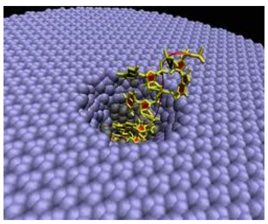
Editorial

Nanotechnology and Patents in Agriculture, Food Technology, Nutrition and Medicine - Advantages and Risks

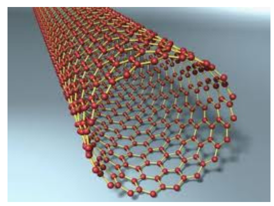
Worldwide Patented Nano- and Absorber Particles in Food Nutrition and Agriculture

Abstract: The keywords nanotechnology, super absorber, agriculture, nutrition, and food technology exhibited 28,149 positive matches under more than 68 million patents worldwide. A closer look at the first 500 nanotechnology, agriculture, nutrition and biotechnology related patents, published during 2011-2012, unveiled that 64% are parts of machines and control devices while about 36% comprise metal oxides, fertilizers, pesticides and drugs, which are compounds and often applied in combination with inorganic or organic super absorbing polymeric structures. The latter compounds are in the focus of this special issue.

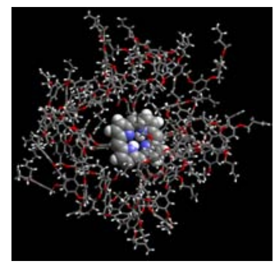
Nanopores [5]



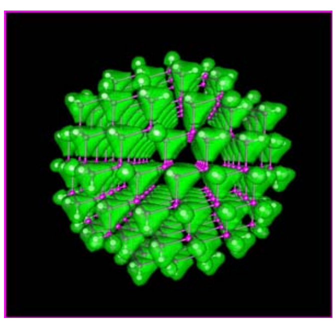
Nanotubes [6]



Dendrimers [7]



Quantum dots, portion of matter (e.g., semicon-ductors) whose <u>excitons</u> are <u>confined</u> in all 3 <u>spatial dimensions</u> [8]



Nanoshells, types of spherical nanoparticle con-sisting of a dielectric core which is covered by a thin metallic shell (usually <u>gold</u>) [9**]**

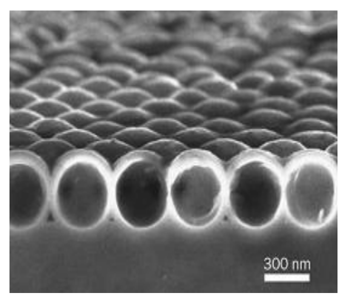


Fig. (1). Nanostructures such as nanopores, nanotubes, dendrimers, quantum dots, and nanoshells are often used as vehicles for transporting nano-particles to locations where the payload can perform a variety of functions.

The most famous nanotechnologist is the Nature. Micro-structured, water repellent surfaces of *Lotus* plants, the water repellent wings and legs of crane flies and gnats (*Culicidae*; *Nephrotoma australasiae*), the brightly coloured feathers of birds, or pathogen-host interactions exemplify this [1-4]. On nature's inventions more than 68 million patents are based, registered worldwide with the International Patent Documentation Centre (***INPADOC***), the World Intellectual Property Organisation, the Patent Cooperation Treaty (WIPO PCT), and country patent offices, predominantly in America, Europe, Germany, and Japan. A search under more than 68 million patents using the keywords: nanotechnology, super absorber, agriculture, nutrition, and food technology resulted in 28,149 positive matches and a closer look at the first 500 nanotechnology, agriculture, nutrition and biotechnology related, during 2011-2012 published patents unveils that about (320 or 64%) are parts of machines and control devices while about 36% comprise metal oxides, fertilizers, pesticides and drugs,

Table 1. A Selection of the 500 Most Recent Patents Concerning Nanoparticles Using the Key Words: Nanotechnology, Super Absorber, Agriculture, Nutrition, and Food Technology.

Patent Number	Publication Date	Title
Metals/Silica		
US20110253643A1 WO2011107822A1	2011-10-20	High surface area fibrous silica nanoparticles
MX2011006210A	2011-09-15	Silica-based antibacterial and antifungal nanoformulation
US20110219984A1 EP2365035A1	2011-09-15	Inorganic black pigment, and pint resin composition and agricultural multifilm using the same
US7988947	2011-08-02	Mesoporous oxide of titanium
US7968503	2011-06-28	Molybdenum comprising nanomaterials and related nano-technology
Pesticides		
US20120021912A1	2012-01-26	Novel herbicides
WO2011049232A1	2011-04-28	Diaryltriazole derivate as insecticide, miticide, nemati-cide or soil pesticide
US20120027905A1	2012-02-02	Polyene antifungal composition
WO2011092721A9	2011-12-29	A botanical pesticide for agriculture/horticulture crops
US20110190123A1	2011-08-04	Slow-release formulations containing quillay extracts, for controlling wheat take-all disease
EP2322037A1	2011-05-18	Pesticide composition and fruit bag
WO2011031487A2	2011-03-17	Nanotechnological delivery of microbicides and other substances
Fertilizers		
WO2011154843A2 US20110296887A1	2011-12-15	A cellulose based sustained release macronutrient composition for fertilizer application
WO2011151724A2 US20110296885A1	2011-12-08	Compositions for sustained release of agricultural macronutrients and process thereof
Gene based		
US20120023619A1 WO2012006443A2	2012-01-26	Linear DNA molecule delivery using pegylated quantum dots or stable transformation in plants
US20110281736A1	2011-11-17	Nucleic acid sequencing and process
US20110275541A1	2011-11-10	Use of multiple recombination sites with unique specifi-ty in combinational cloning
US20110263023A1	2011-10-27	Genes for modulating coffee maturation and methods for their use
WO2011127219A1	2011-10-13	Circulating biomarkers for disease
US7998679	2011-08-16	Devices and methods for diagnosis of susceptibility to diseases and disorders
US7943363	2011-05-17	Methods and compositions for improving the production of products in microorganisms
Super absorber		
WO2012007505A2	2012-01-19	Polymer composite material with biocide functionality
US20110281726A1	2011-11-17	*Gleditsia amorphoides* seedless pod extract and its use as an agricultural adjuvant
US20110257231A1	2011-10-20	Anthranilamide compounds, process for their production and pesticides containing them
US20110230348A1 WO2011053605A1	2011-09-22	PEHAM dendrimers for use in agriculture

(Table 1) Contd….

Patent Number	Publication Date	Title
WO2011097183A2	2011-08-11	Biological activated biochar, methods of making biologically activated biochar, and methods of removing contaminants from water
US20110113960A1	2011-05-19	Biodegradable litter amendment material from agricultural residues
US7939597	2011-05-10	Acrylic acid and water-absorbing polymer structures based on renewable raw materials and process for their production by dehydration
WO2011032922A1 WO2011032876A1	2011-03-24	Color-stable superabsorber
US20110045975A1	2011-02-24	Meso-sized capsules useful for the delivery of agricultural chemicals
Whole plant, crop or animal system		
US20110299928A1	2011-12-08	Irrigation system using plastic film applied to cultivated furrows to capture rain water or water from irrigation systems that simulate rain and method of installation
US8071342	2011-12-06	Process for the treatment of methane emissions
US8067670	2011-11-29	Plants that produce amylopectin starch with novel properties
US20110263423A1 US20110105579A1	2011-10-27	Plant health composition
US20110152100A1	2011-06-23	Methods of increasing crop yields and controlling the growth of weeds using a polymer composite film
WO2011059507A1	2011-05-19	Method of using carbon nanotubes to affect seed germination and plant growth

which are compounds often applied in combination with inorganic or organic super absorbing polymeric structures Table **1**; Fig. (**1**); [10-12].

With the above key words also patented genes, bacteria, seeds, plants, animals, soils, or even whole cropping systems emerged. According to the ISO definition, nanoparticles are between 10^{-1}-100 nm in size, comparable to water, glucose, antibodies molecules, viruses, respectively. Commercialized super absorbing polymeric structures are often larger, i.e. 1000 to 10,000 nm and hence similar in size to bacteria and cancer cells. “Geohumus”, an example of a larger sized absorber molecule of more than 100 µm is sold as biodegradable water-swellable polymeric hybrid material containing finely grounded stone dust and cross linked polyacryl acid (EP2011/057647, 11, 2011). It has been constructed to improve soil water retention in cropping systems, and acts concomitantly as secondary fertilizer. Smaller sized super absorbing polymers between 15 nm to 1000 µm are mostly used as transport vehicles for metal oxides, pesticides, drugs, fertilizers and find a broad application in agriculture and medicine. Silver or titanium dioxides containing foils in the nm to µm range with anti-bacterial, odour-eating qualities, UV exposures stabilizing, and/or anti-fouling activities exemplify latest nanotechnological innovations. Products containing nanosilver include textiles, food storage containers, antiseptic sprays, catheters, and bandages [13]. They are also used as nanosensors, which may rapidly be predicted, via colour change, food contaminations by pathogens or food spoilage. Such inventions may provide a platform for a range of existing disciplines – such as chemistry, physics, biology, biotechnology, neurology, information technology and engineering, agriculture, and food technology to extend the food, farming, and medicine revolution. Micro capsules containing targeted delivery pesticides or drugs are engineered to break open for example under alkaline (insect’s stomach) or acid conditions (human stomach) and are increasingly used in genes, seeds and livestock, the food industry and medicine. Genes expressing antibodies recognizing antigenes can meanwhile be multiplied in B-cells (lymphocytes) of animals with the advantage of overcoming previously low yielding cell culturing of these antibodies [14].

Nanosensors for monitoring and managing farm and ecosystem, nanoadditives, and increasingly patented super absorber, originally developed for agriculture and the oil industry, are also starting to revolutionize food packing, cosmetic and sanitary products, the textile, toy, automobile and computer industry, the electro technique, astronautics, nutrition, diseases, and medicine. Newly developed nanoforms of existing chemicals or new chemicals and the already marketed nanosilver, nanozinc, nanochlorine, nanotitanium oxide or nanosilicon dioxide may offer solutions to technological, ecological, and medical issues but also may have unintended side effects. For instance, carbon nanotubes can be taken up by microbial communities, root systems, or organs of animals and humans. Dependent on size, disolvability and other novel characteristics unexpected forms of pollution in soils, waterways, food chains, and organs may exhibit and ultimately result in environmental and health problems. Poland *et al.* reported from asbestos like behaviours in test mice inhaling some types of carbon nanotubes [15]. Titanium dioxide or cadmium may act, when accumulating as cytotoxines and for example disrupt signals between nitrogen-fixing bacteria and the plant host [16]. This is increasingly of ecological concern. On the plus side, foods with altered flavour, texture, heat tolerance and shelf life (entirely newly foods, ‘smart’ foods) can assist dietary needs of an individual with allergies [17].

Ultimately, new technologies will only be successful when their promoter can guarantees their safety. However, our daily life is filled with examples with examples of promising technologies that never fulfilled their imagined potential, while at the same time early warnings about their safety was ignored. The nano- and absorber technology community must learn from these prior lessons and needs collective intelligence for benefiting from this exiting and very promising technology by keeping negative effects for human sake low. Are microbes, seeds, plants, animals, soils, and perhaps our whole food production systems in danger from suffering from received nanoparticles, then regulations questioning the manifold nanotechnological advantages are imperative [18]. The US patent 20110191125A1, titled „System and method for identifying and evaluating nanomaterial-related risk”, submitted on 4th August, 2011, is proof of the necessity to think in both directions (the risks and benefits of a new technology) and hence this special issue on nanotechnology tries not only to inform about nanotechnology and its advantages but also aims to elucidate approaches to risk analysis.

More than (328) of the first 500 recent patents concerning nanoparticles and super absorbers in agriculture, food technology, and medicine have been registered in the USA. Of the remaining, 118 are registered with the WIPO PCT, 51 in European, 2 in German and 1 at the Mexican patent offices, respectively. The patents submitted under nanotechnology are very diverse; both chemically and in their applicability,

the first contribution in this issue

“Nanotechnology and patents in agriculture, medicine and food technology”

will give a nanotechnology related overview.

The second paper

”Nanotechnology applications in miniaturized systems”

will give details about the methods allowing the study of the fate of nanoparticles in ecosystems.

The next article

“Antimicrobial and catalytic properties of (bio) engineered metal nanoparticles on microbes”

will discuss effects on the recycler community and

the fourth

“Patents on fiber spinning from starches”

conveys a nano- and absorber example and provides processing aspects.

The fifth paper

“Current applications of nanotechnology in the field of medicine: towards improved therapies using nanopharmaceuticals”

will inform about health aspects and eventual environmental impacts and

the last contribution finally

“Nanotechnology and Patents - how can potential risks be assessed?”

spans an arc from science to ethics.

REFERENCES

[1] Barthlott W. Scanning electron microscopy of the epidermal surface in plants. In: Systematics Association’s Special. 1990; 41: 69–94.

[2] Eliason CM, Shawkey MD. Decreased hydrophobicity of iridescent feathers: a potential cost of shiny plumage. J Exper Biol 2011; 214: 2157-63.

[3] Hu H-MS, Watson GS, Cribb BW, Watson JA. Non-wetting wings and legs of the cranefly aided by fine structures of the cuticle. J Exper Biol 2011; 214: 915-20.

[4] Benckiser G, Bamforth SS. Role of pathogens, signal recalcitrance, and organisms shifting for ecosystem recuperation. A review Agron Sustain Dev 2011; 31: 205-15.

[5] Simonite T. Nanopore will make for speedy DNA sequencing. New Scientist, Nano Letters, 10 April 2006.

[6] Jha A. Carbon nanotubes may suppress human immunity. Guardian 15 June 2009.

[7] Cagin T, Wang G, Martin R, Goddard WA. Molecular modeling of dendrimers for nanoscale applications. Draft paper submitted for publication in the special conference issue of Nanotechnology, October 15 -17, 1999, seventh foresight conference on molecular nanotechnology, California Institute of Technology, Materials and Process Simulation Center and Division of Chemistry and Chemical Engineering, Pasadena, tahir@wag.caltech.edu.

[8] Ekimov AI, Onushchenko, AA. "Quantum size effect in three-dimensional microscopic semiconductor crystals". JETP Lett 1981; 34: 345-9.

[9] Loo C, Lin A, Hirsch L, Lee M, Barton J, Halas N, West J, Drezek, R. "Nanoshell-enabled photonics-based imaging and therapy of cancer". Techn Cancer research & treatment 2004; 3: 33-40.

[10] Bruhns, S., Daniel, T., Hermeling, D., Riegel, U. Mixture of surface postcrosslinked super absorbers with different surface postcrosslinking. US20110224379 (**2011**).

[11] Gessler T, Seeger W, Schmehl T. The potential for inhaled treprostinil in the treatment of pulmonary arterial hypertension. Ther Adv Respir Dis 2011; 5: 195- 203.
[12] Tindaon F, Benckiser G, Ottow JCG. Evaluation of ecological doses of the nitrification inhibitors 3,4-dimethylpyrazole phosphate (DMPP) and 4-chloromethyl- pyrazole (ClMP) in comparison to dicyandiamide (DCD) in their effects on dehydrogenase and dimethyl sulfoxide reductase activity in soils. Biol Fertil Soils 2012; 48: 643-650.
[13] Liu J, Sonshine DA, Shervani S, Hurt RH. Controlled release of biologically active silver from nanosilver surfaces. Acsnano org 2010; 11: 6903-13.
[14] Brem G. Recombinant Antibody Fragments produced in Transgenic Farm Animals. -2nd International Congress-Partnering & Exhibtion on Biotechnology and Bioenergy - EurasiaBio; APR 13-15, 2010; Moscow, Russia).
[15] Poland C, Duffin R, Kinloch I, Maynard A, Wallace W, Seaton A, et al. "Carbon Nanotubes introduced into the abdominal cavity of Mice show asbestos-like pathogenicity in a Pilot Study." Nat Nanotechnol 2008; 3: 423-8.
[16] Royal Commission on Environmental Pollution (RCEP), Novel Materials in the Environment: The Case of Nanotechnology. London, 2008.
[17] Hansen SF, Maynard A, Baun A, Tickner JA. Late lessons from early warnings for nanotechnology. Nat nanotechnol 2008; 3: 444-7.
[18] Kuzma J, Priest S. Nanotechnology, risk, and oversight: learning lessons from related emerging technologies. Risk Analysis 2010; 30: 688-1698.

Gero Benckiser

Justus-LiebigUniversity Giessen,
Department of Applied Microbiology
Heinrich Buff-Ring 26-32
35390 Giessen
Germany
Tel: +496419937353
Fax: +496419937359
E-mail: gero.benckiser@umwelt.uni-giessen.de