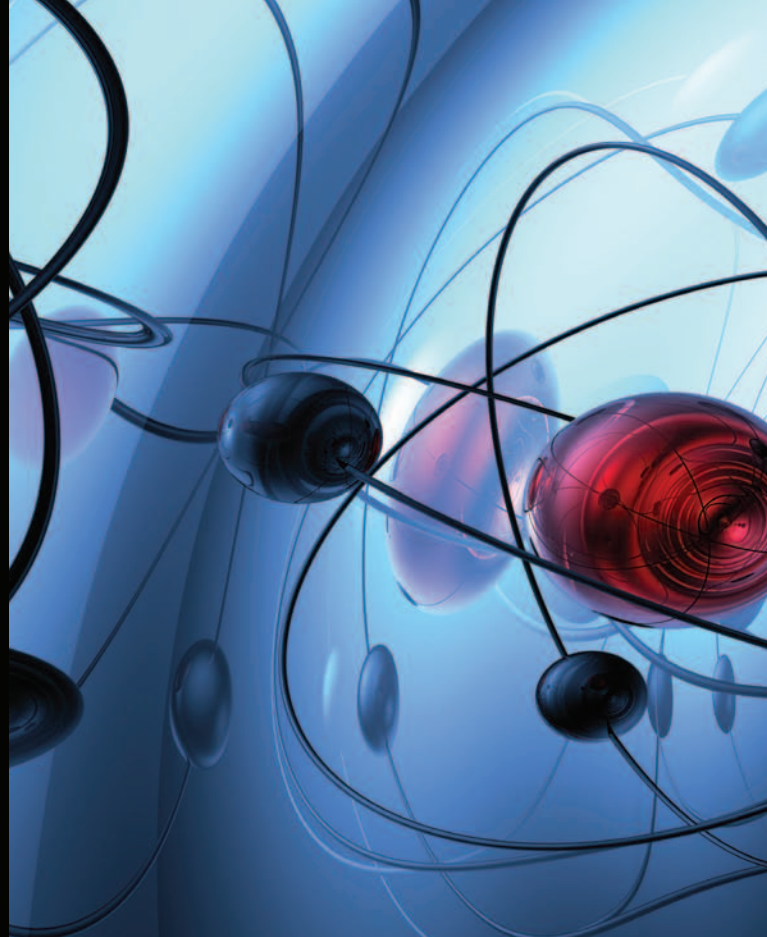


One small step

Materials modified at the nanoscale (10⁻⁹m) provide unique properties which could improve food packaging. **David Cava** and **Alan Smith** explain the benefits of using nanoparticles in packaging, and their commercial viability.



The number of nano-based packaging applications is reported to be growing fast. Three years ago fewer than 40 packaging products containing nanoparticles were thought to be on the market, compared to the 400 plus currently available. The market for food packaging containing nanomaterials has been predicted to reach \$360 million in 2008 and \$20 billion by 2020.

Nanoclays

Currently, clay particles at the nanoscale are the most common commercial application of nanoparticles in food packaging and account for nearly 70% of the market volume. They are less expensive to produce than some other nanomaterials because full-scale production facilities already exist and the basic materials come from available natural sources.

The main advantage of using nanoclays is an increase in the barrier of the material to gas and water. A well-known example of this is the PET beer bottles distributed by ColorMatrix utilising nanoclays produced by Nanocor®. While the storage time of beer in normal PET bottles is about 11 weeks, this increases to 21 weeks when it is kept inside multi layer bottles incorporating Mitsubishi's highest barrier nylon. However, the storage life increases further, to about 30 weeks, when a nanoclay barrier is used.

The incorporation of nanoclays into packaging has also been claimed to offer:

- **Reduction in raw materials.** Improved stiffness enables the use of less raw material and down-gauging by 20% can be achieved. Lighter packaging may lead to savings in the cost of transportation, storage and recycling.
- **Less dependence on speciality products.** Polymer-clay nanocomposites can be alternatives to expensive speciality materials. The nanocomposites can be cheaper to recycle.
- **Elimination of secondary processes.** High-cost operations such as laminations for barrier packaging or mechanical

Nanofacts

- Nanotechnology is the manipulation of matter on an atomic and molecular scale.
- It can mean the creation of lighter, stronger materials.
- Companies are already using nanoparticles to prolong the shelf life of food.
- UK studies have indicated there is still consumer reluctance over nanotechnology in food packaging.

surface finishing can be eliminated.

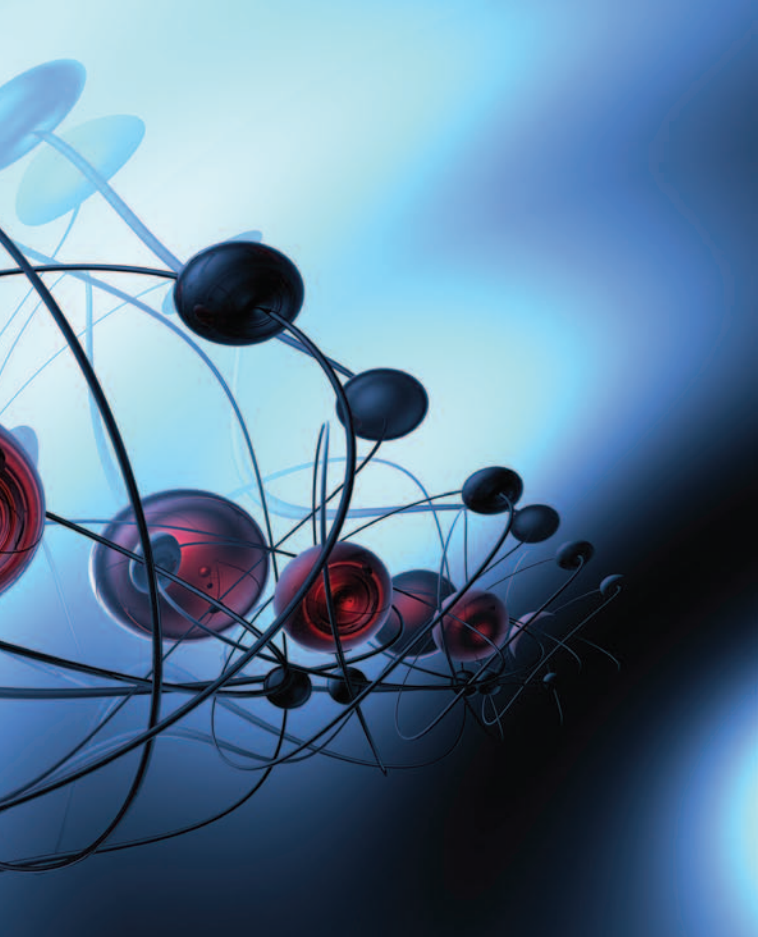
- **Less complex structures.** Nanocomposites may have less complex structures than, for example, multi-laminates and this can lead to easier recycling.
- **Reduction in machine cycle time.** By changing the physical and thermal properties of polymers it is possible to reduce pack production times.

The surfaces of nanoclays are naturally more active

than those of many polymers. Therefore, nanoclays added to the polymer can also be used to incorporate active substances like oxygen scavengers or aroma compounds to the packaging. They can be permanently bonded to the clays and act as scavengers or be released during the shelf life of the product to, for instance, counteract aroma losses during storage.

Metal nanoparticles

The incorporation of silver nanoparticles can give a polymer the ability to kill micro-organisms. This is probably the most often cited application of metal nanoparticles in surface treatments. Silver at the nanoscale is known to be an effective anti-microbial and is claimed to be effective against 150 different bacteria. It has been incorporated into plastic food containers. Sharper Image® and BlueMoonGoods in the US, Quan Zhou Hu Zeng Nano Technology in China, and A-DO Global in South Korea, sell these products. These companies claim that the particles provide anti-fungal, anti-bacterial and anti-microbial properties



that keep food safer, fresher, healthier and tastier.

Zeolites are minerals with a micro-porous structure. When loaded with silver ions and incorporated in packaging, they kill micro-organisms in it. 1% of silver zeolites in polyethylene reduced the levels of microorganisms from 10^5 per ml to less than ten cells in 24 hours. Zeomic (Sinanen Zeomic Co. Ltd.) is one of the commercial silver zeolites used in household food preparation items and packaging film and this has FDA (Food & Drug Administration) approval for food contact use. Silver zeolites from Agion Technologies have approval for use by EFSA (European Food Safety Authority) for processing appliances, consumer foods and food packaging.

Gold nanoparticles can have the same applications as silver ones. Researchers in Germany have also incorporated both into thin surface layers with polytetrafluoroethene (Teflon). The use of both metals produces a greater anti-bacterial effect than silver alone, although no commercial application has been found.

On its website, American Elements claims that zinc nanocrystals can also be used as an anti-microbial, anti-biotic and anti-fungal agent when incorporated in coatings or plastics. Again, no commercial application in packaging has been found.

Oxide nanoparticles

Zinc oxide and titanium dioxide have been used in sun creams for many years and as white colorants for paper, paints, plastics and printing inks. They are white in appearance but they are no longer visible in sun creams when their particle sizes are reduced below 100 nanometres (nm). Although these nanoparticles block UVA and UVB, there have been concerns that the particles can damage DNA because they absorb UV radiation and yield hydroxyl radicals. However, in guidance published in 2006, the Australian government indicated this reaction would only be of concern if the particles penetrated

viable cells, but considered that the particles would remain at the surface outer layer of dead cells. However, there is still a risk that similar concerns could be raised after the incorporation of zinc and titanium dioxide nanoparticles in food packaging.

The company Advanced Nanotechnology has examined the use of zinc oxide nanoparticles as a UV blocker in packaging. Existing chemical blockers were said to migrate out of the packaging whereas the company was looking to block the movement of zinc oxide.

A research paper published in 2006 also found that the addition of zinc oxide and polytetrafluoroethylene nanoparticles could increase the water resistance (x400) and reduce the friction coefficient (x7) of epoxy resins. Silicon oxide coating has been added to the inside of containers to increase their barrier properties. For example, SIG Cormoplast's Plasma Impulse Coating Vapour Deposition (PICVD) system applies a silicon oxide coating of less than 100 nanometres inside PET bottles. According to the company, it increases the shelf life for 12oz carbonated soft drink bottles almost three-fold to more than 25 weeks. The system has also been used on beer bottles. Thin coatings (20-150nm) can also be applied to the outer surfaces of bottles.

Commercial viability

Nanotechnology, defined as the use of material at the nanoscale, has been used by packaging scientists for many years. However, to date, with the exception of some materials such as nanoclays, the costs of manufacturing and using such nanoparticles is too great compared to the advantages achieved in the final commercial pack. Consequently, most packaging incorporating nanoparticles is currently receiving attention at the research stage rather than in commercial applications. This great opportunity for advancement will continue to be overlooked by the commercial packaging industry until the cost of manufacture becomes more affordable. **pci**

About the authors

Dr David Cava is a Higher Research Scientist at CCFRA. As a member of the packaging and manufacturing section, he studies food packaging interactions, especially those affecting the flavour of foodstuffs packed in plastic containers, and new food packaging materials like biodegradable polymers and polymer nanocomposites.

Dr Alan Smith spent ten years in universities prior to 25 years as technical/business director at several large companies. He was a director of the UK's Manufacturing Molecules Initiative and the Micro & Nano Technology Network. He currently works with the Nanotechnology Industries Association.



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