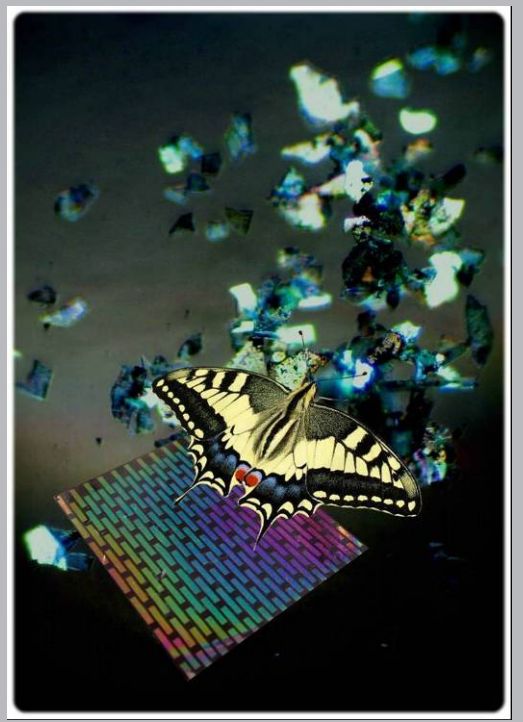
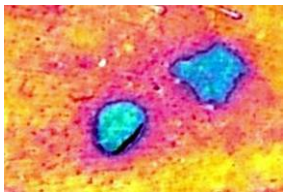
Smart pigments with reactive nanocolors printed on paper and flexibles

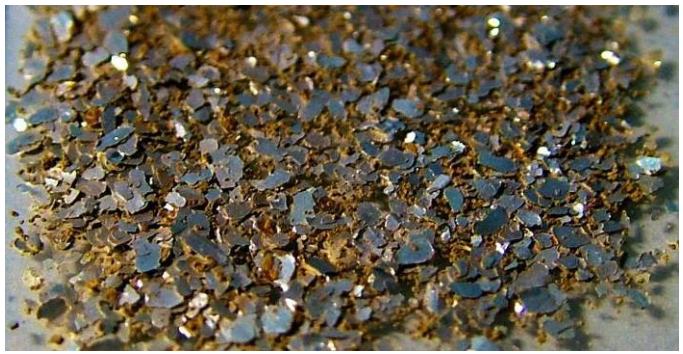
2009 International Conference on Nanotechnology for the Forest Products Industry

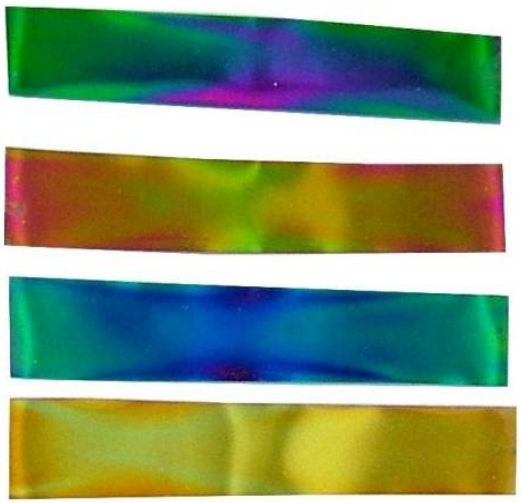


Overview

- What are smart pigments?
- Structure of smart pigments
- Smart pigments for humidity indication
- Smart pigments for food status indication

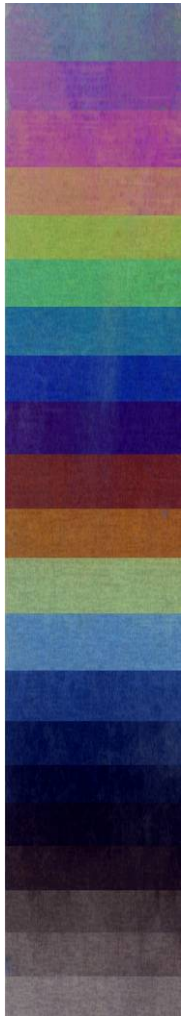






What are smart pigments?

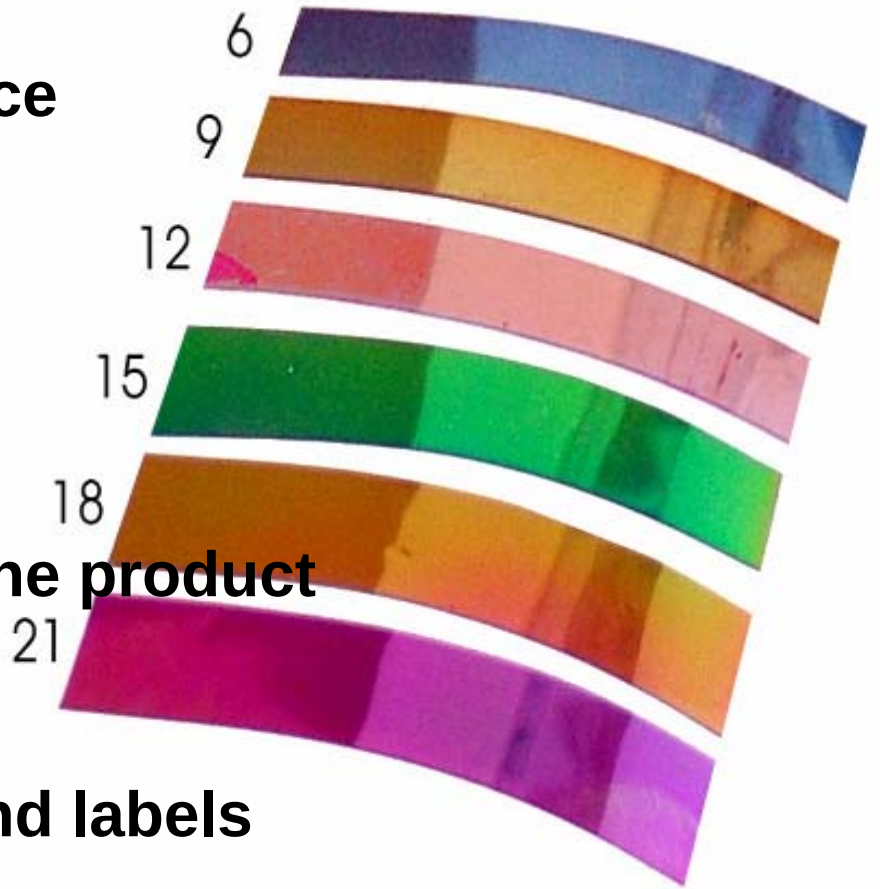
A novel technology to transform nano-structural changes into variable color



- **“Smart" = respond to stimuli (natural or artificial) with particular changes in status.**
- **Depending on changes in some external conditions, "smart" materials change either their properties (mechanical, electrical, optical appearance), their structure, chemistry or composition.**
- **Most "smart" materials are embedded in systems whose inherent properties can be favorably changed to meet performance needs**

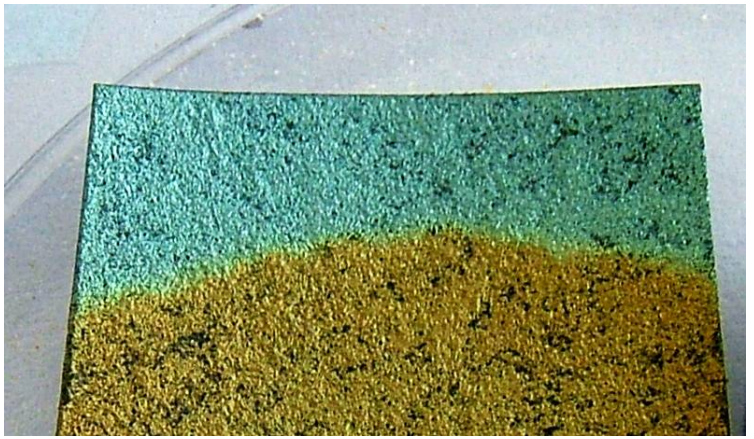
What are smart pigments?

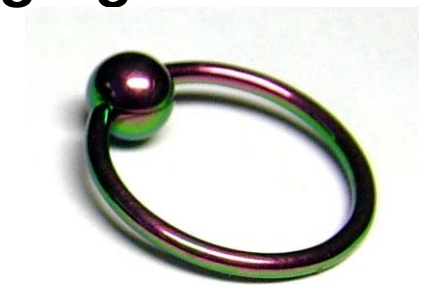
- Tunable color
- Applicable/printable on any surface
- Multi-color same-chemistry
- Stable versus bleaching
- Nano “material use” -> resources
- Smart metallic layout
- Less to non-toxic
- Visible and invisible features in one product
- Machine readable
- Extreme thermal robustness
- Can be combined with barcode and labels



What are smart pigments?

- Novel colors for printing
- Indicators
- Anti-counterfeiting
- Corporate Identity
- Pharma packaging
- Intelligent packaging
- Cosmetics
- Design
- Jewellery
- Pigments for ….



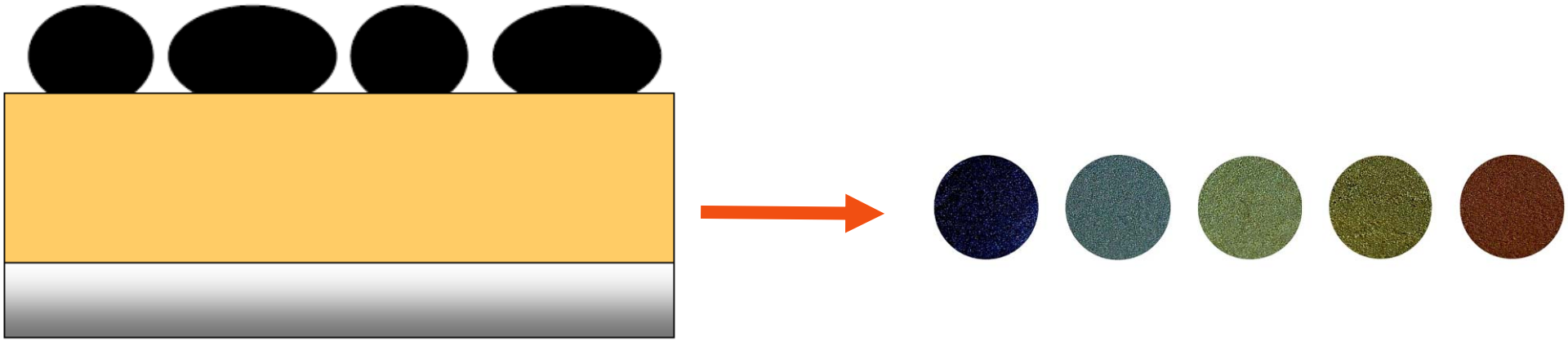


Structure of smart pigments

Smart pigments are based on REA (Resonance Enhanced Absorption) principle

All REA systems consist of three layers:

- **mirror bottom layer (e.g. metal or material with a high refractive index)**
- **middle layer (e.g. photo reactive polymer)**
- **nanoparticles on top of middle layer**



Structure of smart pigments

Colour is a function of the layer thickness → it can be changed by increasing/decreasing (“activating”) the polymer layer (multi colour – same chemistry!)

Options:
1.) vary number of clusters
2.) vary cluster-mirror distance
3.) use laser for color - 2007
4.) use pigments for smart inks - 2007

Ad 1: US6669906, 30/12/2003, Reinforced cluster optical sensors,..

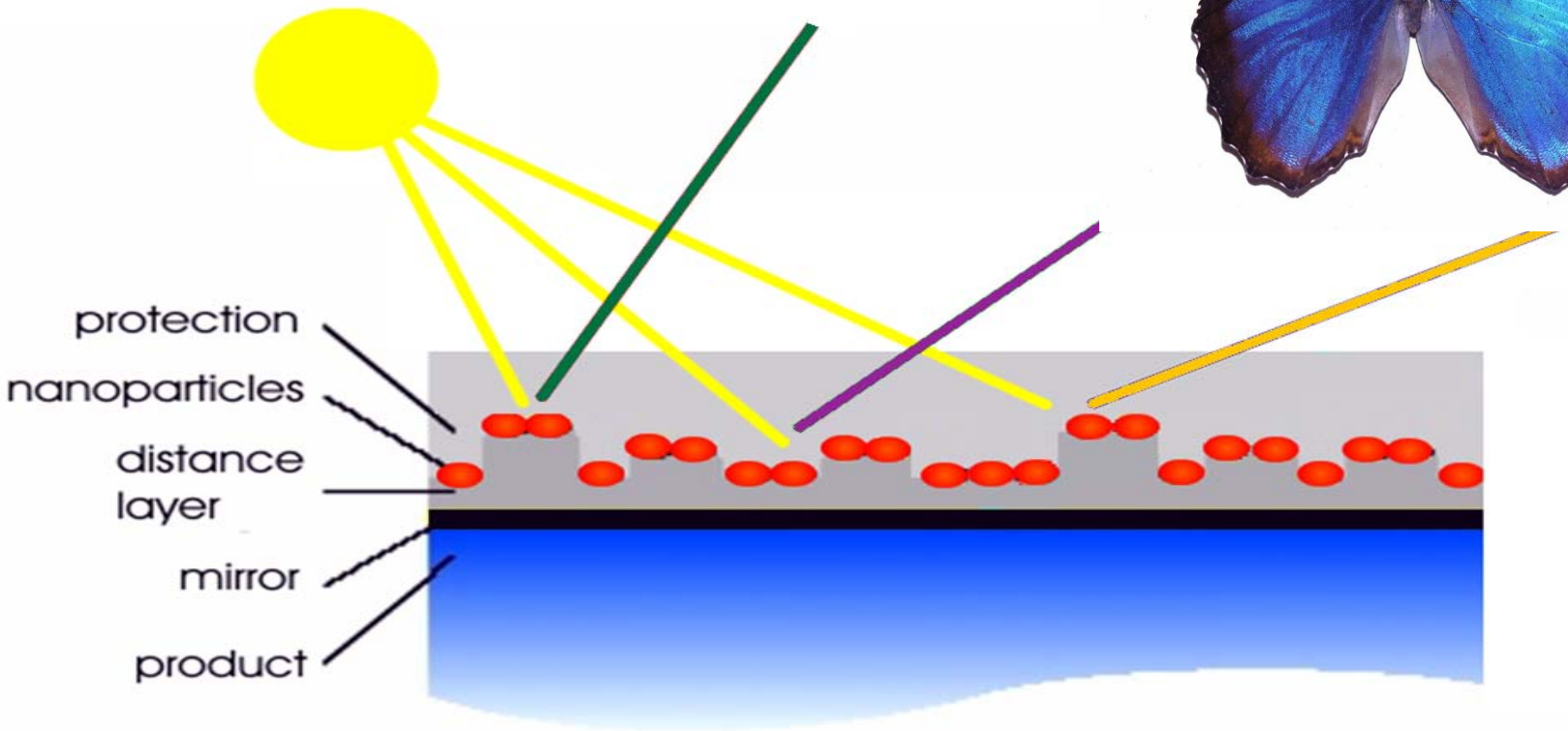
Ad 2: US5611998, 03/18/1997, Optochemical sensor and method for production,..

Ad 3: PCT, Laser color coating 2007

Ad 4: PCT, Smart-nano-color-ink 2007

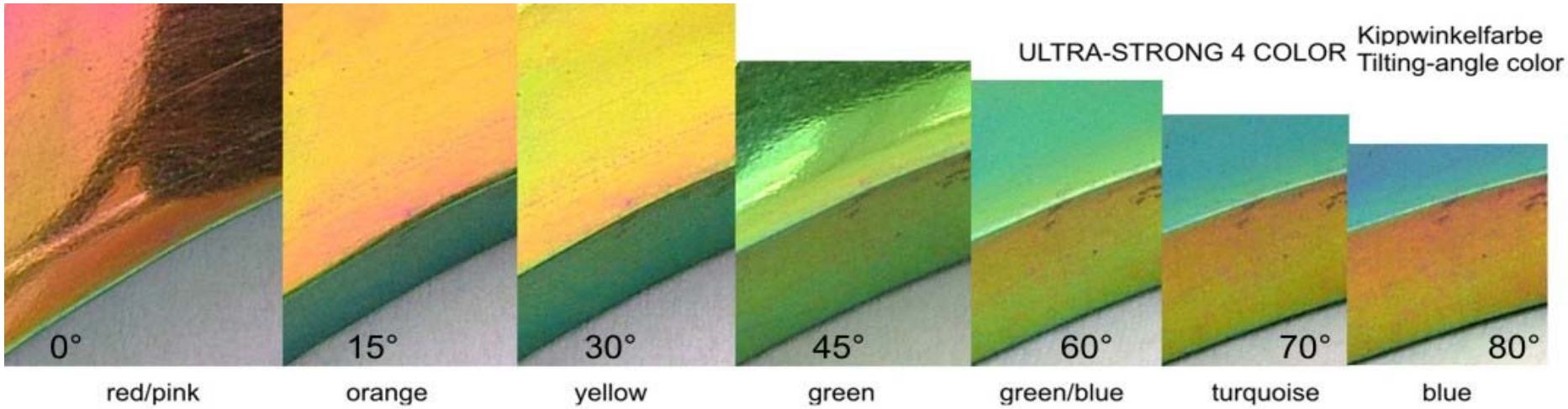
Structure of smart pigments

Viewing angle dependent color

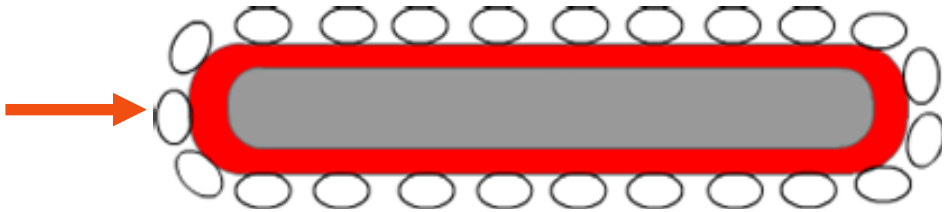


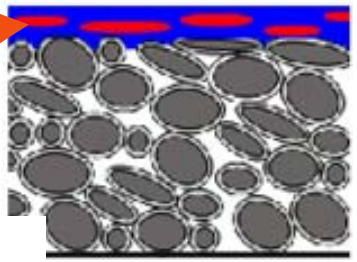
Structure of smart pigments

Viewing angle dependent color on on pressure-compacted aluminum



From smart layers to smart pigments





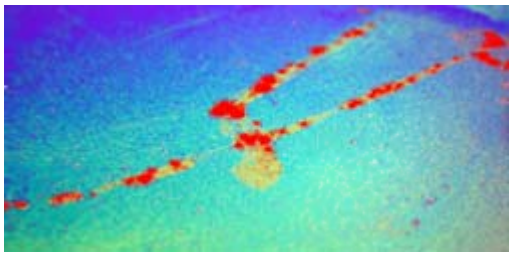
Thermal stability up to 600° C

Smart pigments for humidity indication

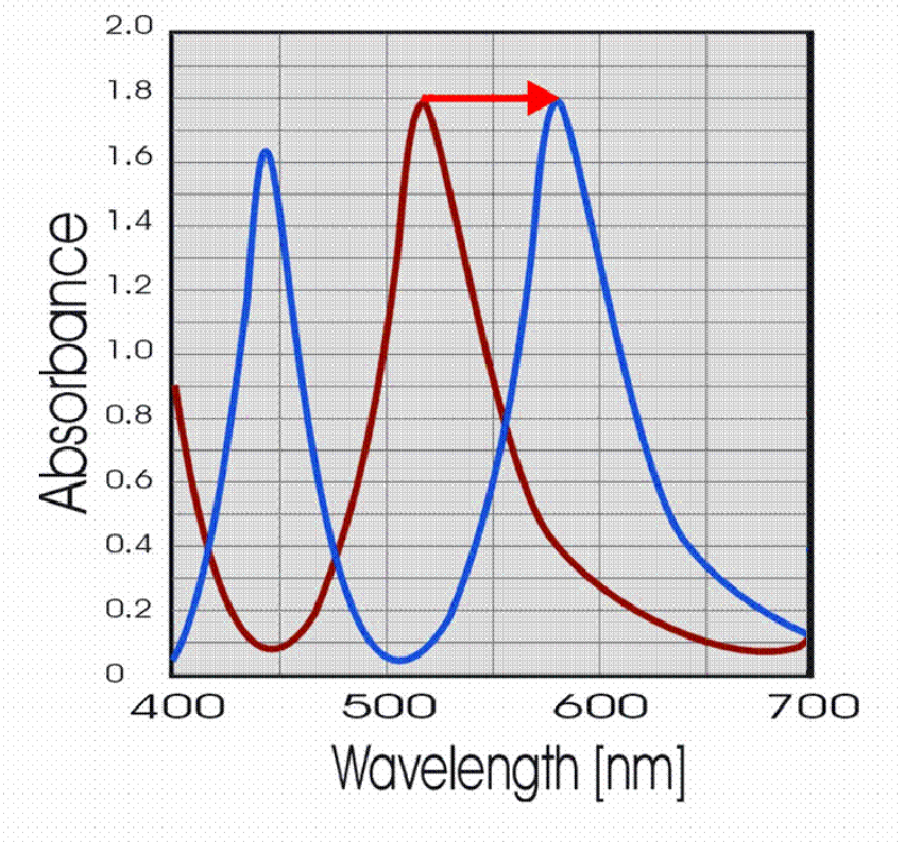
- In 1998 the EC issued a directive which classifies Co(II) chloride used for these indicators as T (Toxic) and R49 (may cause cancer if inhaled).

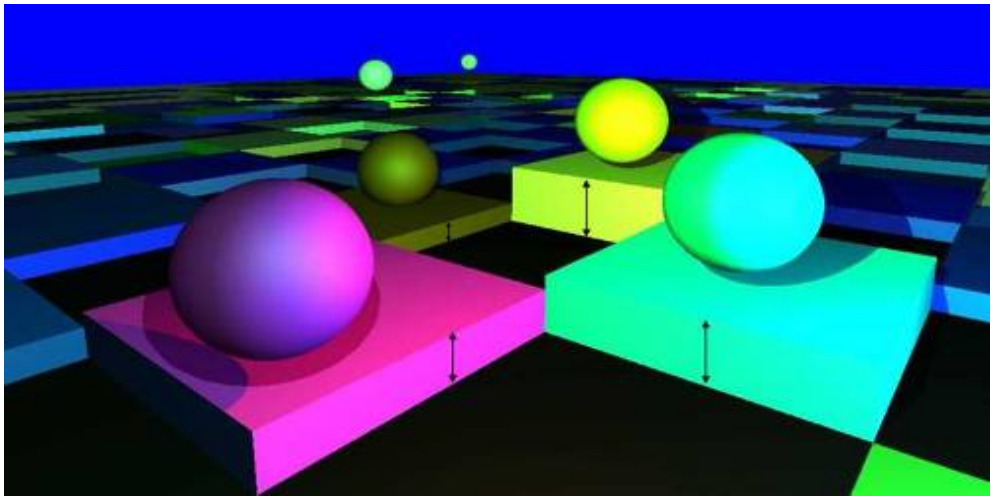
- As a consequence new cobalt-free humidity indicator cards have been developed by some companies based on Copper (II) chloride - not carcinogenic but still using a toxic metal.

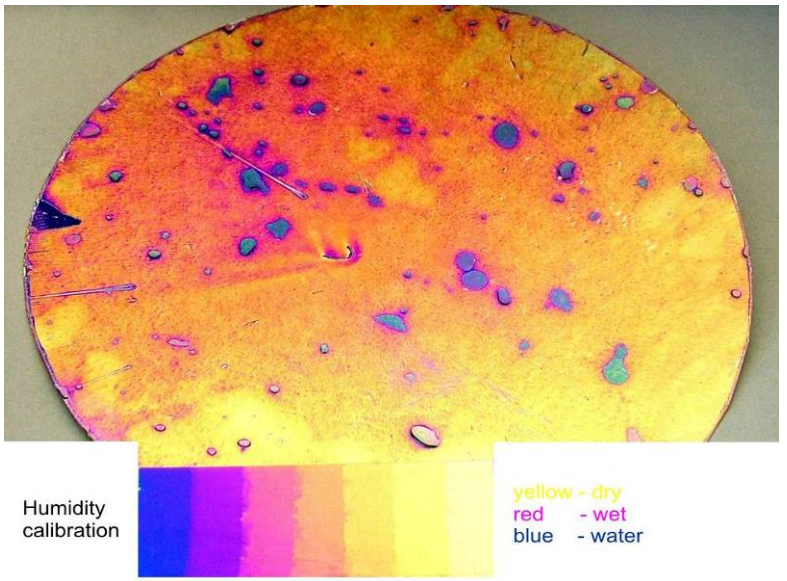
- Smart humidity indicators (SHIs) are next generation products based on nano-structural changes and thus free of heavy or toxic metals and free of soluble metal salts.



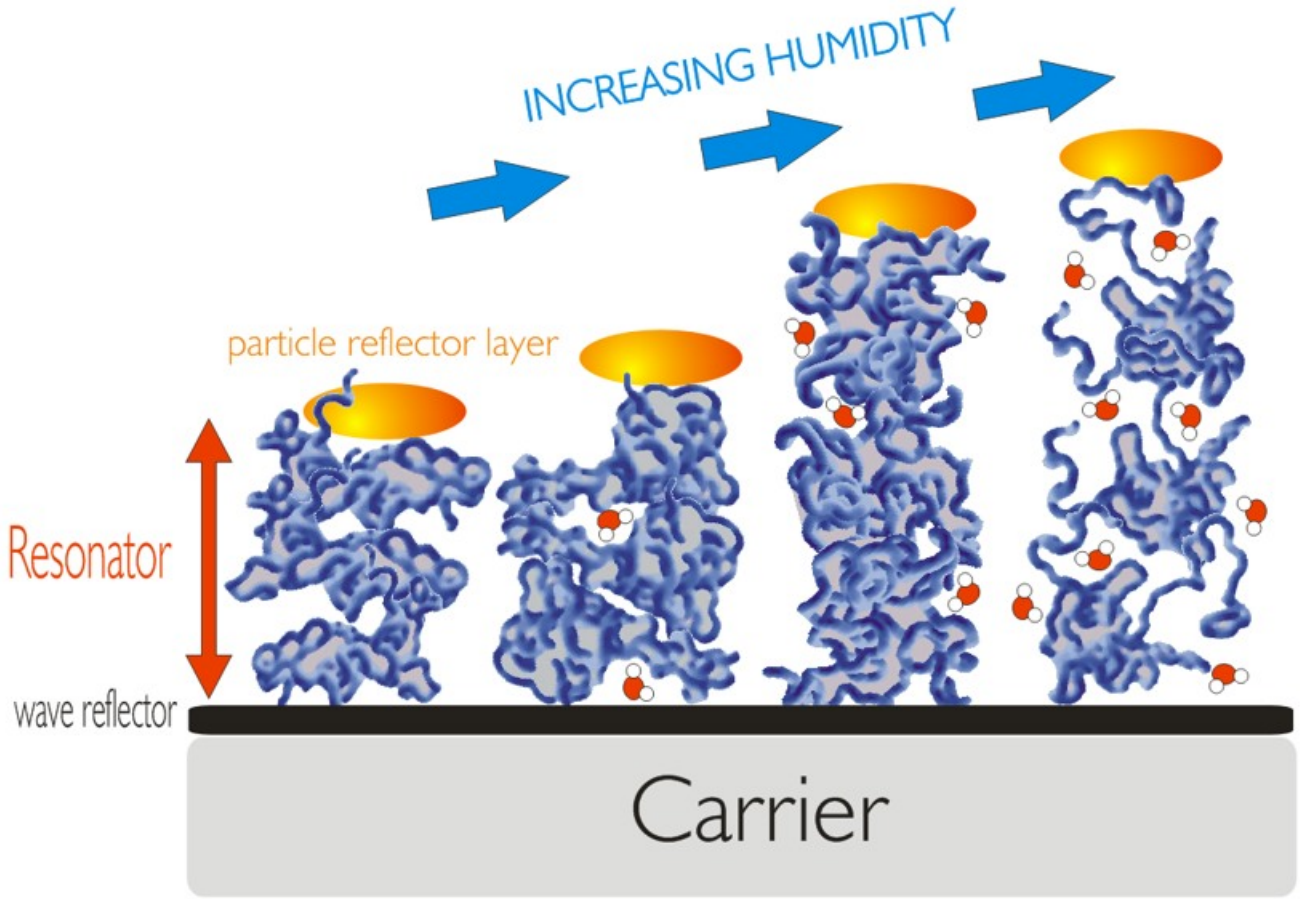
Smart pigments for humidity indication

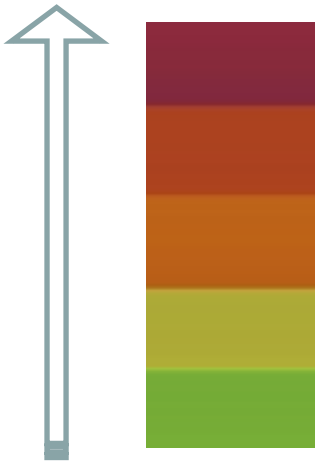






Smart pigments for humidity indication



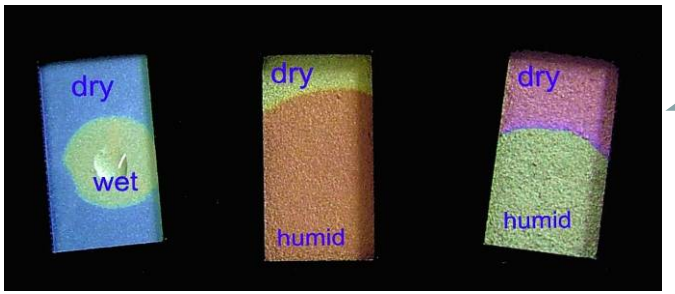


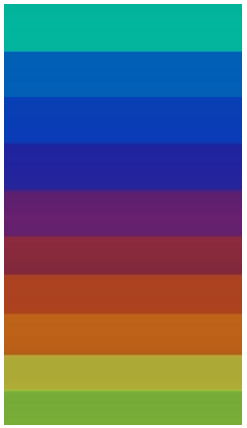
Smart pigments for humidity indication - SHIs

- SHIs are unique nano-materials with a moisture-sensitive nano-structure - not a chemical!
- usually embedded in a polymer coating matrix
- such that it will change color e.g. when the indicated relative humidity is exceeded
- inexpensive way to quantify relative humidity levels inside sealed packaging
- available in many configurations, colors and combinations and used in many applications, including food, packaging, bulk goods and semiconductor industry
- maximum humidity indicators are specially designed to monitor relative humidity (RH) levels in cargo applications.

Smart pigments for humidity indication - SHIs

- SHIs can change color from
  - blue to green
  - from green via yellow to red
  - from red to green (indicating RH level or water penetration)

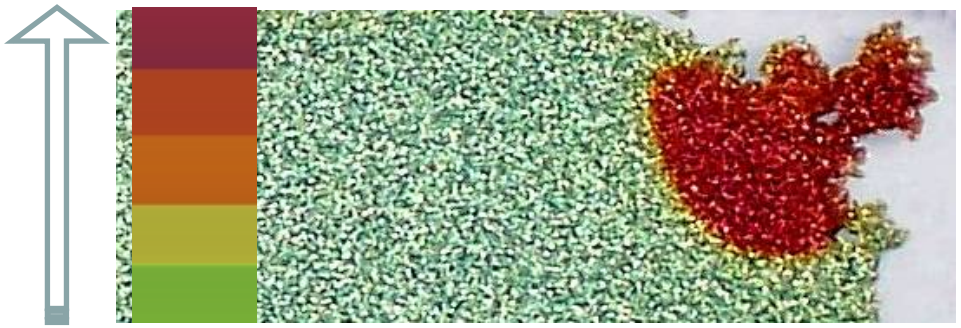


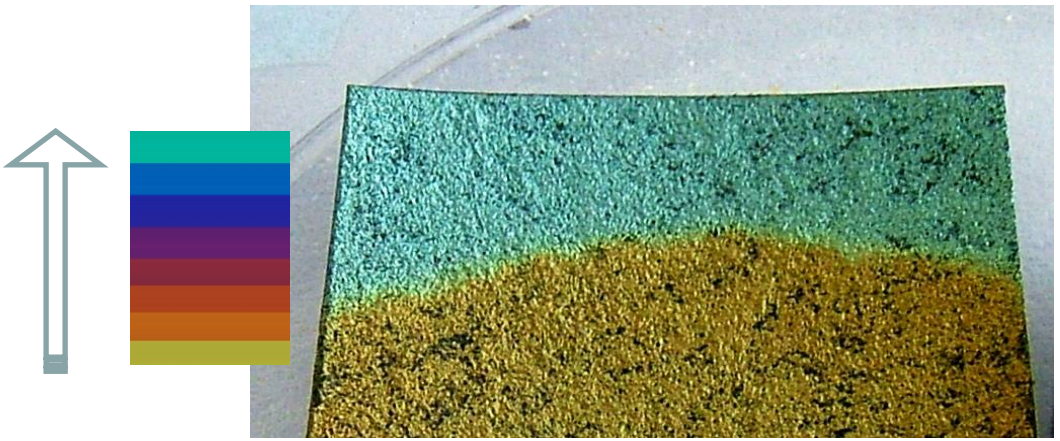


- High humidity coupled with poor packaging methods is causing most corrosion of metals as well as moisture damage to food products.

- An industry wide standard for packaging of semiconductors was released already in 1989. SHIs for the semiconductor industry indicate RH-levels of 5, 10 and 15 % and since JSTD-033B in 2005 require indication of 5, 10 and 60 %.

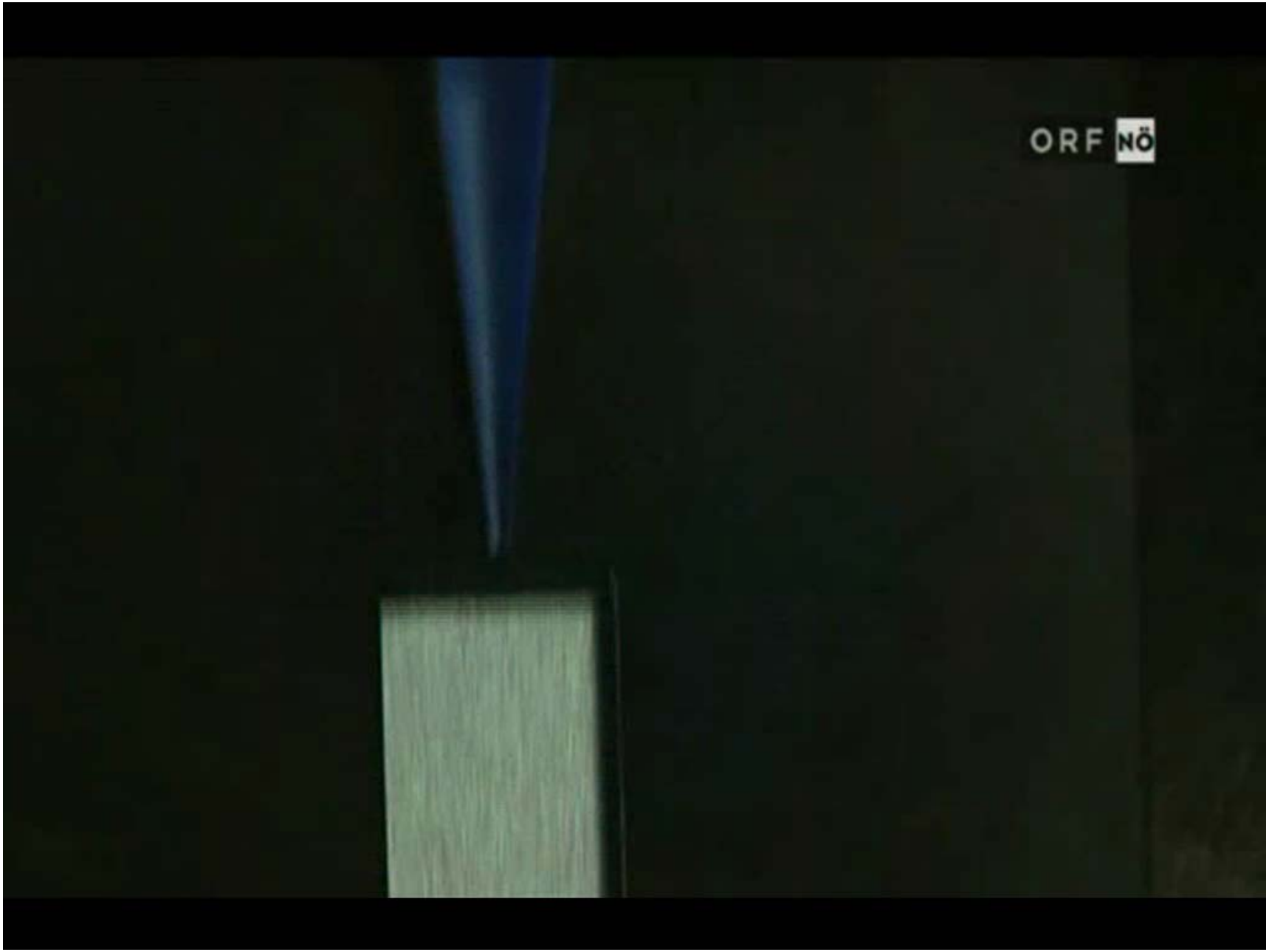
Smart pigments for humidity indication - SHIs





SHI-pigments printed on paper

wet green
dry yellow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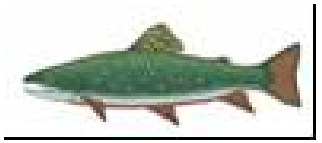
Smart pigments for food status indication

…for fish, meat,

poultry spoilage,..



…for butter indicating souring

…for milk packages indicating spoilage

…and devices for cooling chain,

sweet drinks, baby-food,

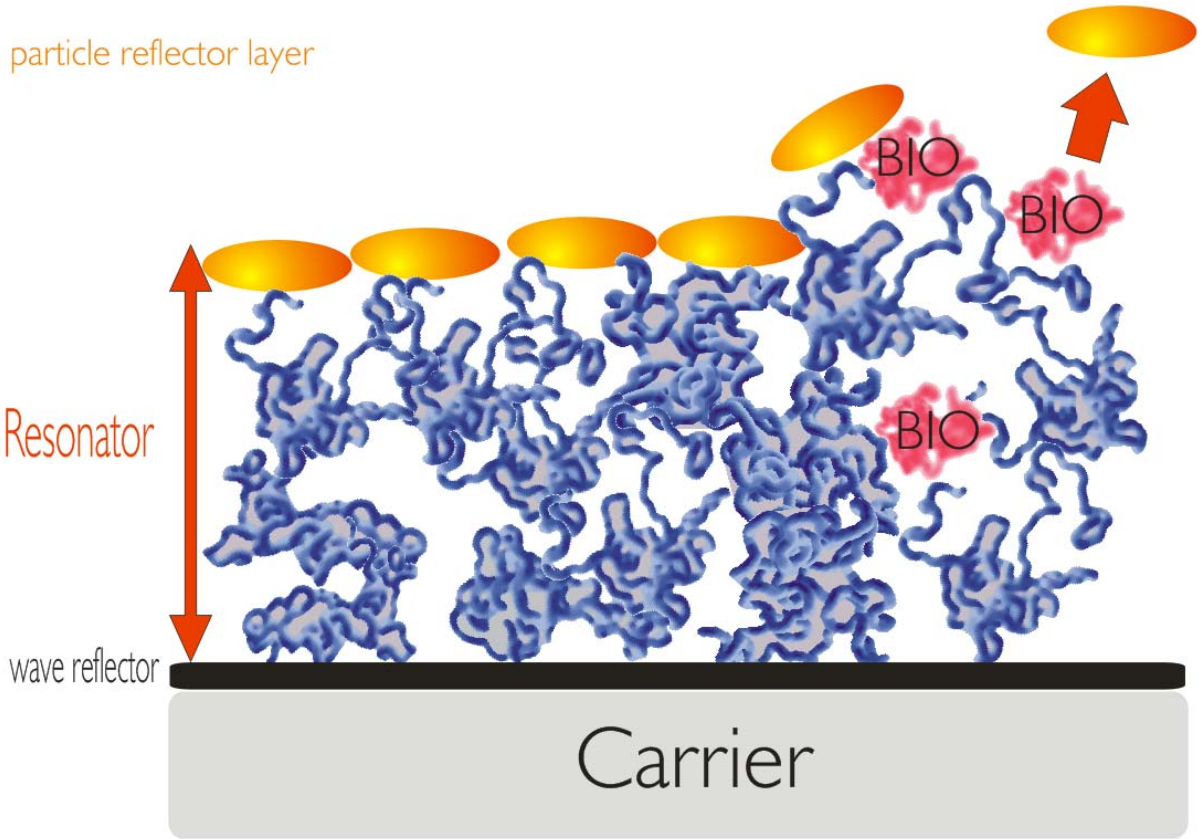
vegetables in glass & canned food…

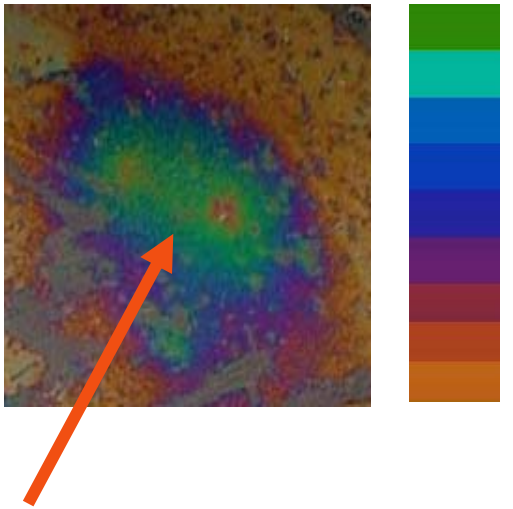
..convenience food, microwave heating,..

Smart pigments for food status indication

Usage of SHIs for humidity control in food packaging

Smart pigments for food status indication



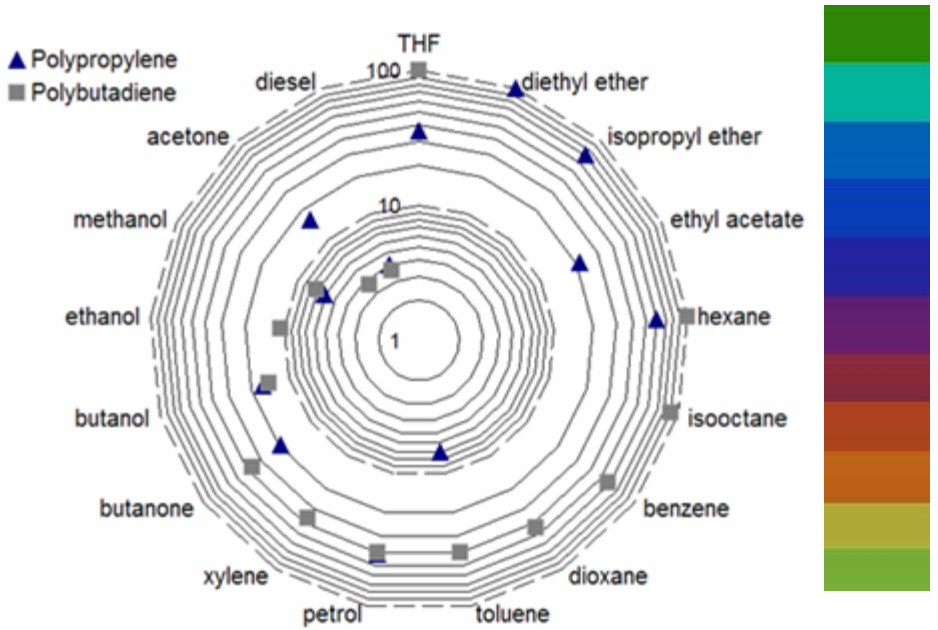


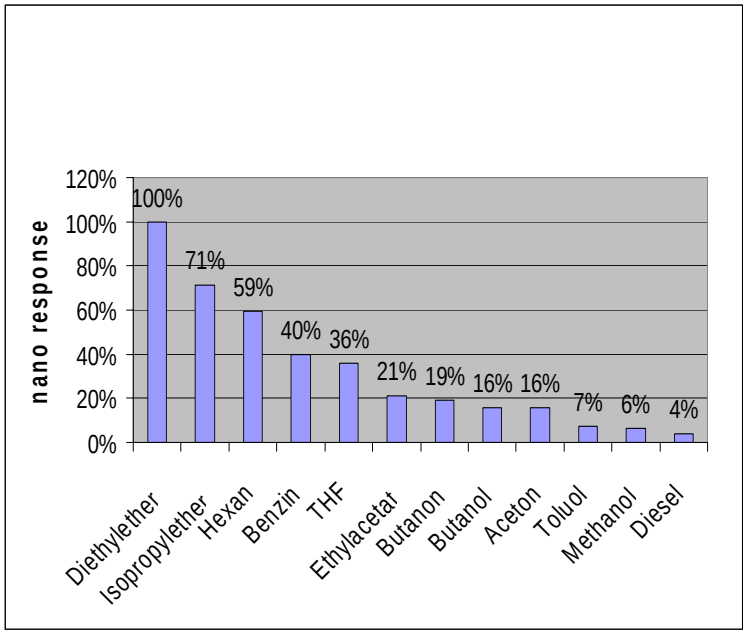
Visualization of bacterial contamination

Smart pigments for food status indication

Microbial contamination of fish

Smart pigments for various applications …

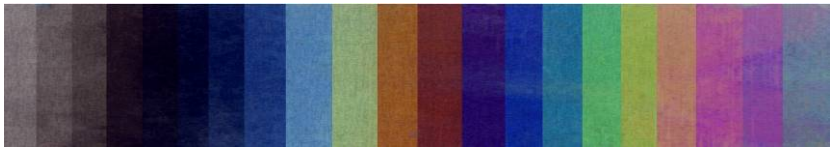




In the gas phase the smart material responds to petrol/diesel mixtures of various compositions and temperatures. The higher the petrol percentage the more significant is the color response.

Summary

- Color change can be triggered by any chemical or physical stimulus
- Wide range of different colors



- Minimum material for maximum effect
- Intelligent material which can be used for
  - Indicators (packaging, pharmaceutical, medical, technical applications)
  - Design (jewellery, surface finishing, etc.)
  - New printing technologies
  - ...

Acknowledgment & Disclaimer

Many thanks to

- plus eco
- FFG
- nano initiative

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