Potential Applications of Nanotechnology in Food Packaging

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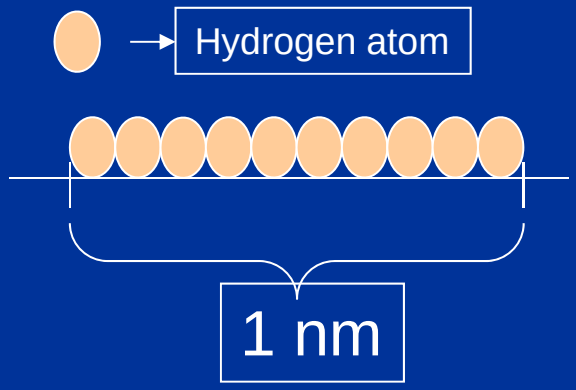
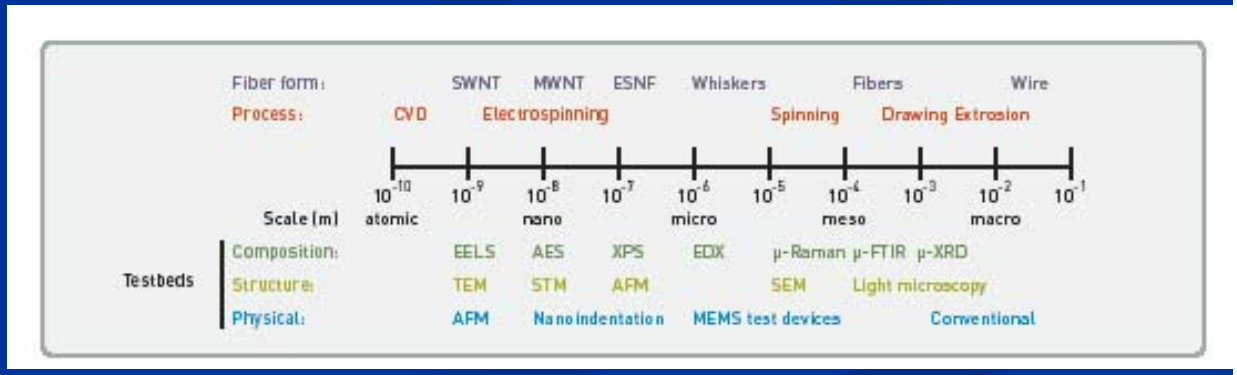
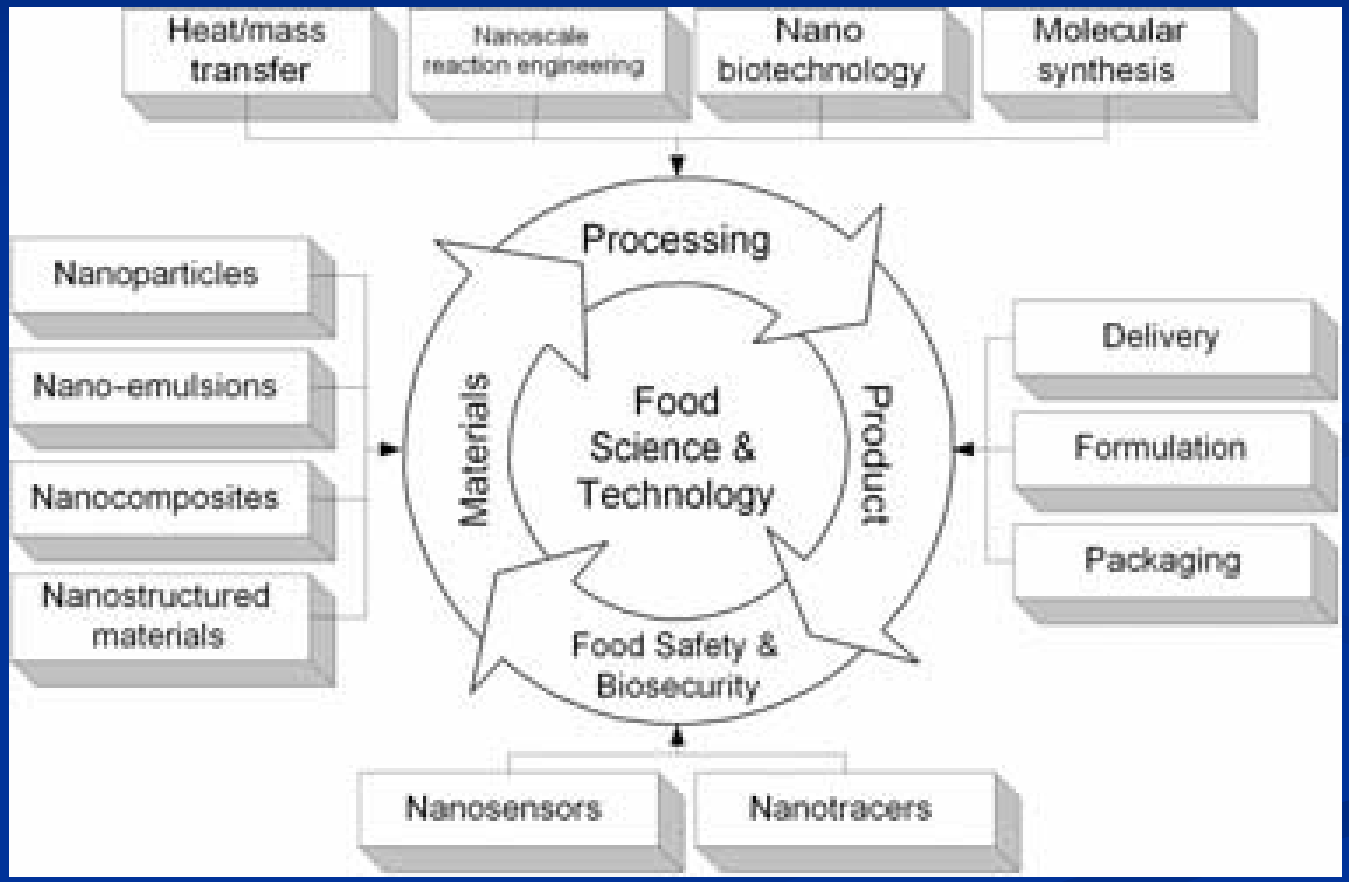
Nanotechnology?

- Technology involving structures with one or more dimension between 1 and 100 nanometers (1nm =10^{-9} m)





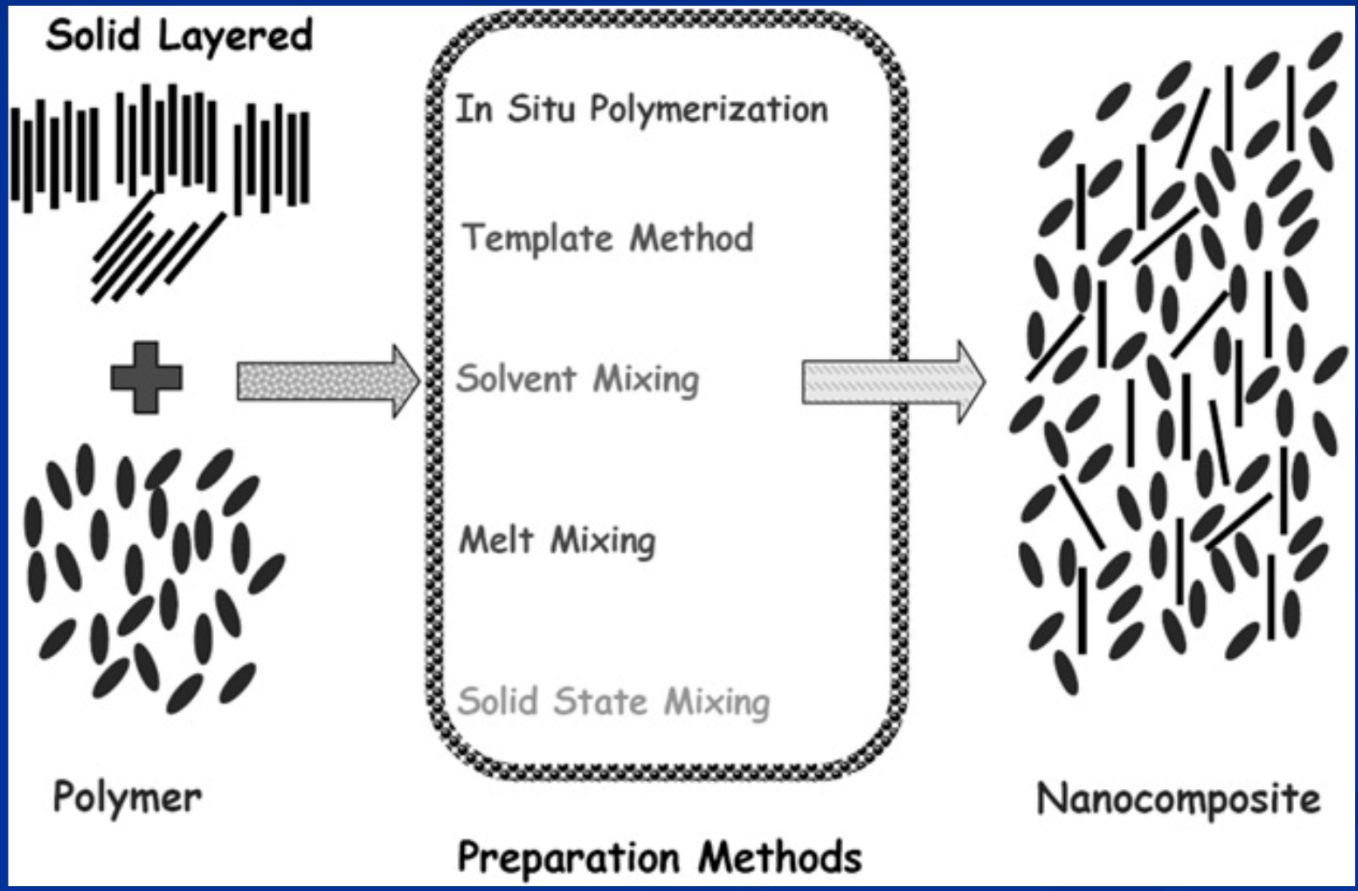
Nanotechnology in Food Sci & Tech



Nanotechnology in *food packaging* applications

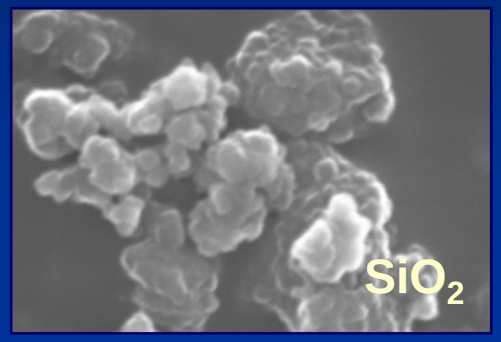
- Nanocomposites
- Biodegradable nanocomposites
- Edible nanocomposites
- Active nanocomposites
- Intelligent packaging (nanosensors)

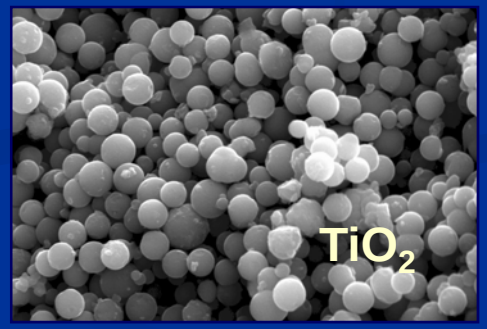
Preparation methods of polymer nanocomposites

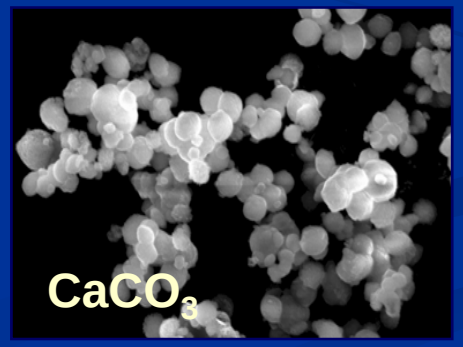


Nanofillers

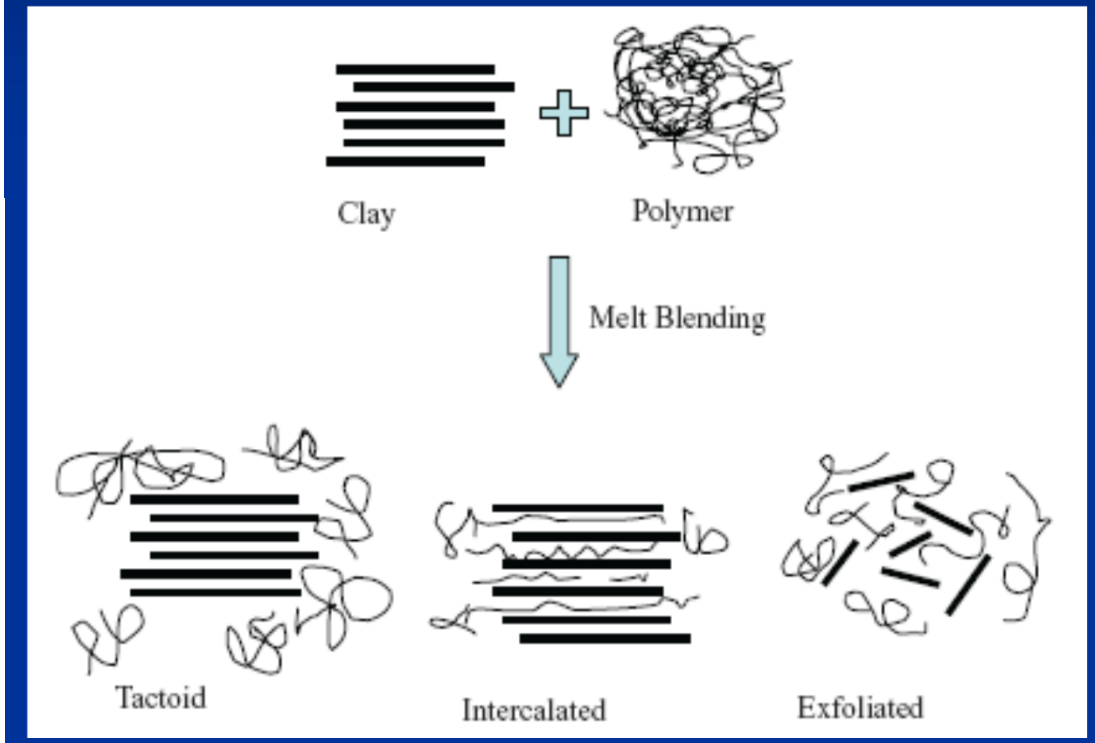
- Nano-clay
- Silicates (SiO_2)
- $CaCO_3$
- TiO_2

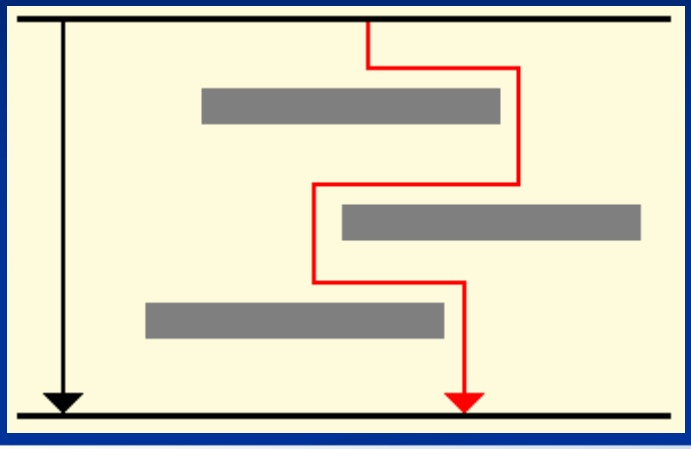


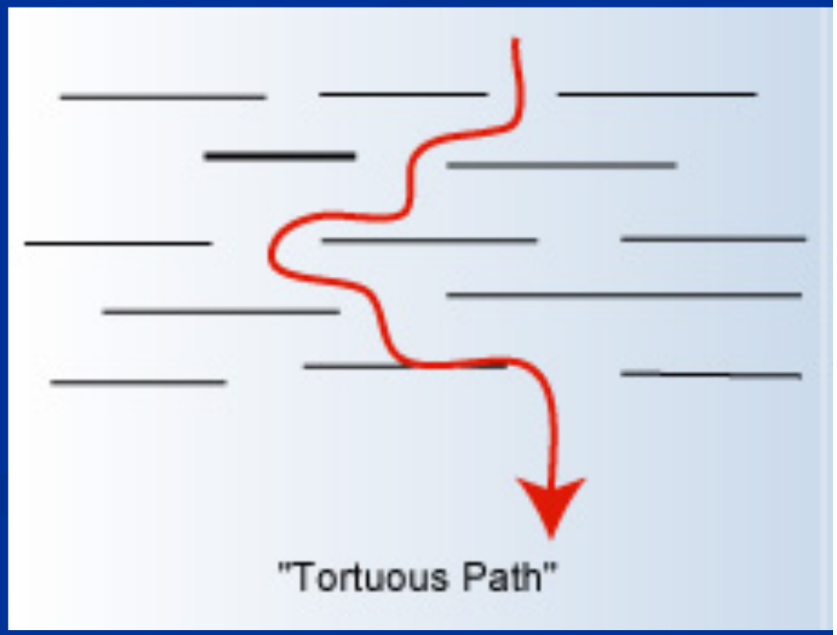




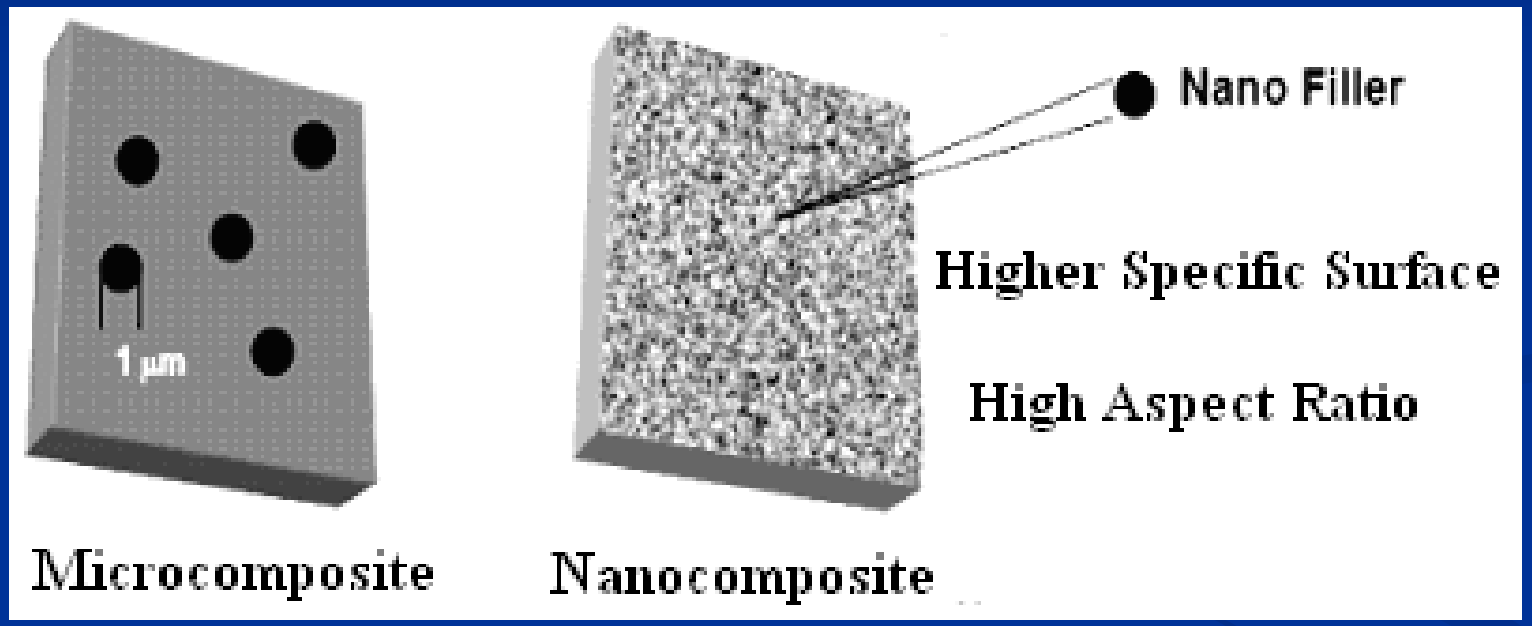
Clay nanocomposites



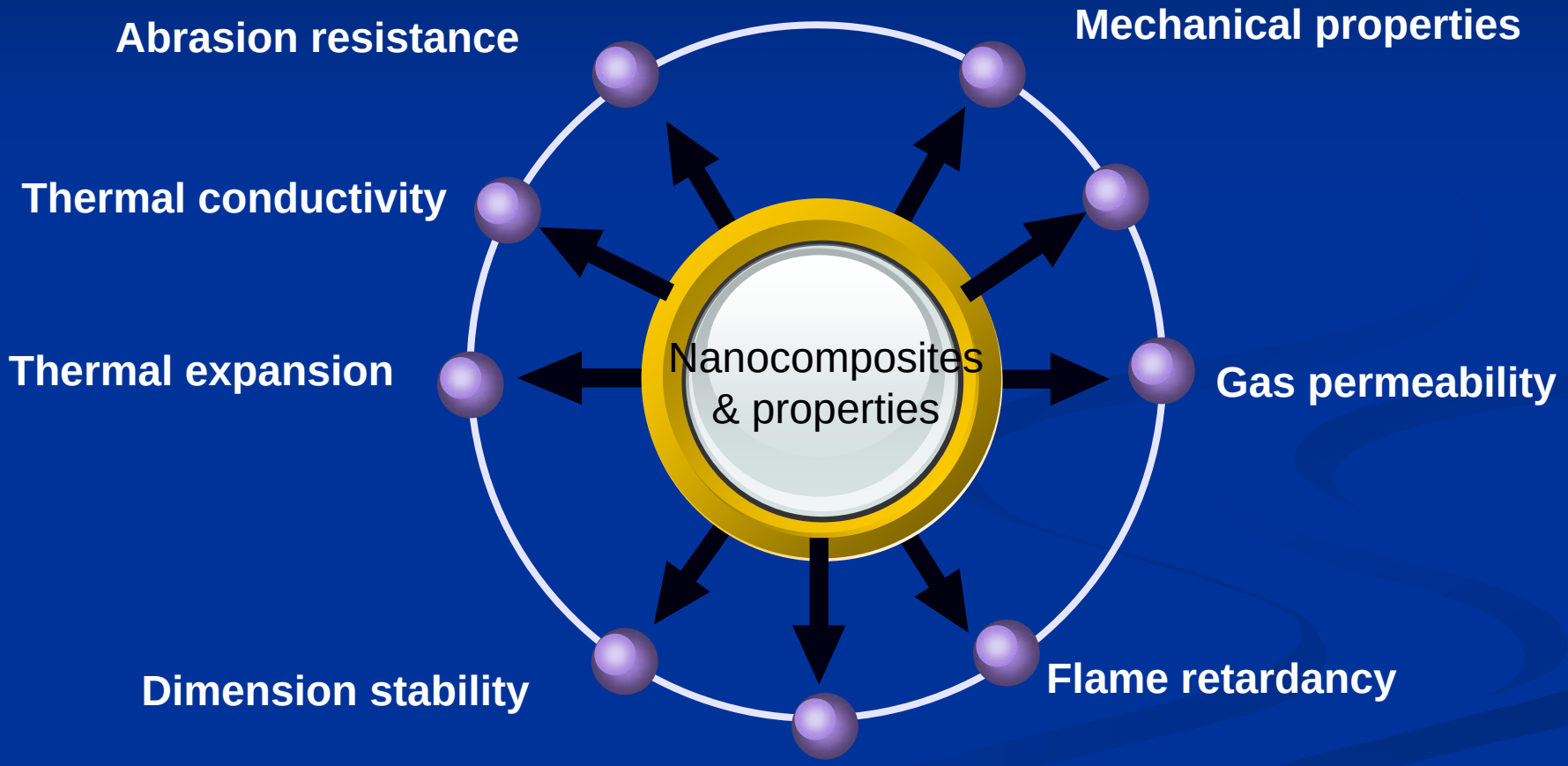




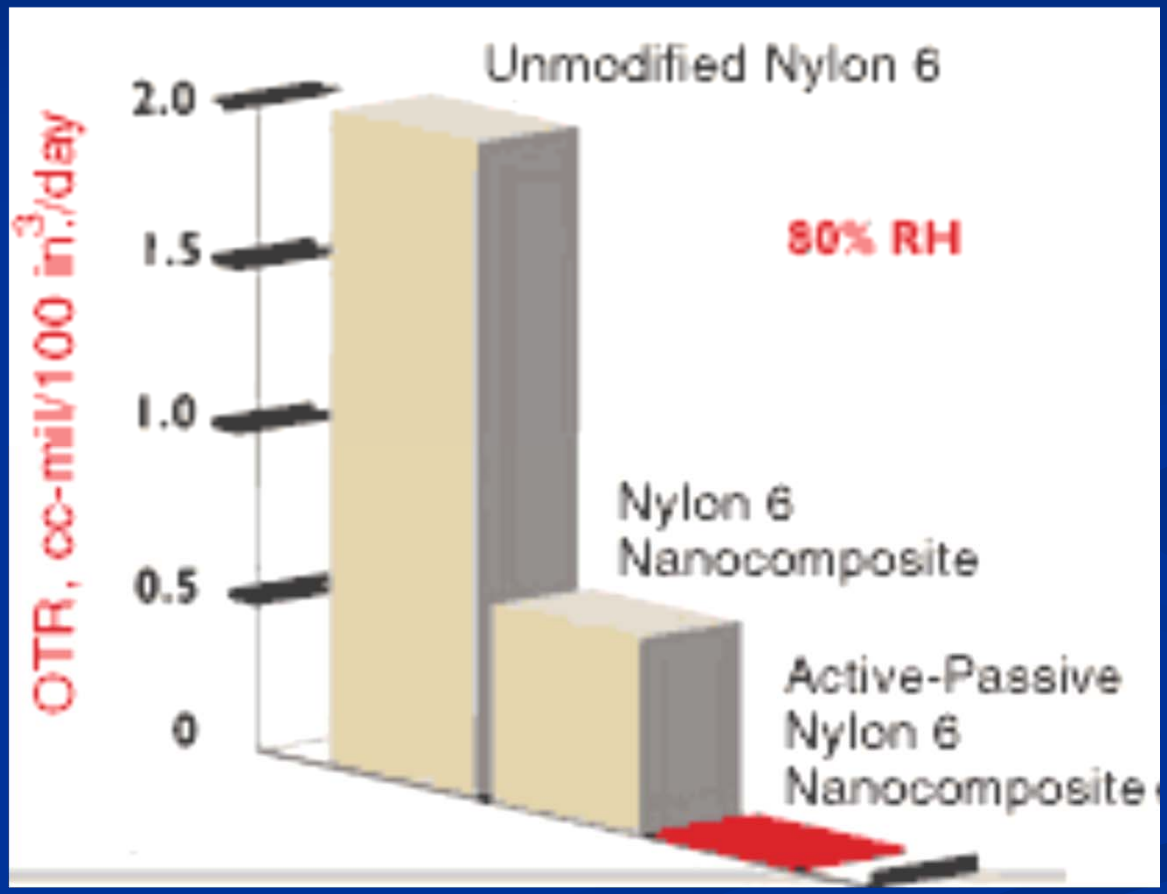
Nanocomposites



Improved material properties by nanotechnology



Nanoclay composites

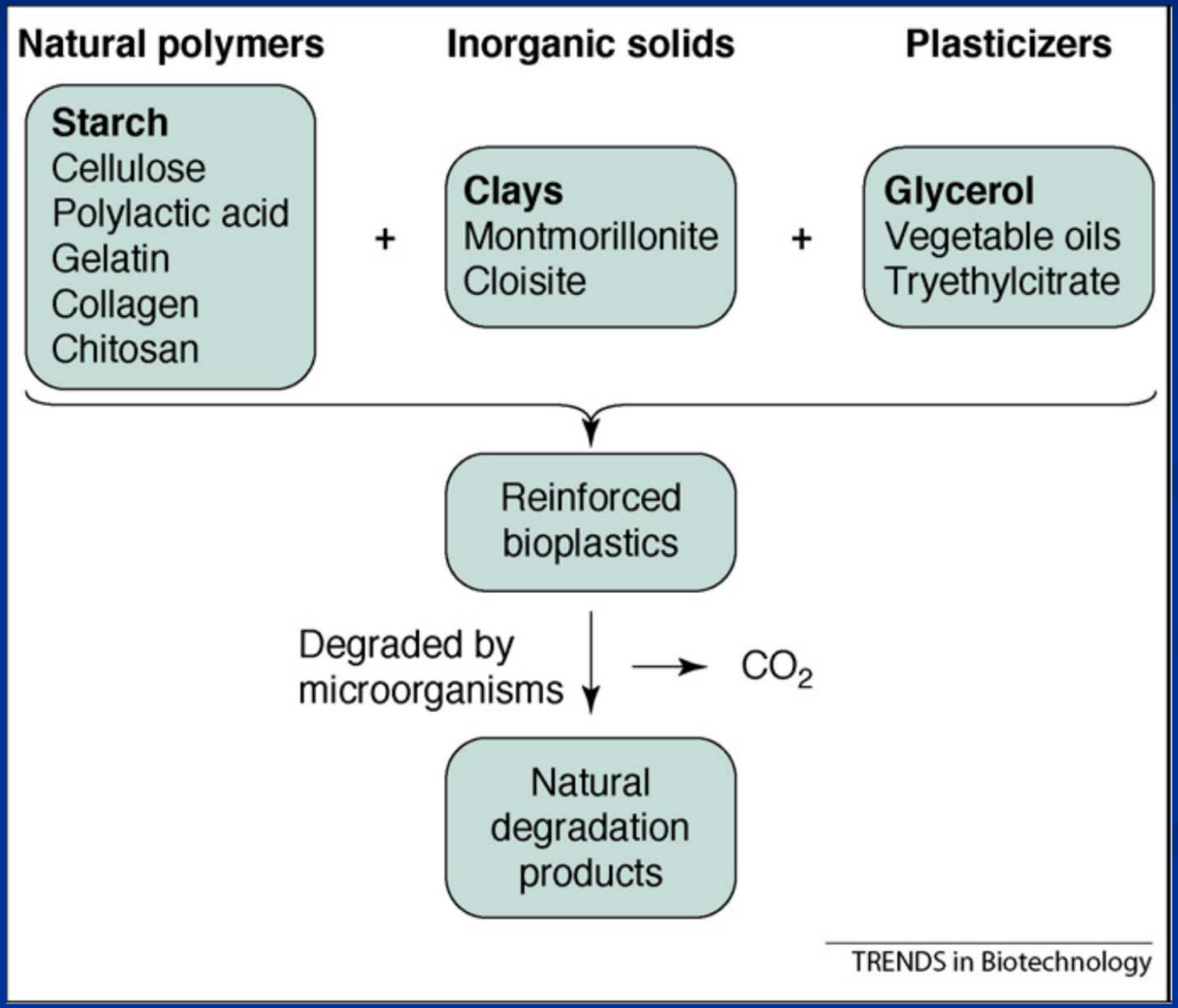


10% clay can cut OTR as much as 75%

Biodegradable nanocomposites

- Use of natural polymers is limited because of poor
  - barrier
  - mechanical properties
- Barrier & mechanical properties of natural polymers can be improved by
  - blending with other synthetic polymers
  - chemically modifying
  - adding nanoparticles

Biodegradable nanocomposites



Edible materials

- Polysaccharides
  - Starch
  - Cellulose
  - Gams
- Proteins
  - Collagen
  - Zein
  - Gluten
- Lipids

Edible nanocomposites

- To improve properties of edible material
  - physical
  - mechanical
  - barrier
- Nanoparticules could be used in edible films
  - as carriers of antimicrobials and other functional additives
  - controlled release
- To improve food properties
  - color and texture
  - food stability during transportation & storage

Edible nanocomposites

- Addition of nanoclay to pectin
  - to decrease oxygen permeability
- Addition of nanoclay to gelatin
  - to improve the physical properties
- Adding nanoparticules to chitosan
  - to improve its stability

Active-Antimicrobial nanocomposites

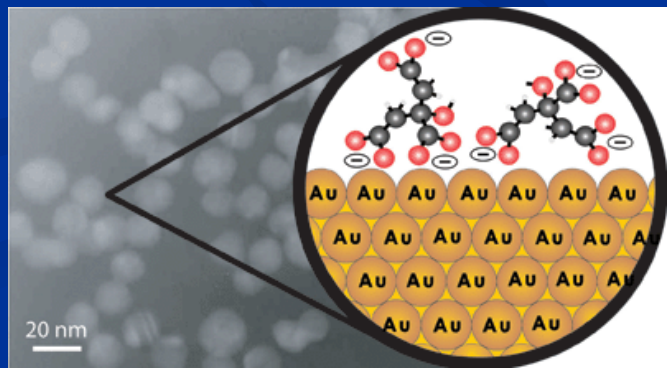
- Materials including
  - Nano-silver
  - Nano-calcium oxide
  - Nano-magnezyum oxide
  - Nano-zinc oxide
  - Nano-titanium dioxide

Antimicrobial nanocomposites- Nano-silver

- Strong antimicrobial activity inhibiting a range of metabolic enzyme
- High thermal stability
- Low volatility

Antimicrobial nanocomposites

- Ag-substituted zeolite is the most common antimicrobial agent incorporated into plastics
- Addition of silver nanoparticles into chitosan/poly (ethylene oxide) fibers had bacteriostatic effect on *E. coli*
- Nanosilver absorbs ethylene and could be used to increase shelf-life of fruits & vegetables

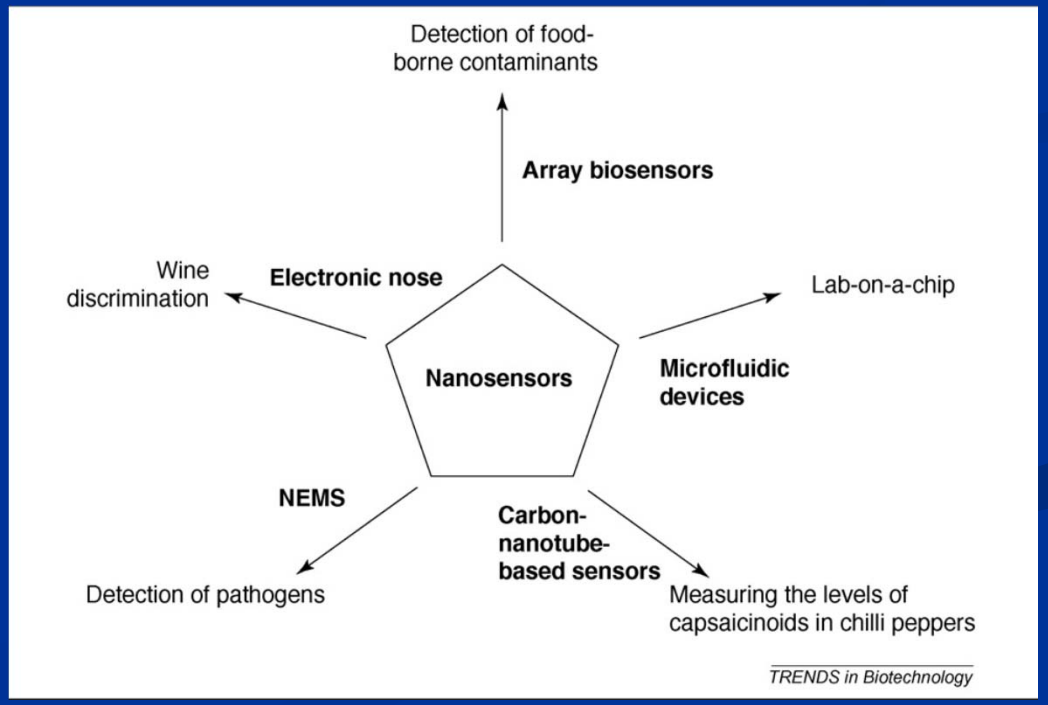


Nanoencapsulation

- The use of inorganic particles at nano-scale within edible capsules
  - to help the delivery of fragile micronutrients
    - nutraceuticals, vitamins and flavors
  - to help controlled release of encapsulated nutrients
- Nanoencapsulated bioactive compounds in the packaging
  - to control oxidation
  - to prevent off-flavor formation and undesirable texture of food
  - to help controlled release of bioactive compounds

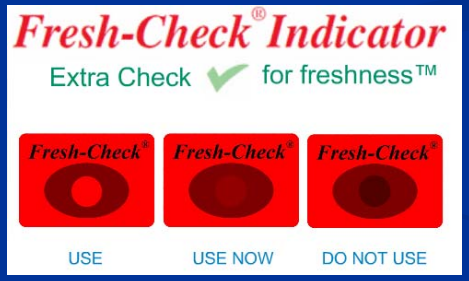
Nanosensors

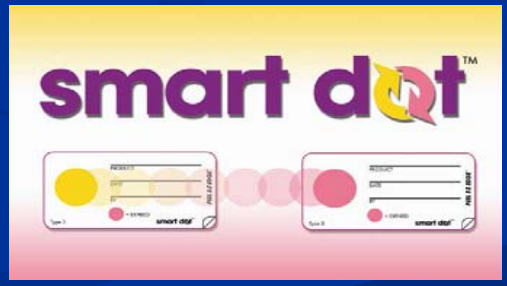
- Sensors
  - Environmental or package conditions
    - Temperature
    - Oxygen
  - Contaminants
    - Bacteria
    - Toxins



Intelligent packaging concepts

- Time temperature indicators (TTIs)
- Gas indicators
- Freshness indicators
- Biosensors

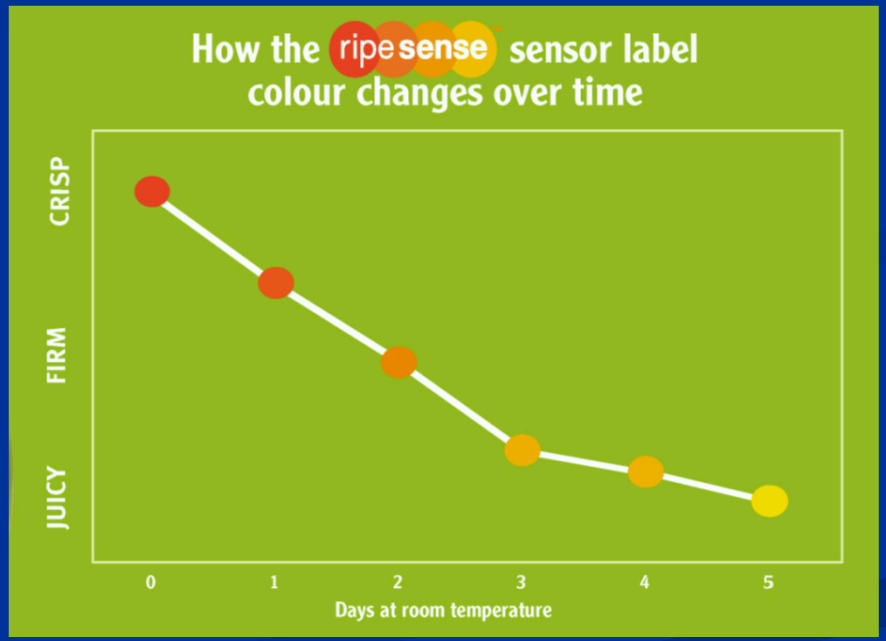




Oxygen sensors

- Film that changes color with oxidation of food inside package
  - UV-activated colorimetric oxygen indicator which uses TiO_2 nanoparticles to photosensitize the reduction of methylene blue by triethanolamine in a polymer encapsulation medium
  - Upon UV exposure, the sensor bleaches & remains colorless, until it is exposed to oxygen when original blue color is restored
  - The rate of color recovery is proportional to the level of oxygen exposure

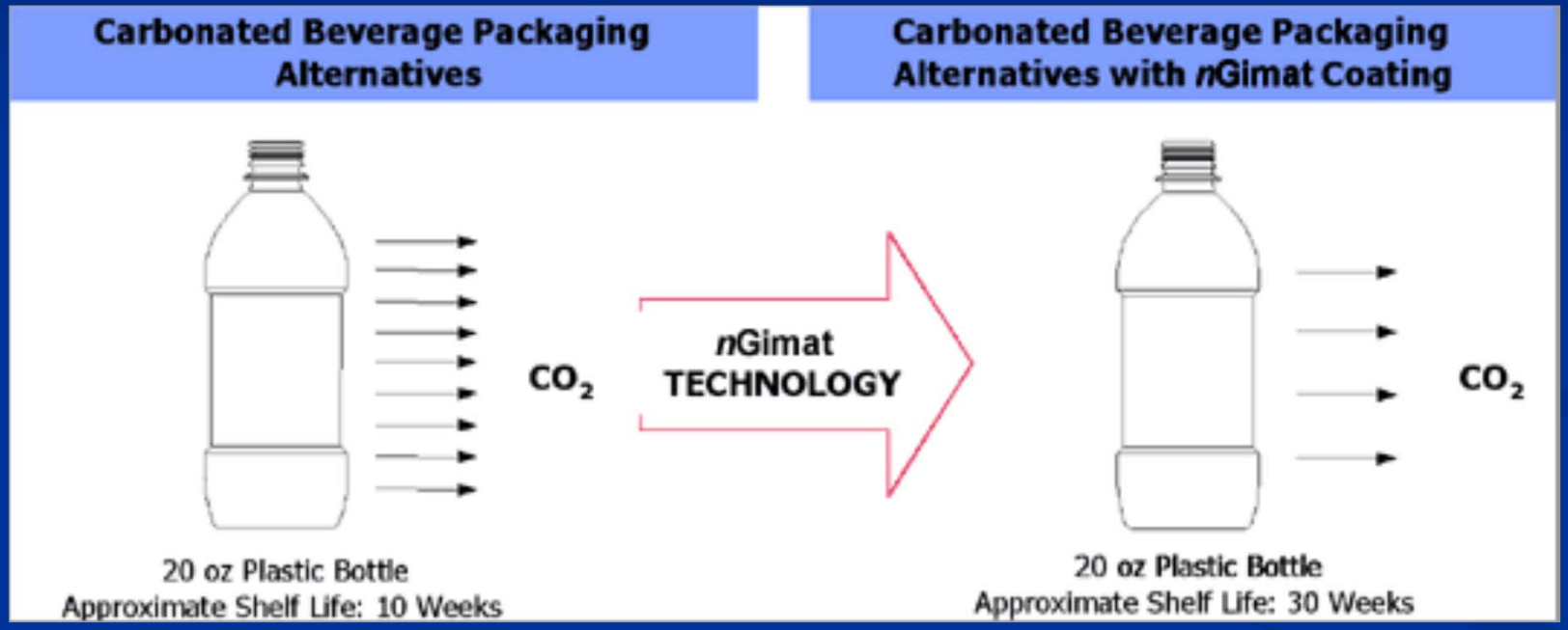
Ripeness sensors



Biosensors

- There are two components:
  - Bioreceptor
    - Organic or biological materials such as enzyme, antigen, hormon or nucleic acid
    - Determine the targeted analytes
  - Sensor
    - Converts biochemical signals into readable electrical signals

Commercial applications of nanotechnology



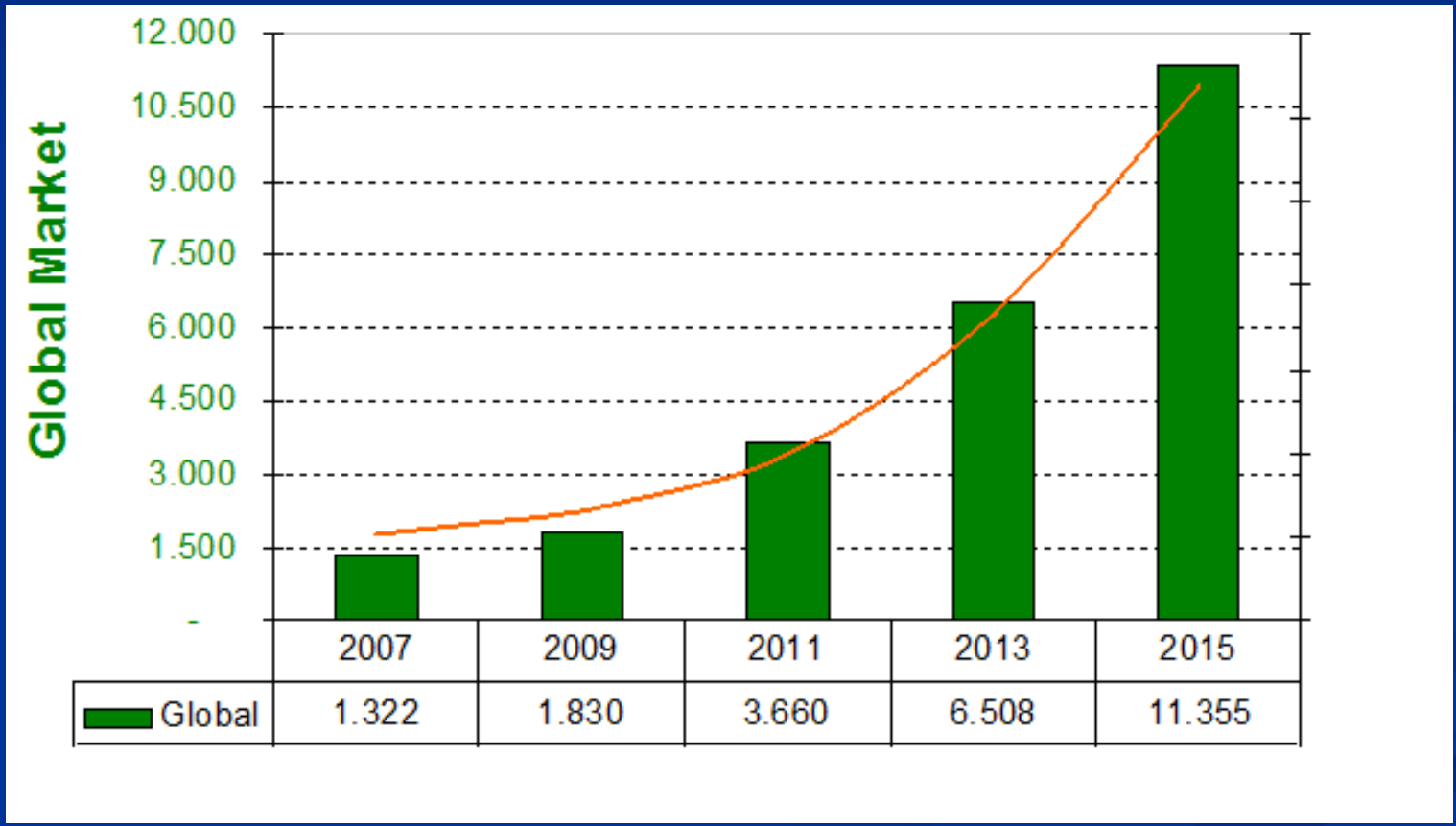
Barrier coatings for improved CO_2 and O_2 barrier on PET bottles, 30-60 nm thick layers, Si-based nanoparticles

Commercial applications of nanotechnology

- Nanoclay with MXD6 nylon in barrier layer in PET beer bottles (Ageis OX®)
- Improved barrier to O_2 & CO_2
- Comparable to glass

Polymer nanocomposite market

Projection-MM US$



29% increase between 2005-2020

Conclusion remarks

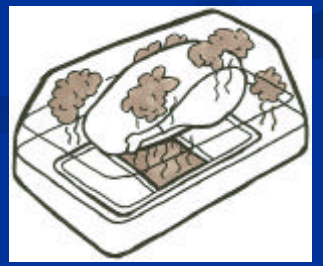
- Nanomaterials with improved barrier properties
  - to improve food quality & safety
  - to extend shelf-life
- Nanocomposites could expand the use of edible and biodegradable films
- Nanosensors
  - to track temperature history, fruit maturity, package leakage
  - to detect food freshness & safety
  - to communicate with the consumer

Conclusion remarks

- Safety/toxicology issues
- Environmental impacts
- Economics
- Consumer acceptance

Future trend in MAP

- Adaptive MAP combined with intelligent and active packaging (How?)
  - Initial MAP application (MAP)
  - Sensor in the pack detecting gas levels (intelligent packaging)
  - Release of gas activated by the sensor to compensate for gas losses (active packaging)



THANK YOU!