



THE FUTURE IS NANO



A REVOLUTION IN MATERIAL SCIENCES

Carbon nanotubes (CNTs) are a shining example of cutting edge nanotechnology and are well on the way to revolutionizing material sciences. Numerous products and applications benefit from optimized or even entirely new properties thanks to the enormous advantages of tiny carbon nanotubes.



COST EFFECTIVE INDUSTRIAL SCALE CNT PRODUCTION

As one of the world's leading manufacturers of polymers and high performance plastics, Bayer MaterialScience recognized the huge potential of nanotechnology early on. It has carried out intensive research into the carbon nanotube production process and kept on finetuning this process. The company has now filed a patent for a new process that makes it one of the first manufacturers in the world to be capable of industrial scale, low cost production of multi wall carbon nanotubes (MWNTs) – Baytubes®. The consistently high quality of Baytubes® and the outstanding material purity of up to 99 percent open up completely new development potential.



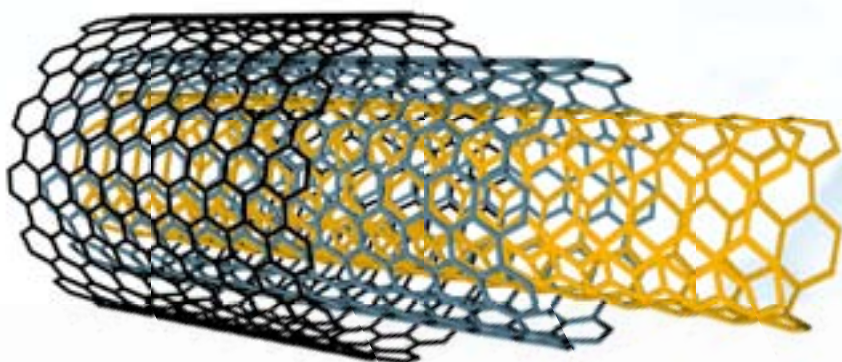
BAYTUBES®

**Be inspired by Baytubes® and discover
new ideas for intelligent and innovative materials
management in tomorrow's world.**

IMPRESSIVE PROPERTIES

The benefits of Baytubes® are just as varied as their possible applications. Even small quantities of the revolutionary carbon nanotubes can bring new properties to established materials such as plastics, dispersions, metals etc – from enhanced electrical and thermal conductivity to exceptional mechanical load bearing capacity.

Baytubes® multi wall nanotube agglomerates boast a combination of superb properties. In addition to the numerous benefits of the material itself, this ensures easy handling and processing.



THE KEY BENEFITS OF BAYTUBES® AT A GLANCE

Consistent quality and high purity

With a material purity of at least 95 percent, even standard multi wall Baytubes® offer unprecedented quality consistency at low cost and on an industrial scale. It is also possible to manufacture Baytubes® with a purity of over 99 percent for special applications.

Mechanical strength

Thanks to their high modulus of elasticity and excellent tensile strength, Baytubes® exhibit a mechanical strength which is five times higher than that of steel – at only a quarter of the specific weight.



Electrical conductivity

The electrical conductivity of Baytubes® is comparable to that of copper, allowing non-conductive plastics to be transformed into conductive materials.

Thermal conductivity

Baytubes® can match the thermal conductivity of the best natural thermal conductor of all – diamonds.





A GLOBAL SUCCESS STORY

Conductive plastics, semi-finished products made from polyether ether ketone, robust sports equipment – the list is endless. Baytubes® show huge potential and we are only just starting to discover all their possible applications. More and more companies are using Baytubes® to achieve significant product improvements and gain a vital competitive edge. At the same time, Bayer MaterialScience is continuing to develop product modifications that are in line with market demands in order to ensure optimum properties for different applications.

EXAMPLES OF INDUSTRIAL APPLICATIONS

High-tech nano dispersions

Baytubes® are used to produce high-tech nano dispersions in patented dispersion processes for a number of applications, e.g. in the marine industry.

Semi-finished products made from polyether ether ketone (PEEK)

The outstanding electrical conductivity of Baytubes® is put to effective use in the production of antistatic semi finished products made from polyether ether ketone (PEEK).

Composite materials

In combination with special epoxy resins, Baytubes® boost the strength and load bearing capacity of composites used in shipbuilding, automotive applications and rotor blades of wind power plants.

Plastic containers

Until now, 1000-liter IBCs have been the only cost effective alternative to steel drums for packaging that is to be used in explosion protected zones. New multi-wall containers with a conductive outer layer can save time and money even where only small volumes are involved.

Flying camera

Baytubes® are used to reduce the weight and improve the strength of a remote controlled flying camera. This significantly increases its flight time and the number of possible applications – for example at sports events.





EXAMPLES OF SPORTS APPLICATIONS

- Ice hockey sticks

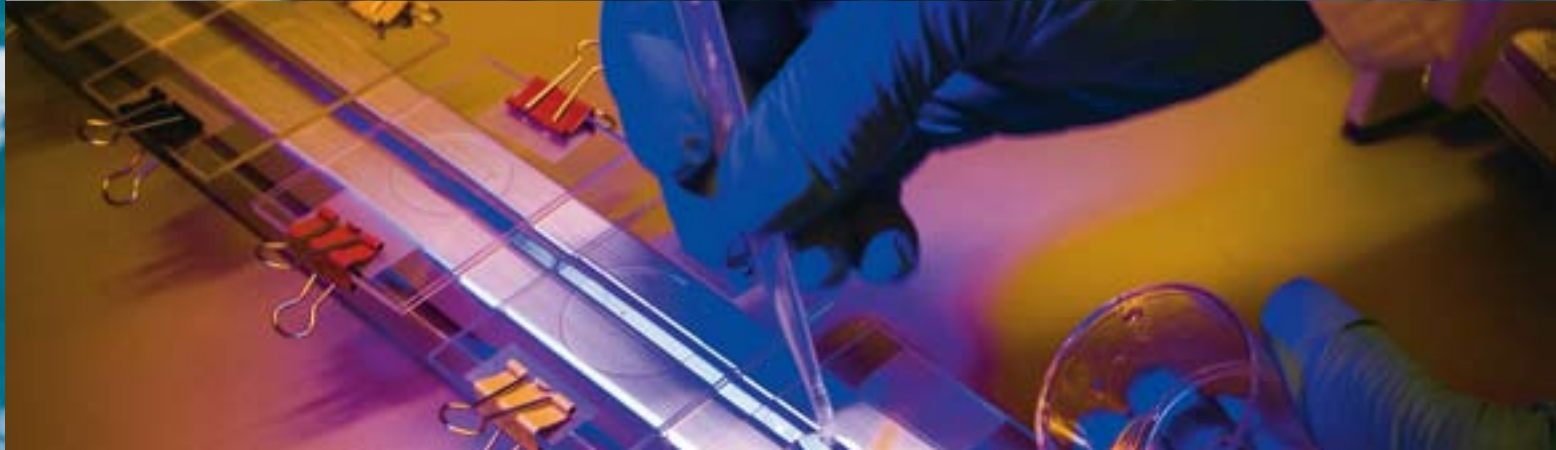
- Baseball bats

- Surfboards

- Skis and ski poles

- Hunting arrows

When added to composite materials used to make sports equipment, Baytubes® can provide a whole host of benefits, including lighter weight, higher strength and greater stiffness.





NEW IDEAS FOR THE FUTURE OF MATERIAL SCIENCE

Time now for a look into the future. With their outstanding properties, Baytubes® offer virtually unlimited options for saving energy, cutting costs, optimizing production processes and improving products. Exciting new applications and ideas are emerging on a daily basis. Below is some food for thought on what the future of material science may hold.

Wind turbines – converting energy more efficiently

Baytubes® can be used to make larger and lighter rotor blades, thereby sustainably optimizing energy generation.

Aircraft construction – saving energy

Baytubes® can help make aircraft components extremely light and stable with an excellent load bearing capacity.

Automotive applications – cutting cost

Adding Baytubes® to plastics used in car body parts such as fenders lowers production costs by eliminating the conductive primer usually needed for electrostatic coating processes.

Batteries – increased energy storage performance

When added to the graphite layer as a conductivity component, Baytubes® stabilize the graphite matrix in lithium ion batteries during the charging/discharging process. Their structure prevents the negative effects of volume changes, thus resulting in high storage capacities and a long battery life.

Computer chips – safe packaging for sensitive devices

Baytubes® are used in conductive and antistatic plastic films and trays to provide low cost, secure packaging for computer chips and electronic components.

FURTHER POSSIBLE APPLICATIONS

- Electrically conductive and/or mechanically reinforced thermoplastics, thermosets, rubber and coating systems based on a variety of polymers
- Production of electrodes for fuel cells and electrolysis
- Catalysts for heterogeneous catalysis
- Metals with enhanced mechanical strength
- EMI shielding of computer and cell phone housings
- Ceramic components in turbines
- Sensors and actuators
- High performance materials



BAYTUBES®



OVERVIEW OF THE MANUFACTURING PROCESS

BAYTUBES® – 50,000 TIMES THINNER THAN A HUMAN HAIR

From a purely chemical viewpoint, Baytubes® are made from the same material as pencil leads. Baytubes are agglomerates of multi wall carbon nanotubes. Each tube consists of several graphite layers and the diameter of the tubes averages 13 to 16 nanometers. This means that they are 50,000 times thinner than a human hair.

Exceptional quality and purity

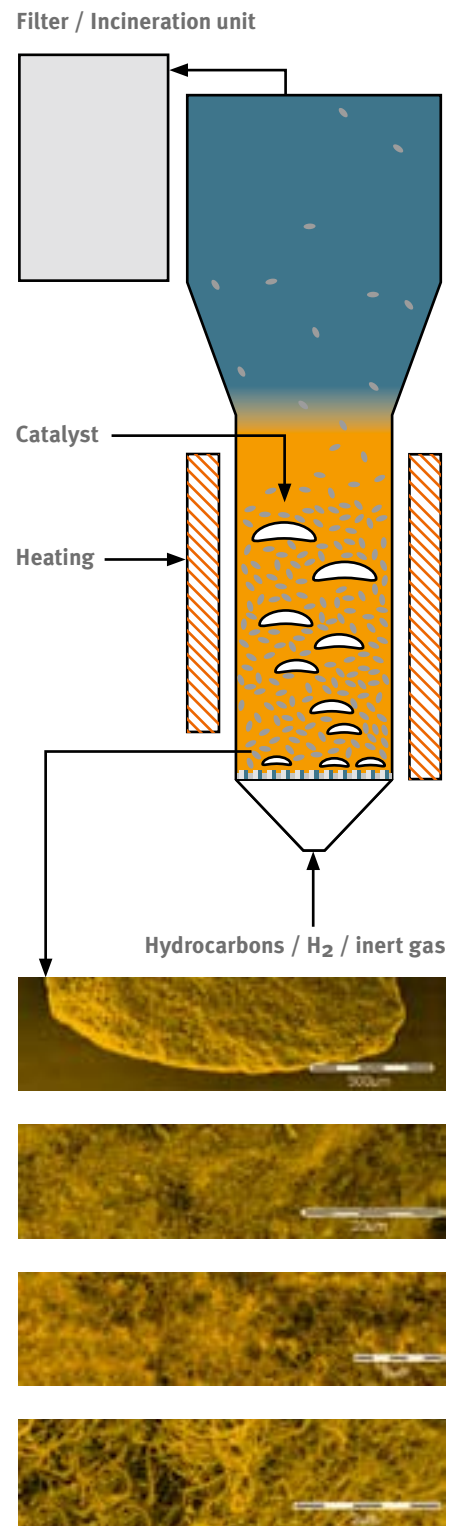
Bayer MaterialScience is one of the first manufacturers anywhere in the world to produce top quality, low cost multi wall carbon nanotubes with consistently high material purities of up to 99 percent. Bayer researchers have achieved this by solving the key problems previously associated with the manufacture of carbon nanotubes – high synthesis costs and impurities in the actual product – once and for all.

Unique catalyst technology

This is made possible by a special fluidized bed manufacturing process based on the company's own catalyst technology, for which a patent has been filed. Essentially, the consistently high product quality of Baytubes® is ensured by the quality of the catalyst and the way it is produced. Bayer's research team has made it a key task to continue developing this catalyst to ensure maximum product quality and customer satisfaction.

Ongoing optimization for high product quality

The second factor ensuring the consistently high product quality of Baytubes® is the manufacturing process within the actual fluidized bed. Precise process parameters deliver optimum product results. The ongoing optimization of process parameters is particularly important to ensure that product quality is maintained or improved while also lowering production costs.



Depending on the catalyst used, different Baytubes® grades can be produced by the catalytic chemical vapor deposition (CCVD) process.



ONGOING EXPANSION OF PRODUCTION CAPACITIES

Bayer MaterialScience laid the foundation for the industrial scale production of Baytubes® early on, bringing production capacities in line with customer demand. Production units with an annual capacity of 60 metric tons of Baytubes® commenced operation in Laufenburg in 2006 and 2007.

Now a new production site with an annual capacity of 200 metric tons is being built in Leverkusen. Further capacity expansions are under consideration.



MAXIMUM SAFETY THROUGHOUT THE LIFECYCLE

As one of the leading manufacturers of carbon nanotubes, Bayer MaterialScience places particular emphasis on responsible care (through the product stewardship program). To ensure safe and environmentally sound handling of Baytubes® throughout their lifecycle, the company is committed to intensive research into the safety of nanotechnology and encourages ongoing dialog with industrial partners, customers and the public. Bayer MaterialScience is also actively involved in associations and public projects, thereby helping to ensure the safety of man and the environment.



CREATING INNOVATIONS – WITH STRONG PARTNERS

Bayer MaterialScience has recently entered into ground breaking cooperation agreements with numerous development partners from the world of science and industry. The joint target is to identify new areas where Baytubes® can be used, improve products and develop new applications. Bayer MaterialScience is keen to continue this successful strategy.

Some of our cooperation partners at a glance

Industry

Amroy Europe Oy

BYK-Chemie GmbH

Clariant Masterbatches GmbH

Ensinger GmbH

FutureCarbon GmbH

Nanoledge Inc.

Schütz GmbH & Co.KGaA

Distribution

Toyota Tsusho Corporation, Japan

Research and Development

Deutsches Kunststoff Institut

Fraunhofer-Institut für Chemische Technologie

Leibniz-Institut für Polymerforschung Dresden e.V.

Martin-Luther-Universität Halle-Wittenberg

Technische Universität Darmstadt



INNOVATION AS A BASIS FOR BUSINESS SUCCESS

Baytubes® carbon nanotubes are still in the early stages of technology driven development and have exceptional potential. Baytubes® R&D activities are therefore focused on developing new kinds of technologies and innovative technical solutions for the manufacture of quality assured and high-quality multi wall carbon nanotubes. One focus of our research is the development of dispersion and processing technologies for use in many new applications. Based on this approach, we are already laying the foundation for our future business success.



BAYTUBES®

- Are you ready for a new dimension in nanotechnology?
- Would you like to find out more about Baytubes®?
- If so, call us on +49 (0)214 30 21055 or visit our website at www.baytubes.com



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Printed in Germany