

## Contemporary chitosan research by Nano3Bio: Significant achievements and further potentials

Chitosans are an amazing class of functional biopolymers, perhaps the most versatile and most promising one. They can be used in medicine, in agriculture, in food industry, in cosmetics, in water and waste water purification, in paper and textile industries – and in biotechnology.

### Traditional chitosan and new requirements

Chitosan can be produced rather easily from chitin, one of the most abundant biopolymers that is wide-spread in nature, e.g. giving strength to insect shells as well as shrimp and crab carapaces. Thus, chitin and chitosans are renewable resources of almost unlimited availability. Waste material from the shrimp fisheries can be transformed into a valuable product of immense potential.

However, there is a catch, as with all things that sound too good to be true. Chitosan has been a ‘promising’ biopolymer for almost fifty years. But initial promises could not be kept. Results on bioactivities reported in the scientific literature did not lead to the development of products because the results were not reliably reproducible. Industry understandably was disappointed and lost interest. Today, two decades of fundamental research on structure-function relationships have led to the development of well-defined chitosans with known physico-chemical properties and reliable biological functionalities. These **second generation chitosans** are ready for the markets – to be used for the development of reliable applications and successful products. As a consequence, the European Commission recently registered chitosan hydrochloride as a ‘basic substance’ which can now be used e.g. in agricultural products without the need for lengthy and costly toxicity studies and registration processes.

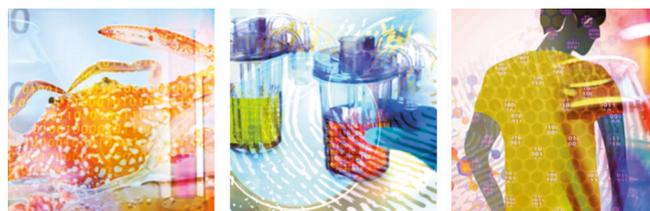
But even the well-defined second generation chitosans are not perfectly suitable for all applications, in particular not in sensitive fields such as health care, pharmacology, and biomedicine. Here, the animal origin of chitosan is a hin-

drance to market entry, as is the – real or assumed – danger of allergen or even viral contamination. This is where the Nano3Bio project sets in, aiming at the development of biotechnological production processes for well-defined, **third generation chitosans**.

### What chitosans can do for you

- ▶ Some chitosan sponges can stop bleeding, and some chitosan-based dressings can support scar-free healing even of chronic or large-scale wounds.
- ▶ Some chitosan nanoparticles can transport drugs across cellular barriers, including the blood-brain barrier, and DNA or RNA into cells.
- ▶ Some chitosans can stimulate the immune system, including that of animals, so that they can be used as a feed additive to reduce the use of antibiotics.
- ▶ Some chitosans can promote plant growth and induce disease resistance and stress tolerance in plants by strengthening the plant’s own defensive system.
- ▶ Some chitosans can form transparent films to be used e.g. as food packaging, keeping fruits and vegetable fresh and preventing spoilage.
- ▶ Some chitosans can stabilize creams and shampoos and at the same time, preserve them.
- ▶ Some chitosans can clean drinking water, filter wine and remove proteins or heavy metals from the waste water of breweries or industry.
- ▶ Some chitosans can be used as a biocompatible surface to cultivate human cells, e.g. as a 3D matrix in organ models.

Furthermore there are a multitude of other possible applications of this versatile class of biopolymers. Chitosans are completely non-toxic to plants, animals, and humans. They are non-allergenic and easily degraded in the environment.



## New approach, advanced opportunities

Nano3Bio convenes an international team of researchers from universities, research centres and companies around Europe and India, joining forces to make a dream come true: the **biotechnological production of third generation chitosans**. They will be even less polydisperse than hitherto existing chitosans, or even monodisperse in the case of oligomers, with defined, non-random patterns of acetylation, clearly defined biological activities, and known cellular modes of action. These chitosans will create **new market opportunities** in the future.

The project will deliver chitosans with known and defined, non-random patterns of acetylation. These will then be compared to their conventional counterparts, to benchmark their properties and functionalities against the best performing chitosans available today.

## Major achievements of Nano3Bio so far

The Nano3Bio project will continue until autumn 2017. It already created a host of innovations, such as:

- ▶ A new low-cost protein engineering technology.
- ▶ Novel chitosan polymers produced biotechnologically in a bio-refinery process.
- ▶ Novel chitosan oligomers produced biotechnologically in a cell factory approach.
- ▶ First natural microalgal chitosans from micro-algal sources characterized.
- ▶ Novel chitosan nanoformulations developed for drug and gene delivery.
- ▶ First detailed life cycle assessment of chitosan production processes established.
- ▶ A chitosan-based hand cream formulation developed.

Learn more about Nano3Bio's achievements at [www.nano3bio.eu/press/](http://www.nano3bio.eu/press/)

## The nano aspect

Nano3Bio aims to develop biotechnological ways to produce chitin and chitosans as well as their nano-formulations, and to analyse their nano-scale solution properties for a wide range of possible applications, e.g. in biomedicine and pharmaceuticals.

Novel chitosans can be used in aqueous solution, as physical hydrogels, or in the form of nanostructures such as nanoparticles, nanocapsules or nanofibre hybrid materials. In addition, Nano3Bio explores molecular nano-imprinting strategies to confer the surface of nanoparticles and nanofibers with high affinity towards biologically relevant molecules that can be exploited in drug delivery and antibacterial activity. While nano-formulations can be bio-compatible carriers for drug, gene and vaccine delivery, nano-structured physical hydrogels are promising bio-materials for tissue engineering, e.g. bio-mineralisation for bone repair.

One example of a promising Nano3Bio achievement are nanocapsules made of a specific novel chitosan which accumulate in tumours. When loaded with a marker, these capsules will allow early diagnosis of even small tumours and metastases. They can also be loaded with anti-tumour drugs which are thus targeted specifically to the tumours, minimizing unwanted off-site effects. The Nano3Bio consortium is currently optimizing the uptake of these drug-carrying chitosan nanocapsules into the tumour cells. The next step in this development will be to use a biotechnologically produced designer chitosan which will be fully degradable in the human body, preventing the long-term accumulation of the nanocarrier, thus further minimizing adverse effects of targeted cancer therapies.

## Aggregated international capacity

Leading experts from 22 universities, research institutes, and companies from Belgium, Denmark, France, Germany, India, the Netherlands, Spain and Sweden have formed the Nano3Bio consortium, led by Prof. Bruno Moerschbacher from the University of Münster.

Learn more about Nano3Bio:

[www.nano3bio.eu](http://www.nano3bio.eu)

