Report of the Second NanoBio RAISE Workshop
Performed on 19th and 20th of March 2007 in Frankfurt a.M. Germany

Nanotechnology in Food and Environment

The NanoBio RAISE workshop was held at the Mercure Hotel Frankfurt Fairground with the participants of the project consisting of people with a background e.g. in society, ethics, religion or consulting. Experts in nanotechnology were invited for lectures and as partners for the subsequent discussions. The two day workshop focussed mainly on food; in a short lecture some aspects of environmental technology were shown out. The workshop aimed on informing the participants on nanotechnology in food and environment and was intended to showing the participants opinion on the discussed topics.

During the workshop a number of lectures were given. After each lecture some questions were asked and a first discussion started. As time was short, occasionally discussion was divided in several groups to achieve results on the many topics mentioned during the workshop.

This report describes the discussions held at the workshop and summarises the opinions of the workshop's participants.

Executive Summary

Right from the planning stage of the workshop it became clear that it should become difficult to contact the food industry and motivate them to have them at the workshop. A usual answer to the invitation was, that they do not do any nanotechnology and thus it should not be necessary to visit the workshop.

The participants of the workshop consistently stated food industry should not sit on the fence when discussing nanotechnology. Though food industries' point of view is comprehensible, not to start a potentially difficult discussion, before it is needed, the refusal to join the discussion could give the impression, food industry had something to hide, even though no really problematic nano substances have been found up to now.

A central outcome of the workshop was the urgent suggestion of the participants to the food industry to join in the discussion on nanotechnology.

Concluding the impression of participants and reported impressions of citizens it became clear that nanotechnology is regarded positively in general on the one hand. On the other hand it was equally clear that customers will not favour nano in food in general. An improvement of food with the help of nanotechnology will be acceptable, i.e. the (make-believe) need for a special diet for a modern person is accepted. But as soon as an advantage for the customer is not visible, nano in food will be rejected. Arguing "that will help industry" will fail. The only accepted aspect that does not meet the customers concerns directly is helping the world, e.g. feeding the hungry.

For environmental techniques the summary is comparable. If positive effects for the environment can be identified acceptance is high. Any negative effects for environment will be rejected.

One general aspect was stressed during the workshop: Customers expect products with or without nanotechnology to be generally safe. This prerequisite is a sine qua non and must be achieved by the industry. All other subsequent measures will base on safe products. A tag, labelling if and what kind of nanotechnology is in a product could give the customer the opportunity to choose between nano and non-nano. The workshop’s participants recommend such kind of labelling as it seems to be appreciated by the public.

Reported topics in food

Processing Food

Processing of milk

Milk and other fluid can be cleaned by micro-/nanofiltration. Bacteria, dust and other solid impurities can be filtrated off. Although milk-fat is of the same size as bacteria, it is flexible enough to pass the pores of the filtrating membrane by deforming. Thus pasteurisation is no longer needed. Reduction of the pore sizes makes it possible to gain components of the milk for separate usage.

Issues

Open questions were whether such kind of nano-manipulation must be reported on a tag, because obviously no nanocomponents will reside in the milk after nanofiltration. But is has had contact with nanotechnology. For example one might suggest, that this ultra pure milk may have influence on humans immune system, as the milk becomes just too clean.

Nanonnaise

Micro- to nanometer sized drops of oil in water can be achieved by pressing oil through a membrane with nanometer (or micrometer) sized pores. Such emulsions of fat in water can be tuned to pass the stomach unaffected and reach the small intestine. This effect happens usually when someone has eaten so much fat, that it passes the stomach without getting digested. An arrival of fat in the small intestine recognises the body as “I am full”. As fat-emulsions are an essential part of mayonnaise, this “nanonnaise” could be used to reduce fat consumption.

Issues

Obesity is mostly a societal and dietetic but not a technical problem. Producing nanonnaise will not solve the problem but could help treating symptoms of malnutrition. A correlation between malnutrition and (un-) education is evident and has been shown for the lower class in Great Britain. For that reason nannonaise must be produced cheaper than normal mayonnaise to succeed on the market.

Up to now it is unclear, which side effects nannonaise could have. Lipoproteins that can be used for encapsulation of the fat in nanoemulsions may show side effects on their own. This makes clear, up to now nanonnaise will not succeed on the market.

Enhancing Food

Meat from plant proteins

Meat consists of higher quality proteins than plants. If artificial meat could be produced in industrial facilities that could be much more effective than natural production. In principle it is possible to convert plants proteins to animal like proteins. Nowadays the most important difficulty to overcome is shapening the texture so that the artificial meat resembles natural animal meat.

Issues

This production method seems as a contribution for feeding the hungry, e.g. in the third world, if the difficulties mentioned above can be overcome. If a high tech industry is needed and high licensing fees must be paid, poor countries will not be able to finance this technology.

Functional Food

The metabolism of humans needs certain ingredients which it cannot produce on its own. These vitamins and dietary supplements must be provided with the food. Many of them are improving the conditions of humans, some of them are essential for humans (and other mammals).

An often used example is carrots containing beta-carotene which is used for formation of Vitamin A. If people get too few Vitamin A, their eyesight may decrease. Vitamin A is poorly water soluble and cannot be absorbed. If brought into a nanoparticular shape and encapsuled in a matrix, uptake can be improved immense. Nanoparticles of vitamin A (and others) are sold since the 1960s.

A more recent example is lycopene, contained in tomatoes and there responsible for their red colour. Lycopene is said to be a radical catcher and thus to guard against cancer. Again, lycopene is very poorly water soluble and is formulated as a starch complex to increase uptake rates.

With the approved technologies should the encapsulation of other additives like bad tasting or smelling substances as well as even medicaments be possible.

Issues

It seems to be accepted by the public to need a special diet. If no negative effects will be shown and furthermore the rumoured qualities not vitiated the nanoparticular additives they will be appreciated in our food. Customer queries make sure, that she/he would like to be informed whether nanotechnology is in a product or not.

Ensuring Food Quality

Food packaging

Materials with barrier properties for gasses like oxygen or steam can help to improve food quality. This can be done with silicon dioxide particles, embedded as discs in a plastic foil. The silicon dioxide is a clay that can be mined in an open pit.

If oxygen cannot penetrate a plastic packaging material and so cannot reach meat in a packaging, stability of the product can be increased. The other way round, aromas and water cannot penetrate the foil and so stay in the product, keeping the original taste and smell.

Issues

Improving food quality in general is a good thing. But if this invention leads to rotten meat that looks only fine because of the foil around it, it will be depreciated. Furthermore unintended transfer of nanomaterials from the packaging material to the food must be avoided!

Here is an example of a natural nanoproduct. No new nanoparticles are synthesised but natural nanotechnology is used. But what will happen with the foil at the end of it’s lifecycle?

Nano-Silver

Silver nanoparticles can be used in surfaces of walls and stocking trays in refrigerators as well as lunchboxes. They are applied to avoid mould infestation and bacteria contamination on all surfaces that can come in contact with food or where air-transported contaminants can settle. These surface modifications are only operative at contact areas between food and “silver surface”.

Issues

As in the example before, it is unclear what happens, when the product has reached the end of it’s life cycle. In case the product will be burned, silver nanoparticles might reach the atmosphere. A recent example of a marketed product showed some other potential problems: silver particles could be leached out of a washing machine during the washing. Some organisations like the German BUND (~ federation for environment and protection of nature) warned and recommended to phase out this machine.

Sensors

Sensor arrays can report on the properties of food. Nowadays sensor arrays with more than 300 sensors on one chip are available. These sensors can be used to monitor ripening of fruit, rotting of meat, mould infestation and bacteria

contamination. The simplest case could be a kind of tag, showing whether a product is spoilt or not.

Issues

A societal problem remains: tampering the tag must be prohibited by other sanctions.

Beneficial or Bad Nanofood

Recent research

Science, industry an politics recognised the need for intense research on the field of nanotechnology and possible impacts in biological systems. A number of research projects have been started, e.g. Nanoderm, Nanosafe, Tracer, INOS and so on.
The projects are aiming to find out whether nanoparticles can be absorbet via the GI-system, if they stay intact or not, what effects are happening and which or any toxical effects - local or systemic - result.

Some results have already been worked out:
The Nanoderm-project showed, that TiO_2-particles used e.g. in nano-paint for the intention to enhance air quality in rooms do not pass the healthy skin [see Krug presentation: Lit: Skin Pharmacol. Appl. Skin Physiol. 14 Suppl. 1: 92-97].
Examinations on the penetration of nanoparticles through the intestinal wall did not show any hints on an uptake, too.

In the workshop no results were presented which gave evidence for a basic toxicity of engineered nanoparticles. But examinations are going on. In this regard it should be mentioned that mankind has always been exposed to (aggregates of) natural nanoparticles from volcanic eruptions or sand storms.

Furthermore it must be stated that scientist strive and often fail to examine single nanoparticles. This is because nanoparticles are often highly reactive (that is the reason why they are suspected to be anyhow toxic) and thus react with other substances (before they can be resorbed by the human body). A simple and obvious conclusion from this nanoparticles property is, that it should be even more difficult to bring nanoparticles unintentionally to the human body if it already fails when having the intention. But this statement does not proof anything, it is only a thought on obvious facts.

Nano Research Needs

Obviously more research on nanoparticles' effects is needed. Many hazards and risks are not yet known. Quantum effects bring in new parameters that have to be monitored. For example up to a certain lower size limit, effects will behave linearly. Regulations how to treat those materials are available and can be applied. But below this limit, quantum effects will appear and must be considered. Finally the lowest limit

is from particular to molecular level. Molecular substances are well known and analysed very well. Existing regulations fit.

The workshop attendees proposed a two stage procedure: First identifying the areas of highest risk, second examining these areas and the relevant substances within.

Communication of Nano

Publications on new technologies require a certain liability of the publisher. Careless publication (or in the worst case intended “sensational press”) may lead to intended or unintended misunderstanding of the new technology. That kind of misunderstanding may lead to fears that are not necessary (despite all reasonable scepticism). Many stories, gaining much attention in the public are beyond any laws of science and fail to be proven by any reliable scientist. Others are blown out of all proportions or interpreted wrong.

That leads to interpretations like on the grey goo, invented be Eric Drexler, one of the “founders” of nanotechnology (see http://en.wikipedia.org/wiki/Grey_goo). Grey goo means a large number of nanometer sized machines, being able to self reproduce. A lot of discussion has followed this virtual invention. Is it possible to build such machines of are any fundamental natural laws broken? While the discussion on these questions is still going on (and the supporters of grey goo might loose it, see “Risks and Precautions” in the Wikipedia article), authors like Michael Crichton have written the first books on it (“Prey”, see http://www.amazon.com/Prey-Michael-Crichton/dp/0066214122), describing horrible consequences for mankind after building such machines. Fortunately the public did not panic concerning nanotechnology after this book, but it might have happened. This unfortunate development shows how things can go wrong and Drexler today states: “I wish I had never used the term 'grey goo'”.

In the opinion of the workshops’ participants, food industry people should be trained to communicate open on the issues of their nanotechnology concerns.

Perception of nanotechnology

Nanotechnology is a typical representative of modern science and technology which cannot be regarded with the eye as it is usually to small to see. Quantum effects are not predictable and hard to understand for an average human. Quantum world differs fundamentally from the macroscopic world. Only the effects of nanotechnology can be seen (in some cases).

To determine perception of nanotechnology citizens were queried on their knowledge of nanotechnology. Many answered, they do not know much about nanotechnology but were surprisingly better informed than the interviewers thought. In general nanotechnology is regarded as positive but only if it is not in our food without some advantage for the consumer. Grey goo scenarios (s. above) and other make-believe horror news as discussed in some media are ignored by the public. An influence on the publics' opinion is not measurable.

Some comments during the workshop indicated that some companies already might have investigated whether nano in food can be harmful or not. Those studies are not published up to now. One reason for this seems to be the position of the companies to force other food industry companies to do and particularly pay their own research. Another reason is to let sleeping dogs lie, i.e. not to raise the question whether an investigation was started because of an suspicion there was something dangerous in food. That leads to the current scenario where no studies from food industry are published and where some bad news from unqualified sources are the only news.

In consequence consumers at least want to be informed what is in their food. Moreover customers take a very critical look on nanotechnology in food. If nanotechnology enhanced food gives the customer an advantage it has good chances to be accepted. Labelling will give the consumers at least the illusion of control, what to buy or not.

Labelling of Nanotechnology

The workshop participants proposed to install a labelling system for nanotechnology in food. This could look like the established system on E-Numbers for food additives (e.g. E 150a for plain caramel). Thus the customer could inform on nanotech components or processing in food. With the invention of those system it must be clear who takes care of it and who will supervise it. A still open question is whether nanotechnology processing like the separation step described in the section milk processing. Does a product that is nano-filtered have to be labelled as nanotechnology as no nanoparticles remain in the food? Could something harmful result if food is too clean because it is nano-filtered?

Another problem will become evident later: Has natures nanotechnology to be labelled? Or, more serious where is the frontier between natural and artificial nanotechnology?