BINOMIO FOOD-PACKAGING:
Le Frontiere della Ricerca

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CIBUS TEC, Parma
28 Ottobre 2014 ore 16.30 – 18.30

Food Packaging

Background

- Food packaging market: 440 billion dollars
- Food industry uses 65% of all packaging placed on the market
- 40% of total packaging is made of plastic
- Growth rate of the market of plastic packaging

Objectives

- Improved Performance of Packaging Materials
- Longer Shelf-life and Better Food Quality
- Increased Sustainability: Using Less Resources and Producing Less Waste

Tecnologie di conservazione degli alimenti

Tecnologie emergenti

- ***Nanotecnologia***
  - ***Improved Packaging***
  - ***Active Pakaging***
  - ***Smart Packaging***
- ***Biopreservanti***
- ***Radiazione***
- ***Alte pressioni***
- ***Ultrasuoni***
- ***Campi eletrici pulsati***

Tecnologie consolidate

- ***Basse temperature***
- ***Alte temperature***
- ***Disidratazione***
- ***Variazione di Atmosfera***
- ***Conservanti artificiali & naturali***
- ***Affumicamento***
- **Etc…..**

Nanotechnology in Food Packaging

Functions of Packaging

- Containment
- Protection and preservation
- Marketing and communication

Sustainable Packaging

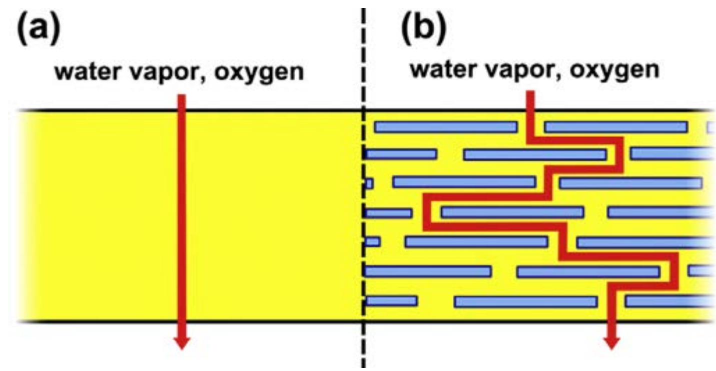
- Safe (health & environment)
- Designed to optimise materials and energy
- Meet market criteria for performance and cost

Nanotechnology implements the functions and increases sustainability

Nanotechnology in Food Packaging

Nanotechnology can improve **barrier properties**, reduce oxidation, add **antibacterial effects** for:

- Better preserved taste, color & flavor
- Slower decay of nutritive value
- Increased shelf life



Nanotechnology in Food Packaging

The Environmental Potential

In manufacture, transport & recycling, nano-coated PET bottles generate:

- 33% fewer greenhouse gases than aluminium cans
- 60% fewer than disposable glass bottles

Scientific breakthroughs: Outline

- Active nanopackaging
  - Comparative Performance of iPP based Nanocomposites versus Multilayered Material for Shelf-life of Ready-to-eat Meat Products;
  - Development of new antibacterial composites based on isotactic polypropylene (iPP) and zinc oxide (ZnO) particles;
  - Active systems with controlled release
- Improved nanopackaging with high barrier;
- Microbial biotechnology and biodegradable packaging;
- Nanotechnology+ radiation technology in food packaging

Methodology: To look at the complete life cycle of the packaging

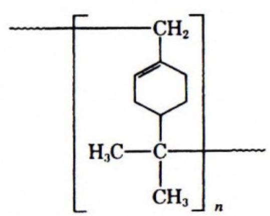
1. **Selection of the materials:**
   - *Matrices: Polymers derived by oil, in particular polyolefins (PE and PP); Biodegradable polymers derived by renewable resources: in particular polylactide (PLA)*
   - *Nanoparticles: Clay nanoparticles ; Metal oxide nanoparticles, graphene*
   - *Other ingredients: Antimicrobial (Poly-terpens, tocoferolo, vanillina, acido fenilattico, etc), Compatibilizers, etc*
2. **Optimization of the processing conditions**
   - *time,*
   - *temperature,*
   - *compositions,*
   - *mixing procedures*
3. **Assessment of properties of the packaging:**
   - *Rheological, morphology, thermal/mechanical, barrier .*
4. **Assessment of food quality/safety**
   - *Migration of particles from packaging to food;*
   - *Assessment of the recycling and degradability properties of the packaging materials.*
   - *Shelf life*

Scientific breakthroughs 1/6

➢ **COMPARATIVE PERFORMANCE OF ACTIVE IPP BASED NANOCOMPOSITES VERSUS MULTILAYERED MATERIAL FOR SHELF-LIFE OF READY-TO-EAT MEAT PRODUCTS**

Materials

- iPP
- 1% nanoclay
- 5% poly-β-pinene



- Commercial multilayer material (control) iPP/PA/EVOH/PE

Film Preparation

- Components were mixed and processed through twin screw extruder and converted into pellets
- The pellets were processed into a single screw extruder for obtaining films

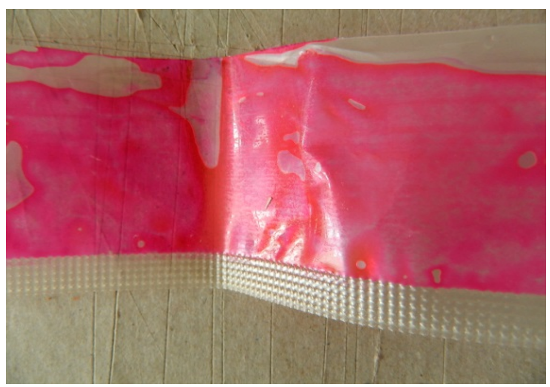
Material (Bags) Preparation

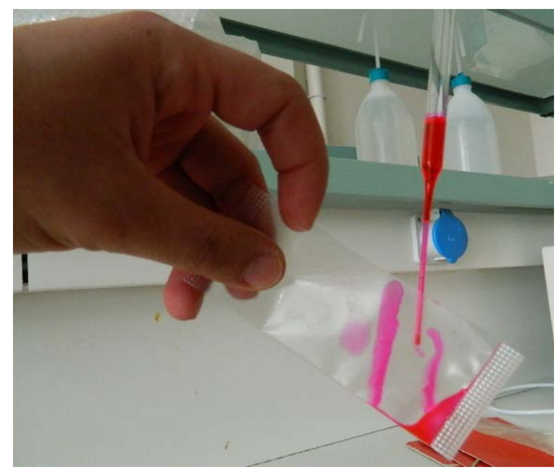
Cutting films

Heat sealing by heat-selaer

Flexible bags

Sanitation by ethyl alcohol





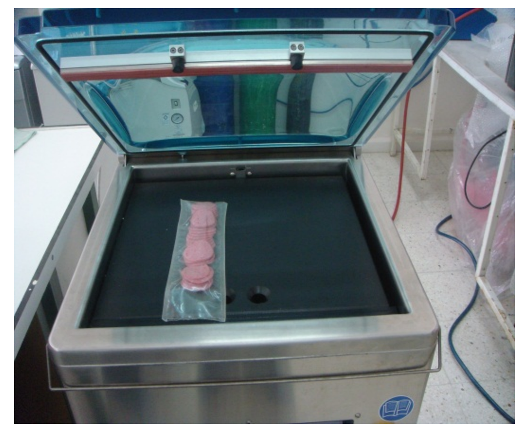
Dye penetration test for seal integrity

Food Processing & Packaging

Peeling

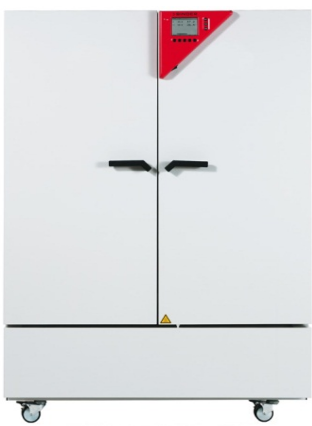
Slicing 1,5 mm

Filling



MAP and vacuum packaging

Labeling



Cold storage

Active nanopackaging

Food	Packaging	Shelf life
Salami	Active-nano-iPP films	50 days
	Commercial multilayer films	75 days
Pastrami	Active-nano-iPP films	150 days
	Commercial multilayer films	150 days

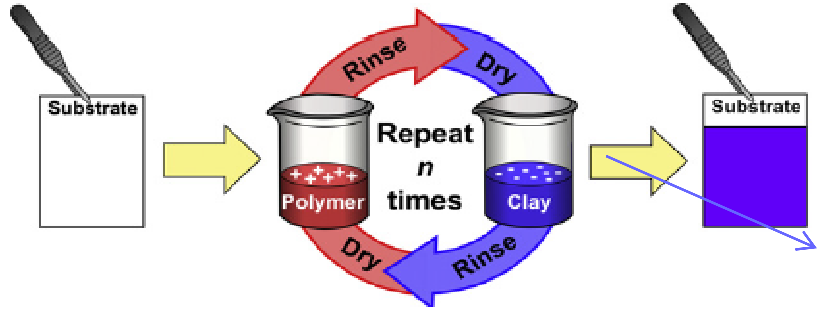
Material type	Thickness (µm)	OTR (ml $m^{-2}day^{-1}$)	WVTR (g m^{-2} day^{-1})
iPP	93	1410	1.88
iPP-nanoclay	89	1282	1.43
iPP-nanoclay-PβP	93	1061	1.30
iPP/PA/EVOH/PE	115	2	4

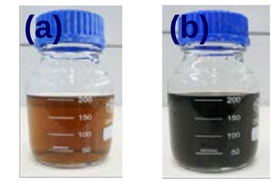
Scientific breakthroughs

➢ NANOMATERIALI AD ELEVATA BARRIERA

DEPOSIZIONE LAYER BY LAYER (LBL)

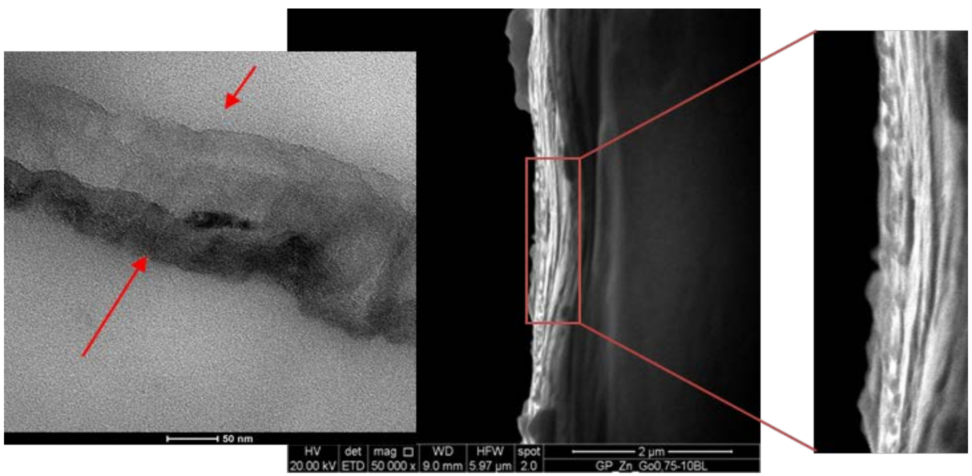
LA TECNICA CONSISTE IN UNA IMMERSIONE ALTERNATA DEL SUBSTRATO IN SOLUZIONI DI POLIELETTROLITI CARICATE OPPOSITAMENTE



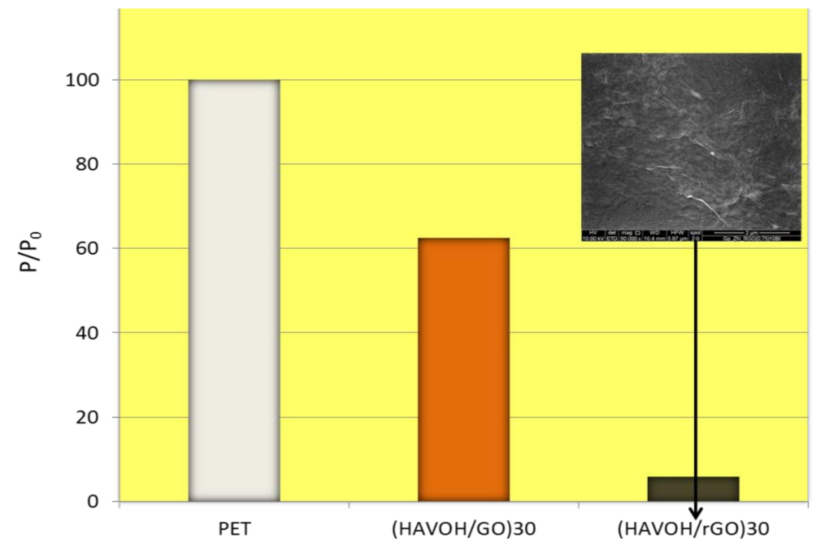


OSSIDO DI GRAFENE (GO)

GO RIDOTTO



NANOSHEET DI GRAFENE SONO ORIENTATI PARALLELAMENTE ALLA SUPERFICIE DEL SUBSTRATO



RIDUZIONE DELLA P_{O2}: 97%

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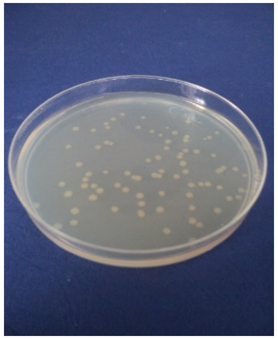
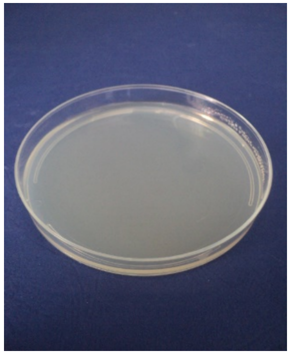
Scientific Breakthroughs 3/6

➢ DEVELOPMENT OF NEW ANTIBACTERIAL COMPOSITES BASED ON ISOTACTIC POLYPROPYLENE (iPP) AND ZINC OXIDE (ZnO) PARTICLES



Control plate without ZnO nanoparticles to measure the Escherichia-coli grow after 48 h



Antibacterical effect of ZnO in iPP (iPP/ZnO 5%) after 48h

95% ethanol 10 days 40°C

	iPP	iPP/ZnO (2%)	iPP/ZnO (5%)	iPP/PPgMA/ZnO (2%)	iPP/PPgMA/ZnO (5%)
Overall migration (mg/dm^2)	0.5	0.0	0.1	0.0	1.7
ZnO migration (ng/dm^2)	-	240	204	108	249

Total and ZnO migration is low

3% acetic acid 10 days 40°C

	iPP	iPP/ZnO (2%)	iPP/ZnO (5%)	iPP/PPgMA/ZnO (2%)	iPP/PPgMA/ZnO (5%)
Overall migration (mg/dm^2)	0.6	18.6	40.5	18.9	44.2
ZnO migration (mg/dm^2)	-	10.4	24. 1	14.0	25.3

Total migration is low for iPP, increases by incresing ZnO content. The quantitative levels correspond to about 20-30% of the added amount of ZnO in the composites

Scientific breakthroughs

➢ NANOMATERIALI ATTIVI A RILASCIO CONTROLLATO

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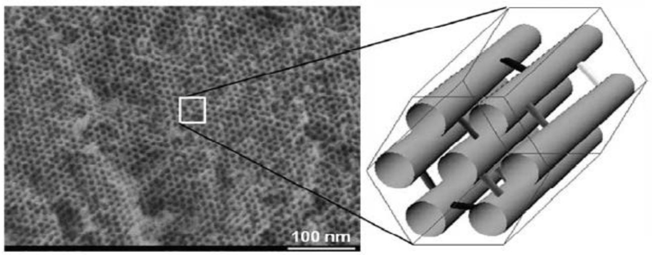
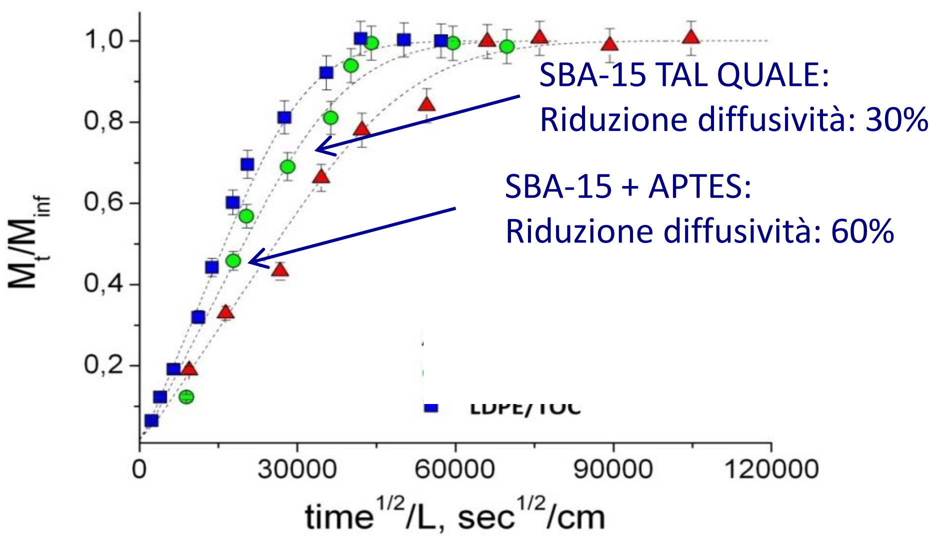
SILICE MESOPOROSA – SBA15

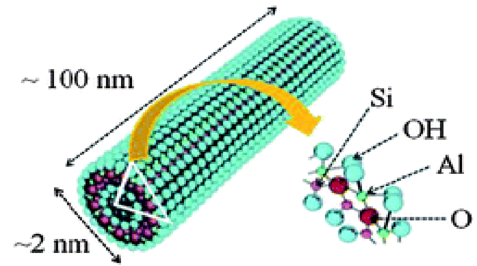


FUNZIONALIZZAZIONE DEI CANALI (APTES)

SOSTANZA ATTIVA:
ANTIOSSIDANTE TOCOFEROLO

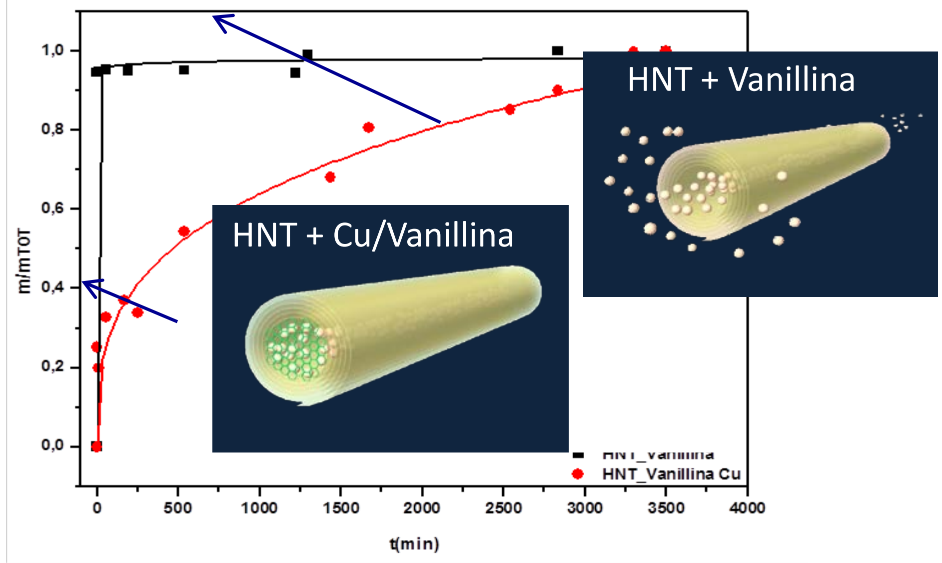


CLAY POROSO – HALLOYSITE



CHIUSURA CANALE: COMPLESSO CON METALLO

SOSTANZA ATTIVA:
ANTIMICROBICO VANILLINA



Scientific breakthroughs

➢ BIONANOMATERIALI ATTIVI

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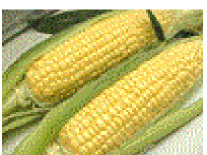
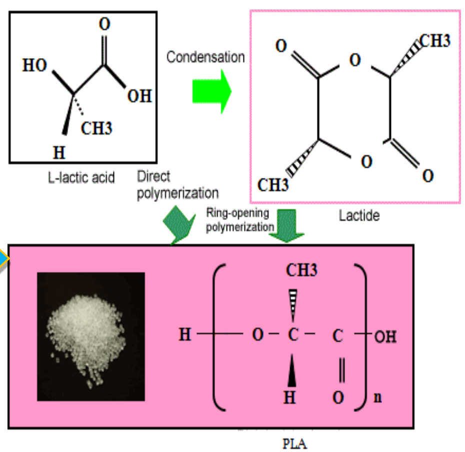
BIOTECNOLOGIA MICROBICA (ISPA) E PACKAGING BIODEGRADABILE E ATTIVO (IPCB) PER ESTENDERE LA CONSERVABILITA' DI ALIMENTI

Preparazione di film per pressofusione utilizzando PLA come matrice polimerica e agenti antimicrobici (biopreservanti) di origine batterica.

***Biopreservanti** (metaboliti microbici come acido fenillattico o mix di acidi organici prodotti da batteri lattici)*





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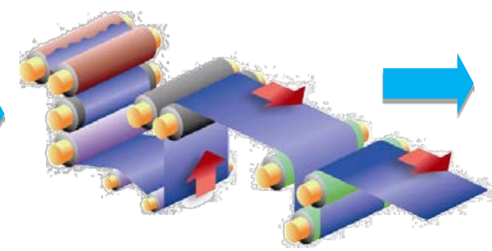


Confezionamento dell'alimento

"Cluster Agrifood Nazionale: SO.FI.A. CTN01 00230 450760

Scientific breakthroughs

➢ **Applicazione sinergica di tecnologie emergenti ecosostenibili per contribuire a garantire cibo sano e di qualità a tutti**

Perchè applicare le ***radiazioni*** nel campo dell'imballaggio alimentare?

Radiazioni

- Eliminano fino al 99% degli agenti patogeni
- Consentite in oltre 50 paesi
- 500.000 tonnellate/ anno di cibo trattato
- Economiche (~ 10 cent (US)/kg carne/pollame
- Approvate come sicure per alimenti e la salute da(OMS, EFSA, FDA)
- Ecosostenbili ed efficienti

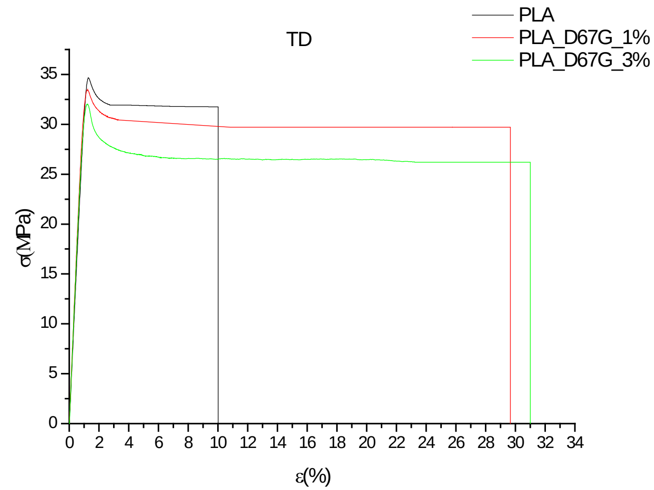
Radiazioni autorizzate per alimenti

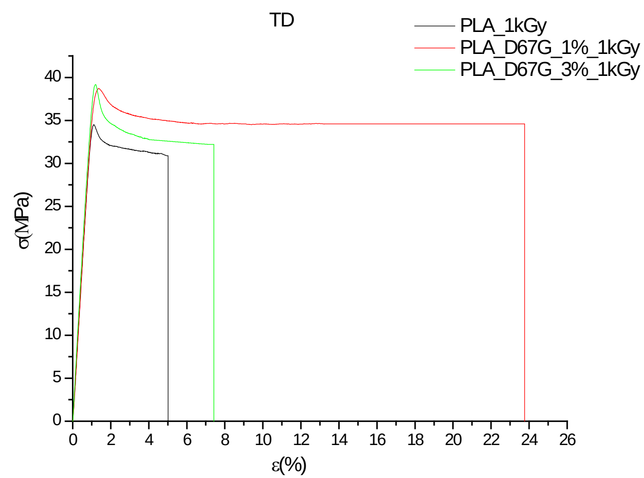
- *Fasci di elettroni,*
- *Raggi gamma*
- *Raggi X*

Dosi: 1 kGy – 10 kGgy

Preliminary results PLA/clay films after irradiation with electron beam

Sample	Permeabilità (cc*cm/m^2*24h*bar)
PLA	2,23 ± 0,22
PLA_ 1kGy	1,61 ± 0,01
PLA/D67G 1%	1,76 ± 0,01
PLA/D67G 1%_1kGy	1,52 ± 0,01
PLA/D67G 3%	1,52 ± 0,03
PLA/D67G 3%_1kGy	1,43 ± 0,09





C. SILVESTRE, et al **"EXPLOITING NANOTECHNOLOGY AND RADIATION TECHNOLOGIES TO DEVELOP NEW ECO-SUSTAINABLE NANOMATERIALS FOR FOOD PACKAGING SUITABLE FOR STERILIZATION BY IRRADIATION in IAEA-TECDOC-1745**ISBN 978–92–0–106414–1

Nanotechnology in Food Packaging + Radiation Technology

[redacted]

9 Billion in 2050, FAO

Impatto spreco alimentare:

- 40% totale
- 1,3 miliardi di ton/ anno
- 600 Miliardi €/anno
- 3,3 miliardi di ton/anno di CO2

Emerging Technologies in Food Packaging:
Benefits V Risks

Benefits:

- Increased shelf life
- Improved taste
- Higher nutritive value
- Increased security/safety
- Increased sustainability

Risks:

- Migration into food: Main concern
- Accumulation in the Environment

Correct information
Regulations