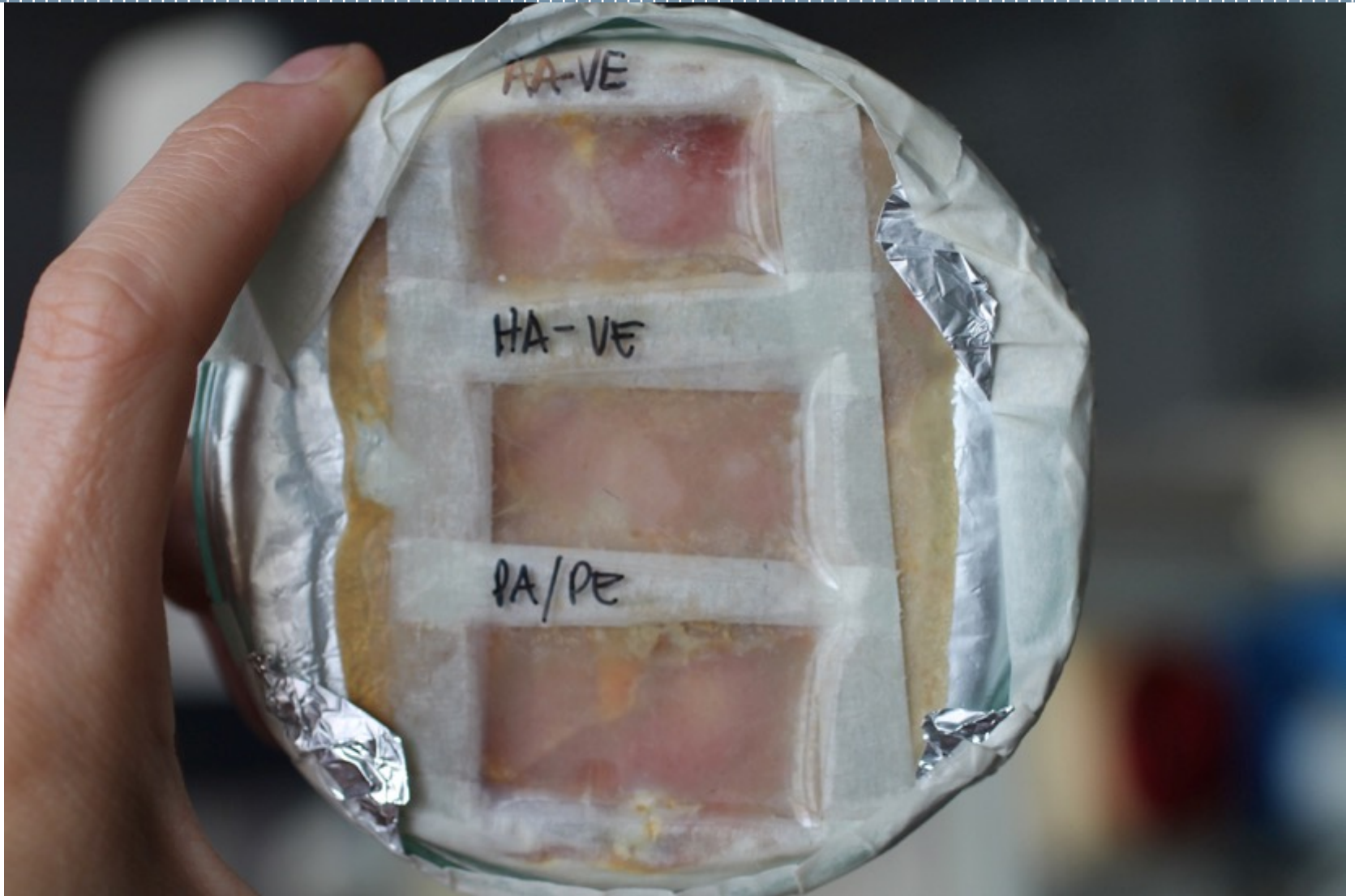
Films for active packaging

Vitamin E – After 120 DD

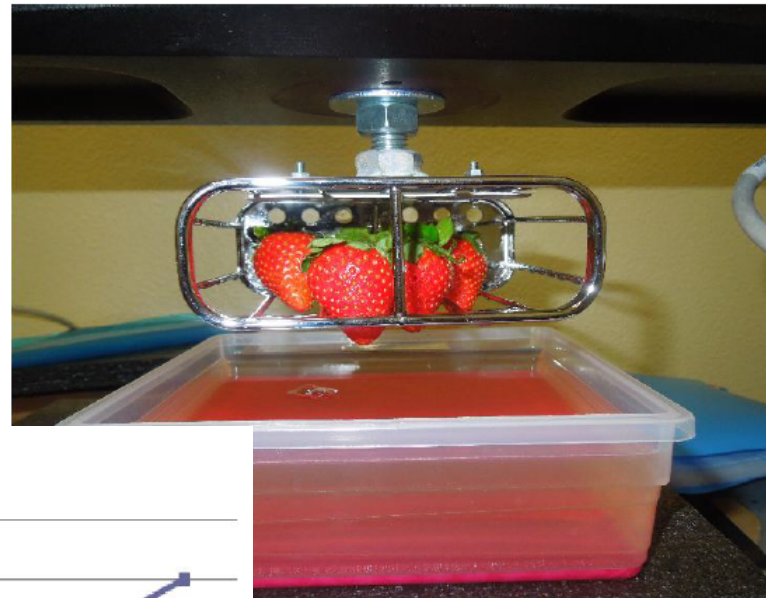


Films for active packaging

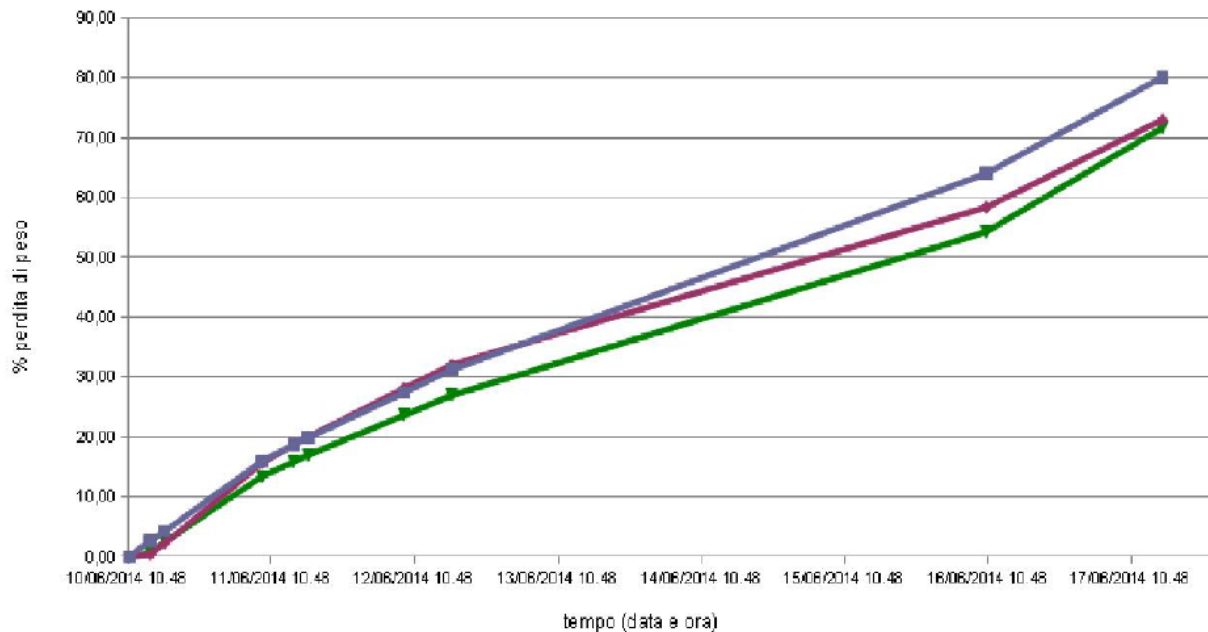
Vitamin E



Edible coatings for strawberries cooperation with UNIMI (prof. IRITI)



% perdita di peso delle fragole lotto II



Take Home Messages

The study of fundamental properties in materials science offer a powerful support to the development of industrial products:

- ↘ New applications in conventional products
- ↘ Reshape the way we think functions

Smart materials and functions can pave the road for such an innovation

... there is always a problem waiting for a material, and a property that can find this solution!!!

Materials for Innovation Lab

A network of cooperation

Extra UE

↘ USA

- Prof. C. Daraio – Caltech University
- Prof. P. Rizzo – Pittsburgh University
- Prof. E. Ebramzadeh – UCLA

↘ QUEBEC/CANADA

- Prof. L'H. Yahia – Ecole Polytechnique de Montreal
- Dr. L.-P. Lefebvre – CNRC-NRC
- Prof. F. Variola – University of Ottawa

ITALY

- Dr. MF Casula – Università di Cagliari
- Prof. L. Visai – University of Pavia
- Prof. A. Montenero – University of Parma
- Dr. L. Lusvarghi – Università di Modena e Reggio Emilia
- Dr Carlo Punta – Politecnico di Milano

Materials for Innovation Lab

Funding agencies

Ministere des Affaires Etrangères au Québec et MAE (Italy)

- ↘ Les matériaux Polymériques à Mémoire de Forme - Programme de coopération

MIUR - Italy

- ↘ Surface-associated selective transfection – SAST - RBFR08XH0H -FIRB – Futuro in Ricerca 2008

Regione Lombardia and Regione Sardegna - Italy

- ↘ ChitoStrip - Tecnologie innovative per bendaggio con biopolimeri – 27013735 - Program Cooperazione Scientifica e Tecnologica nelle aree tematiche biotecnologie e ICT in attuazione dell'allegato all'accordo di collaborazione sottoscritto dalla Regione Autonoma della Sardegna e dalla Regione Lombardia il 16 gennaio 2010
- ↘ Mantello -

Politecnico di Milano - Development of smart surfaces for gene-eluting stents (SURGES) - 5x1000 Junior

Contacts

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