TUBALL

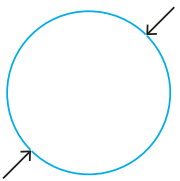
graphene nanotubes

Wall thickness

1 atom

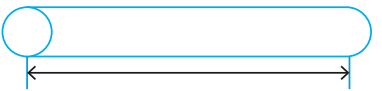
Specific surface area of 1 g

≥300 m^2



Range
of outer diameters

1.6±0.4 nm



Length **>5 µm**

Thermal conductivity
compared with diamond

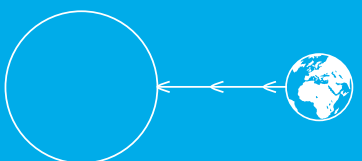
3 times more

G/D
ratio

>90

Amount
pcs in 1 g

10^{17}



1 g of TUBALL™ nanotubes
contains enough to stretch from
the earth to the sun

CARBON NANOTUBES

Human existence is shaped by the materials we use. More than 70% of all basic materials can be improved by introducing a universal additive – graphene nanotubes. These tiny tubes provide us with a rare opportunity to create nanoaugmented materials that have extraordinary properties.

Graphene nanotubes can be described as a one-atom-thick graphene sheet rolled in a tube more than 5 µm length. This material is also commonly called single wall carbon nanotubes (SWCNTs).

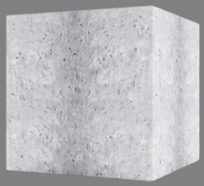
UNIQUE PROPERTIES OF GNTs

With these unique properties of graphene nanotubes, many characteristics of materials are improved.
The pre-eminence of these nanotubes is related to their exceptional properties, such as superior conductivity, high temperature resistance, ultra-low weight, record strength and high flexibility.

Excellent conductor	Stronger than steel	Thermal stability	Length to diameter ratio
5 times lighter than copper	**up to 100 times**	**up to 1,600°C in a vacuum**	**about 3,000 times**

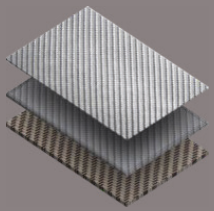
GNTs — THE FIRST UNIVERSAL ADDITIVE FOR MATERIALS

Electrochemical power sources



Concrete

Ceramics



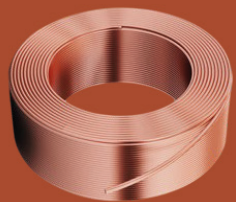
Composites

Rubber materials

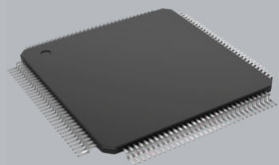
Adhesives

Owing to their extraordinary thermal conductivity and their mechanical and electrical properties, GNTs find applications as additives in an extremely wide range of structural materials.

Glass

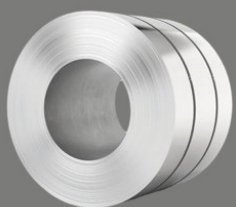


Copper



Sensors semiconductors

Plastics

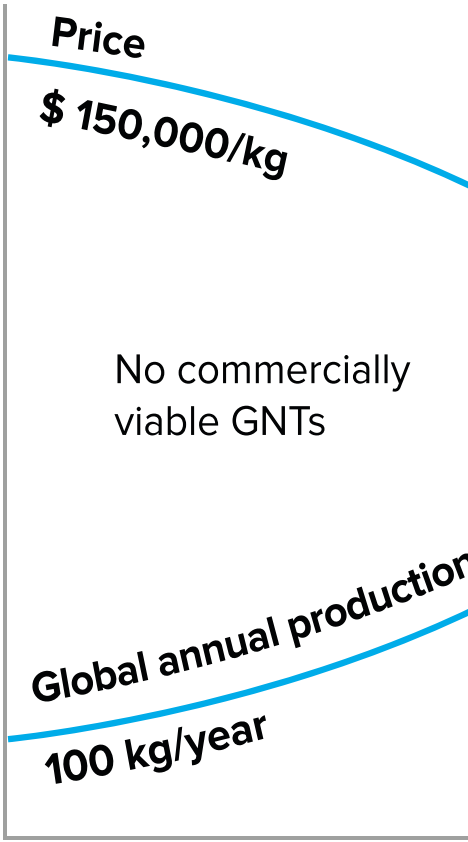


Aluminium

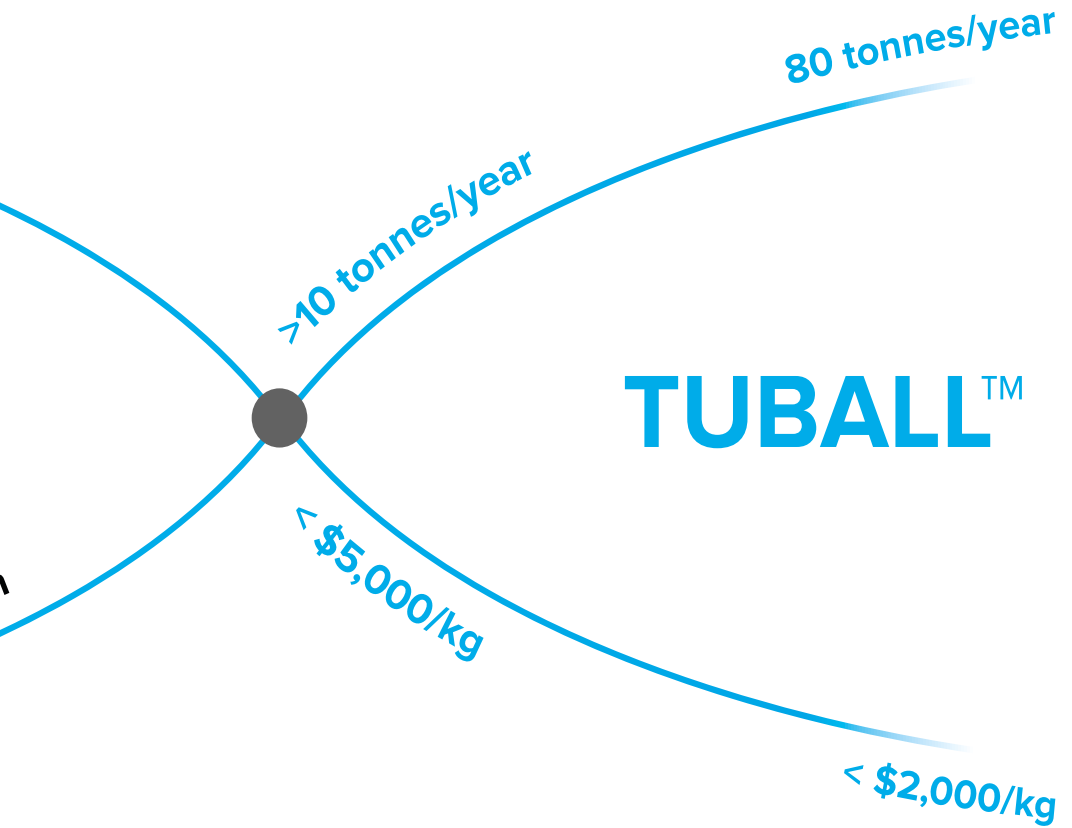
Paints

WHY GNTs LEFT UNUSED

In 2014 GNTs became available to the mass industry

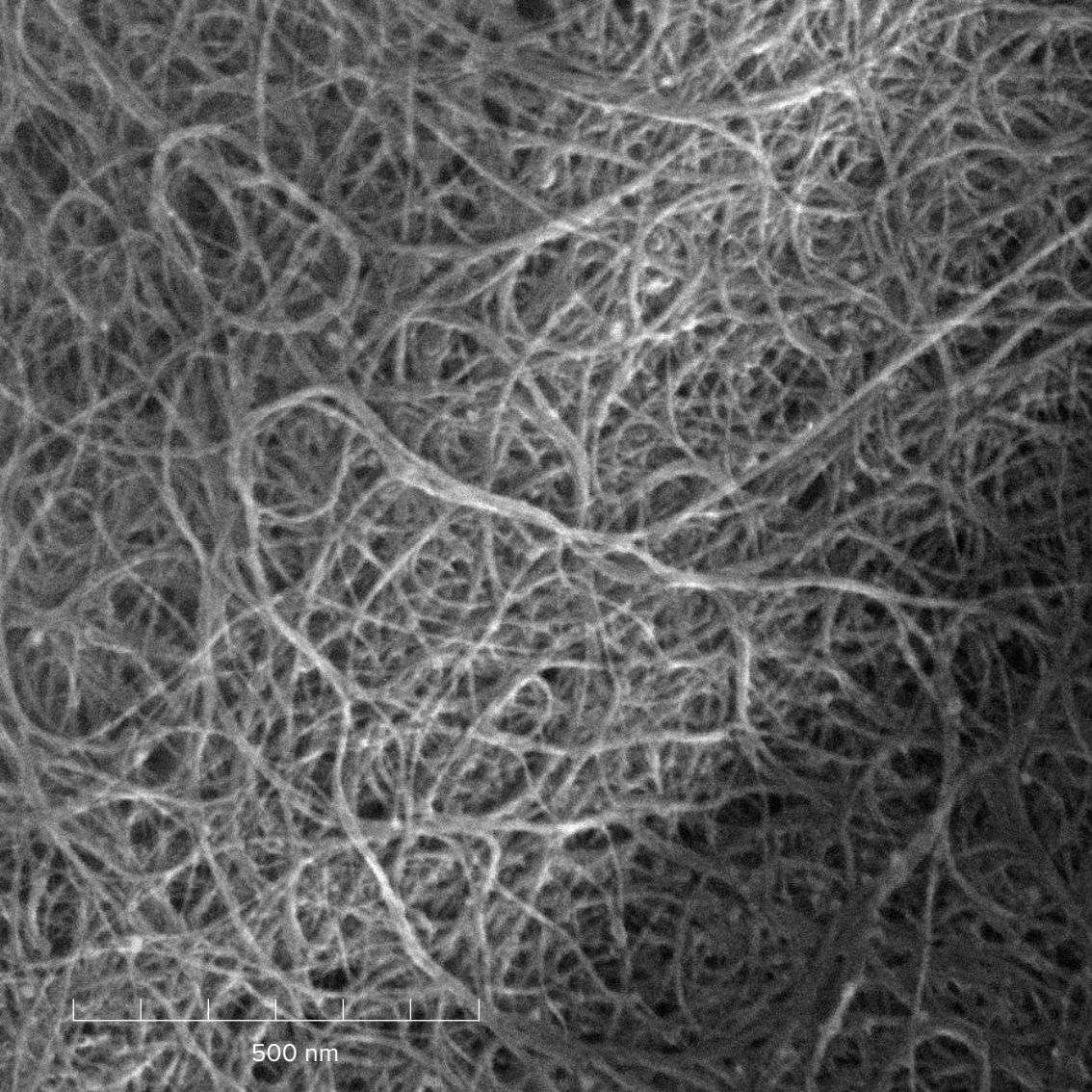


BY CIVILIZATION BEFORE?




FIRST

MASS-PRODUCED GNTs


500 nm

TUBALL™

While the huge potential of GNTs has been recognised for many years, until recently their wide application in industry was not possible because of the absence of technology for their mass production, their high price and the lack of methods for introducing them into materials.

TUBALL™ nanotubes are the first GNTs to be available for commercial applications in a wide range of industries. OCSiAl's breakthrough is low-cost mass-production technology has made the widespread use of nanotubes economically viable while still preserving their high quality.

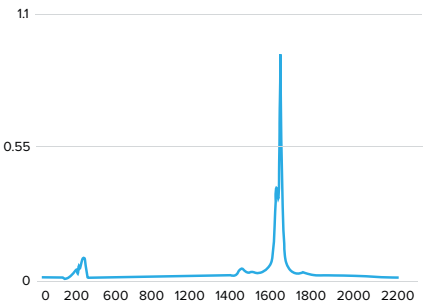
FEATURES

- High-quality nanotubes (G/D ratio > 90)
- Maintains color, elasticity, durability and other key properties of improved materials
- Gains traction starting from ultra-low concentrations
- Enhances mechanical properties of materials
- Adds uniform, permanent and stable electrical conductivity
- Versatile for an extremely wide range of applications

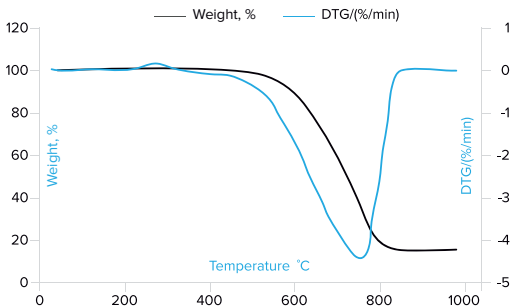
TECHNICAL INFO

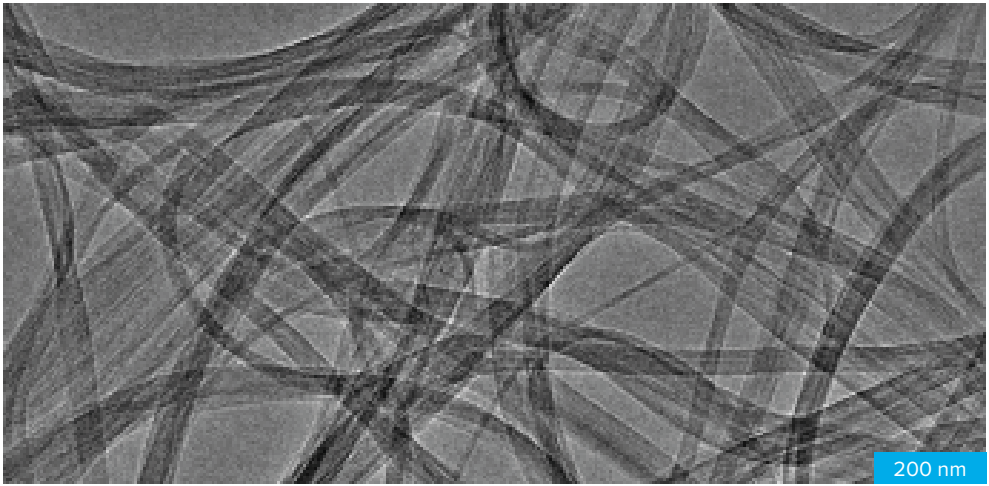
	UNIT OF MEASURE	VALUE	METHOD OF EVALUATION
CNT content	wt.%	≥80	OCSiAl internal method. Ash residue
Number of layers CNT	unit	1	TEM
Outer mean diameter CNT	nm	1.6±0.4	Optical absorption. ISO/TS 10868:2017 (E)
Length of CNT	μm	>5	AFM
Metal impurities	wt.%	≤15	OCSiAl internal method. ICP-AES
Moisture	wt.%	<5	OCSiAl internal method. Infrared thermogravimetry

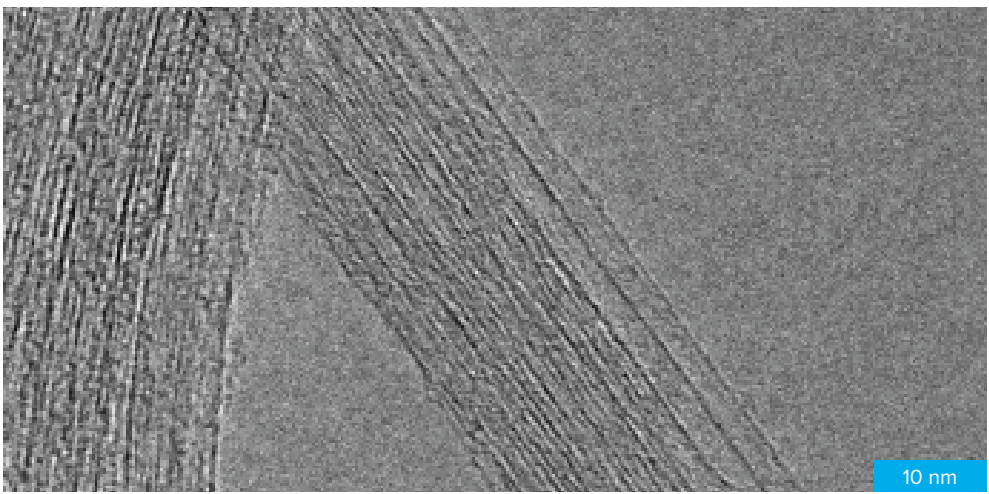
RAMAN SPECTRUM

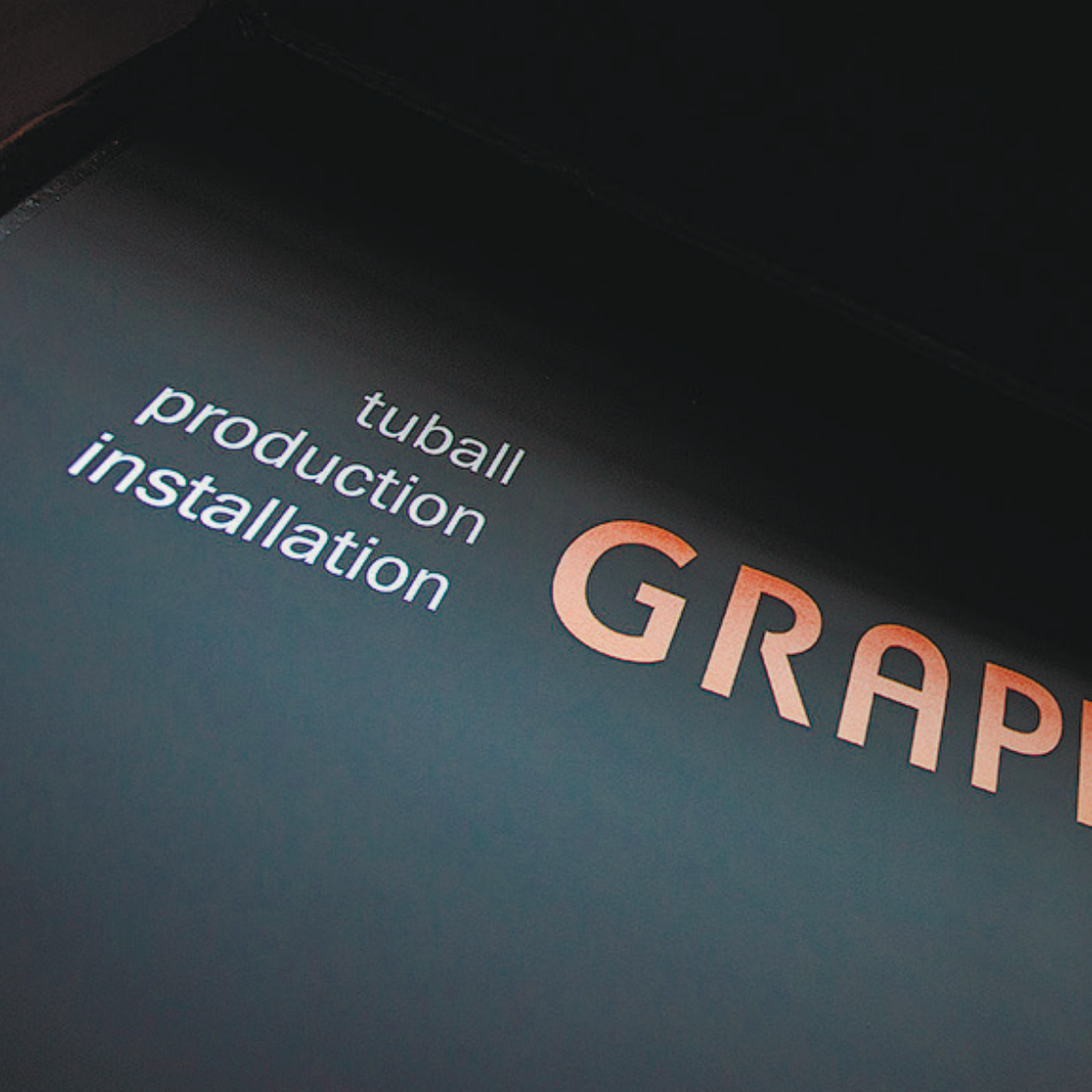


TGA CURVES




200 nm


10 nm


tuball
production
installation
GRAP

PRODUCTION


ГАЗ!
УХОДИ!

INDUSTRIAL PRODUCTION OF GNTs

OCSiAl is the only company with a scalable technology for industrial synthesis of graphene nanotubes.

On 14 November 2013, the company launched Graphetron 1.0 in Novosibirsk – the first industrial-scale facility for graphene nanotube synthesis. With a capacity of 1 tonne of TUBALL™ per year, it became the world's largest facility. In 2019 Graphetron 50 was commissioned in Novosibirsk.

The joint capacity of the two Novosibirsk synthesis facilities now amounted to 80 tonnes per year. It is planned to expand existing capacity and launch a new facility in Luxembourg in 2023.

FACILITIES

2013 GRAPHETRON 1.0

2019 Graphetron 50

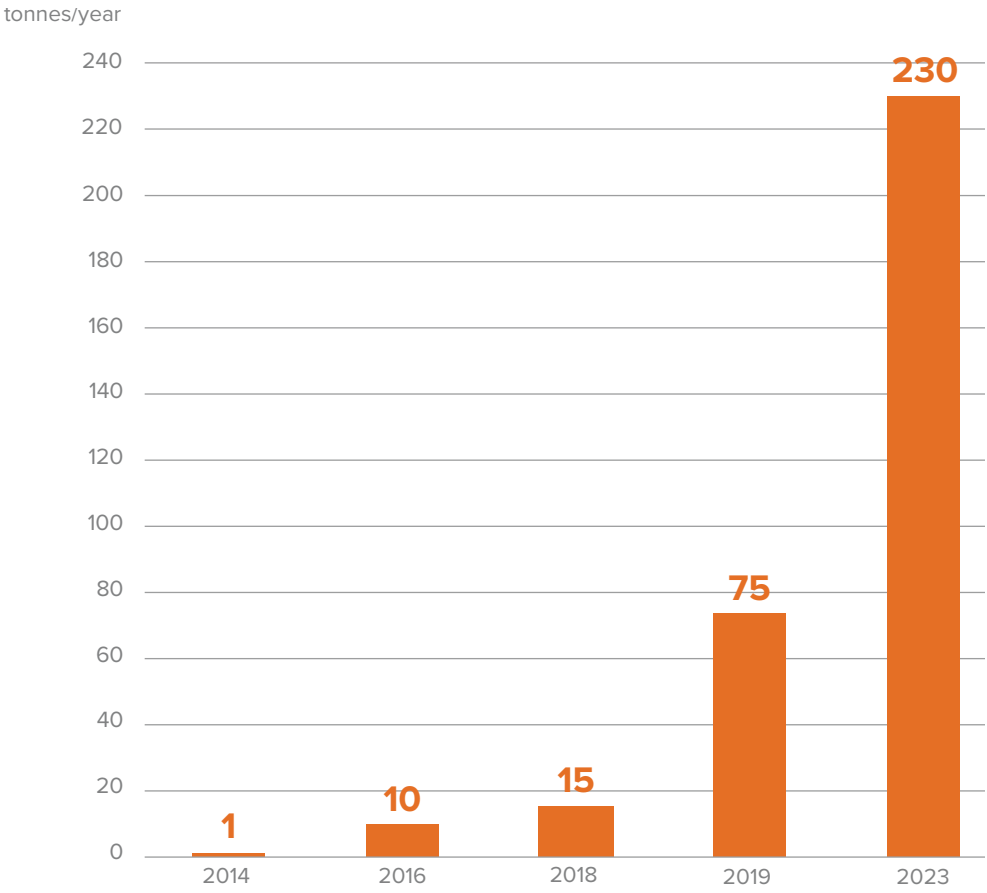
2023 GRAPHETRON IN LUXEMBOURG

IN 2020 OCSiAl HAD MORE THAN

95%

OF THE WORLDWIDE
GNTs PRODUCTION CAPACITY

PRODUCTION CAPACITY: ROADMAP




6
C
OCSiAl
24
УЛИЦА
ИНЖЕНЕРНАЯ

OCSiAl FACILITIES

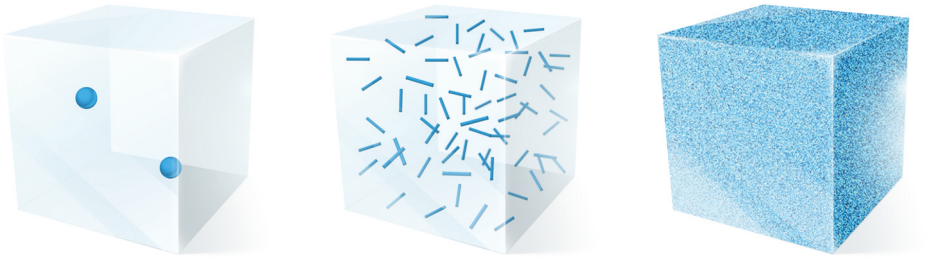
OCSiAl is expanding and optimising its production globally by building new TUBALL™ synthesis facilities in various locations around the world. OCSiAl's annual production capacity at the end of 2020 is 80 tons per year.

ISO certificates obtained from 2017 confirm the required high level of OCSiAl's quality control, environmental, health and safety management systems. Currently, OCSiAl is certified in accordance with ISO 9001, ISO 14001, ISO 45001: 2018 and BS OHSAS 18001.

INDUSTRIAL APPLICATIONS

HOW IT WORKS

TUBALL™ provides significant improvements in material properties upon the addition of ultra-low loadings, starting from as little as 0.01%.



Microparticles | Nanofibers | GNTs

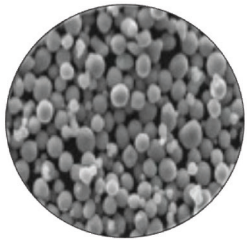
The same concentration of particles (~0.1%) in the same volume.

Unlike conventional additives such as multi wall carbon nanotubes, carbon fibers and most types of carbon black, which all disperse unevenly throughout the material's matrix, GNTs create a uniform 3D reinforcing and conductive network.*

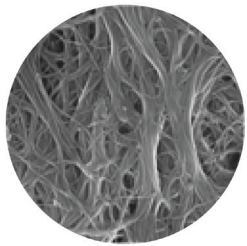
** Ma, P. C., Siddiqui, N. A., Marom, G., & Kim, J. K. (2010). Dispersion and functionalization of carbon nanotubes for polymer-based nanocomposites: a review. Composites Part A: Applied Science and Manufacturing, 41 (10), 1345-1367.*

COMPARISON OF ADDITIVES THRESHOLD OF CHANGE

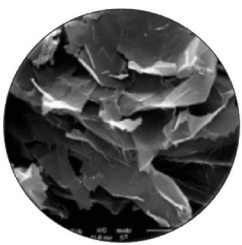
CARBON BLACK
20–40%



METAL FILLERS
15–35%

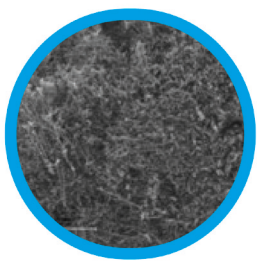


CARBON FIBERS
3–12%



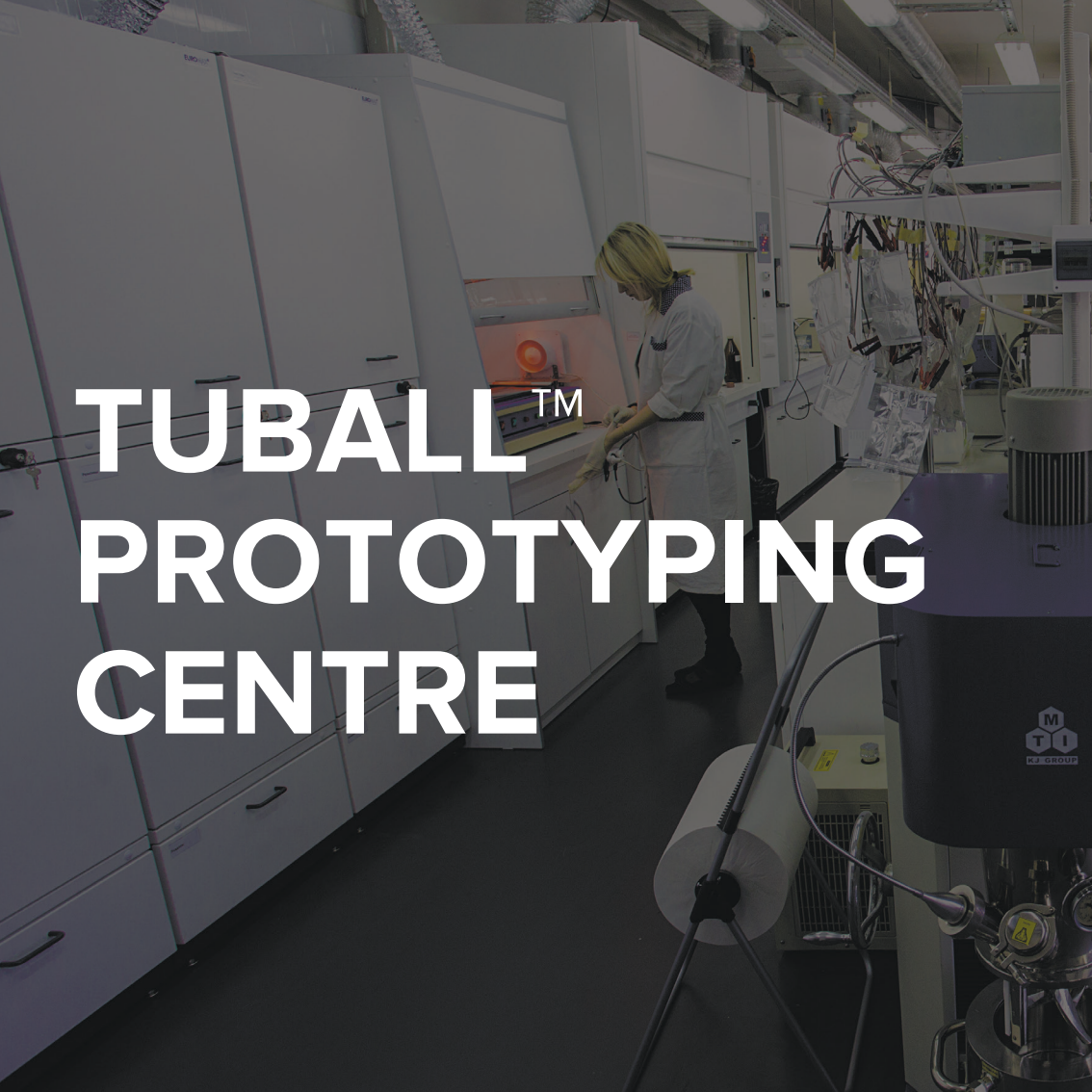
PSEUDO GRAHENES*
1–6%

MWCNTs
0.5–5%



GNTs
0.01–0.1%

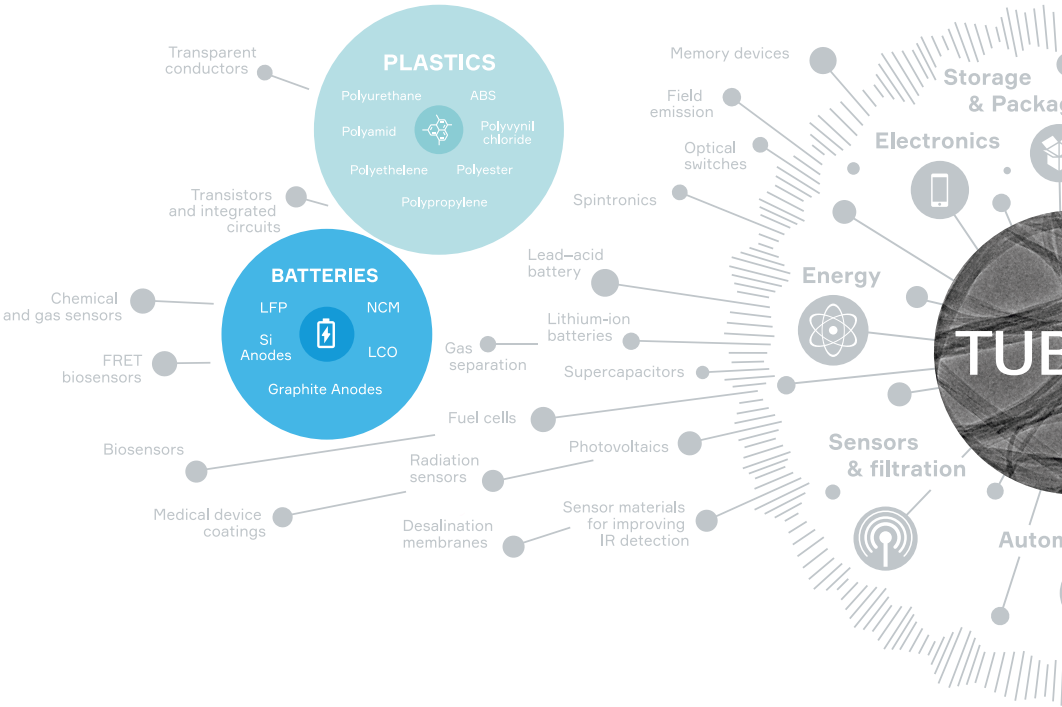
* Graphene nanoplatelets, graphene oxide, reduced graphene oxide, etc.



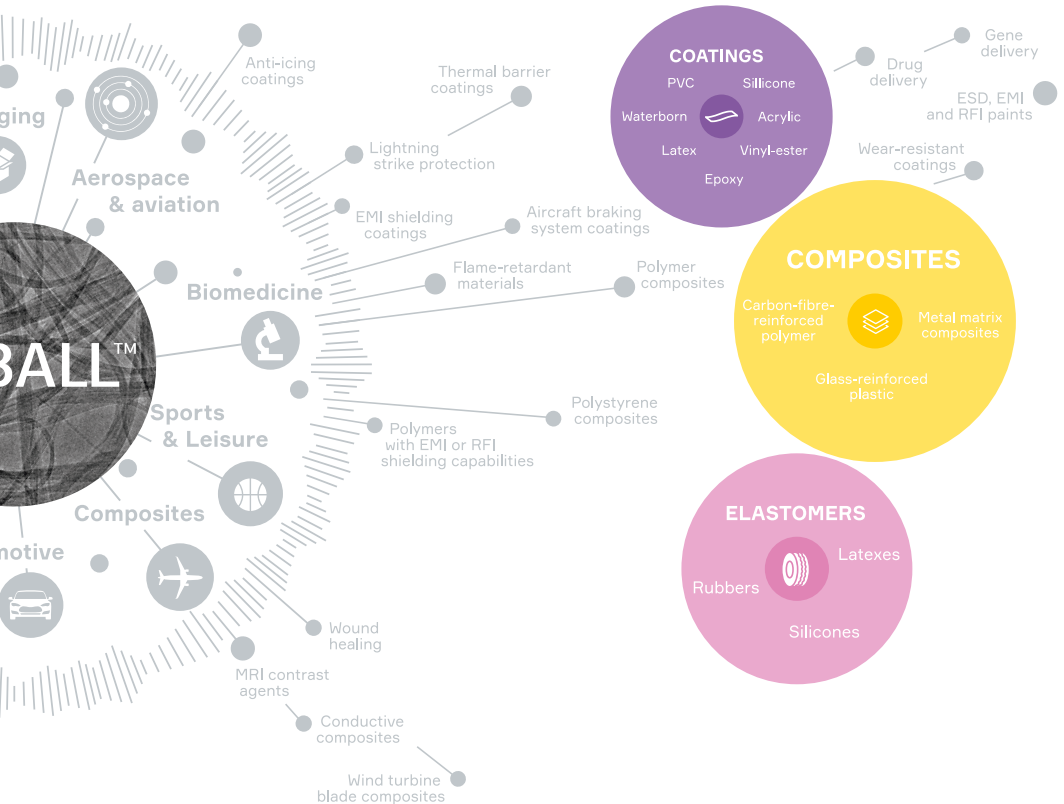
TUBALL™ PROTOTYPING CENTRE


GNTs
coatings
electrochemical power sources
thermoplastics
elastomers
thermosets
others

TUBALL™ APPLICIATIONS: ONE ADDITIVE FOR THOUSANDS OF MATERIALS

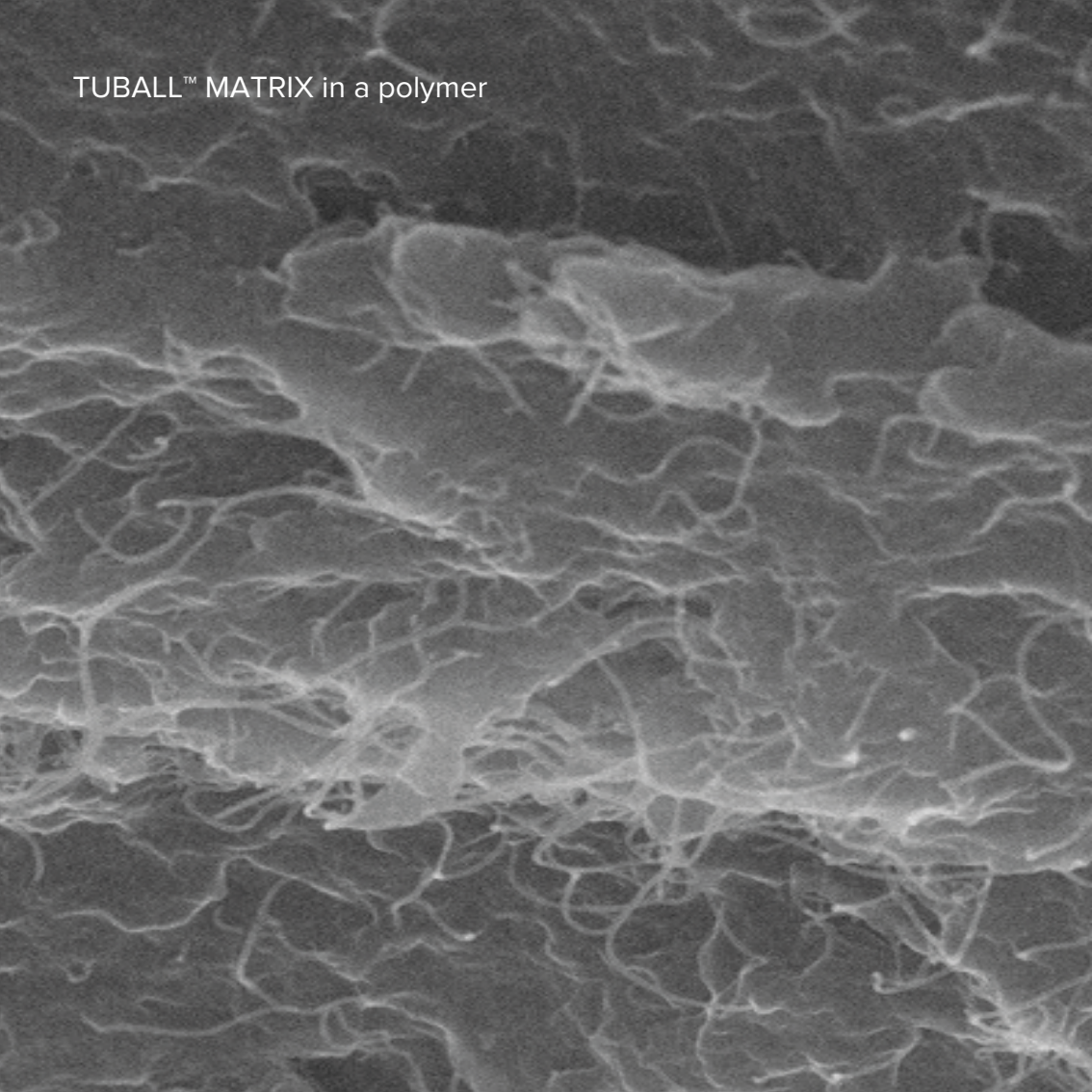


TUBALL™ nanotubes can dramatically improve the properties of the majority of materials used in industry. This wonder-material is just at the beginning of its journey. OCSiAl is taking the lead in the developing of numerous dispersion technologies that allow customers to integrate TUBALL™ into their products without changes in manufacturing technology or formulation.




TUBALL™
MATRIX
206
pre-dispersed concentrate of
single-wall carbon nanotubes

TUBALL™ MATRIX CONCENTRATES


TUBALL™ MATRIX in a polymer

TUBALL™ MATRIX

OCSiAl has taken the lead in the creation of technologies for introducing nanotubes into material matrixes.

In 2016 OCSiAl presented TUBALL™ MATRIX – a line of graphene nanotube-based concentrates that provide materials with uniform and permanent electrical conductivity without compromising the original color or mechanical properties of the product. OCSiAl has now developed concentrates for most of the widely used industry-standard formulations.

BENEFITS

Ultra-low effective concentration starts from just 0.1%

Allows retention of wide range of colors in materials

Maintains or even increases mechanical strength

Ensures permanent and uniform electrical conductivity without “hot spots”

Minimises the impact on viscosity and density of the host material


TUBALL™
MATRIX beta 206
pre-dispersed concentrate of
single wall carbon nanotubes

FOR NUMEROUS INDUSTRIAL APPLICATIONS

Epoxy, polyurethane

Phenolic

Polyester, vinylester, acrylic, melamine

Acrylic

LSR, RTV and HCR silicones

Rubbers

Thermoplastics

...and many more to come

CERTIFICATION AND H&S

HEALTH & SAFETY

OCSiAl is the first company to be authorised to start large volume commercial shipments of SWCNTs to customers in Europe, North America and other key global markets.

REACH

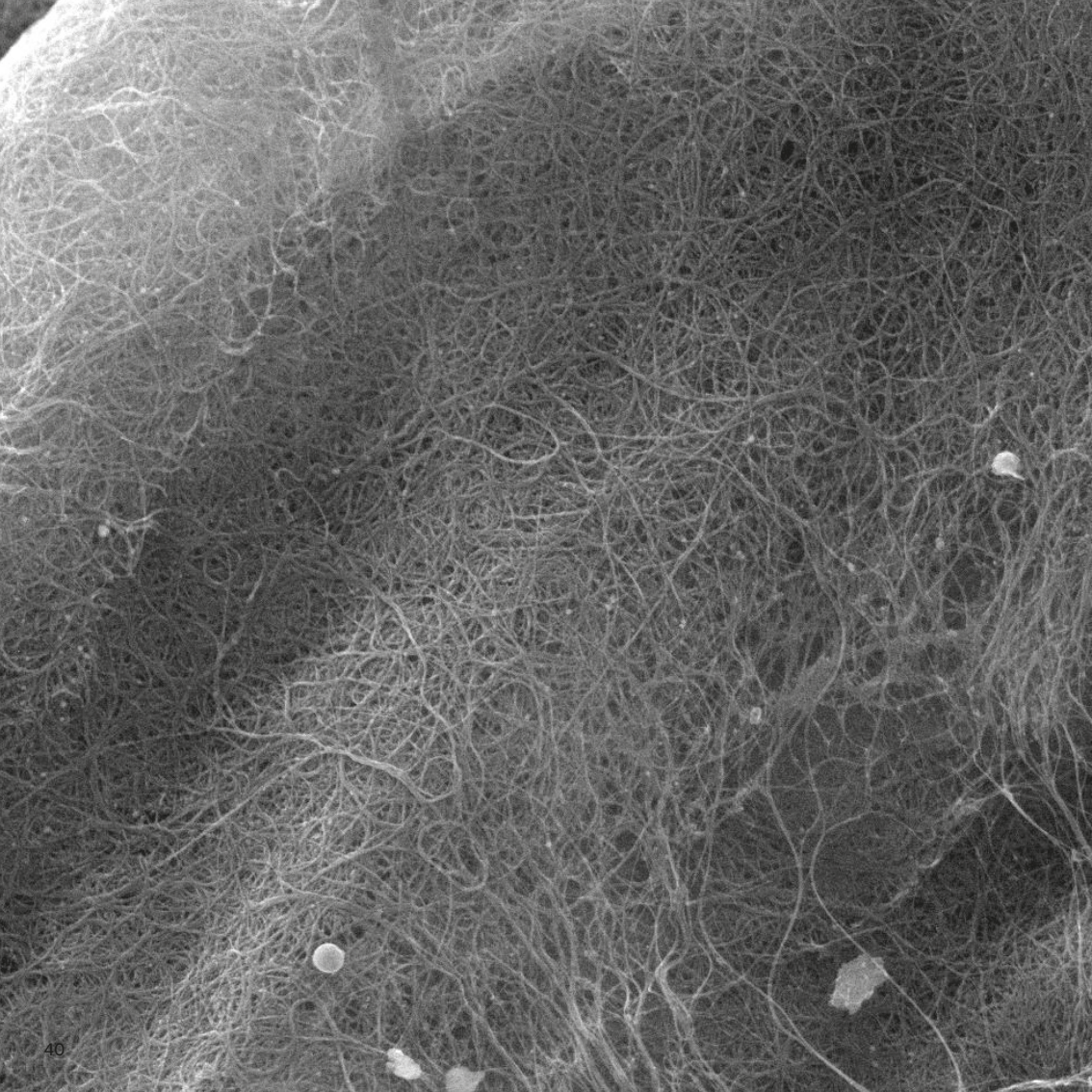
Registration, Evaluation, Authorisation and Restriction of Chemicals

- First and only SWCNT completed (September 2016)
- TUBALL™ is registered under the number 01-2120130006-75-0000
- With the tonnage band upgrade, which is compliant with REACH Annex VIII, as of April 2020, its allowed commercialization volumes in Europe up to 100 tonnes of nanotubes annually

EPA

Environmental Protection Agency

- EPA consented
- PMN number P-17-0257
- On December 5, 2019, OCSiAl's regulatory status with EPA advanced with the publication of a significant new use rule ("SNUR") in the Federal Register covering OCSiAl's products with number § 40 CFR 721.11179 It removes restrictions on the sales and supply of TUBALL™ nanotubes in the United States



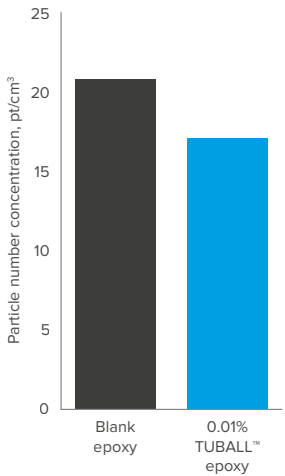
INDEPENDENT NANOSAFETY TESTINGS

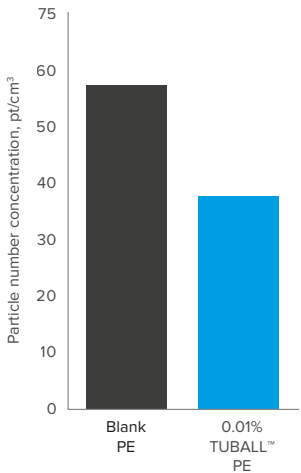
OCSiAl invests in H&S related research projects that are conducted by independent laboratories.

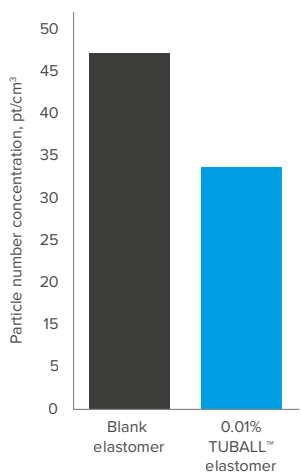
For instance, in 2017 VITO, a one of leading European independent research and technology organisation, conducted Taber abrasion and drilling testing on the release of nano- and microparticles from nanotube-formulated materials.

TESTS HAVE SHOWN THAT

- No protruding or free-standing GNTs were found
- As a result of the strength and cohesion improvement, nanotube-formulated materials release fewer nano-sized particles compared with the neat material







CONTACT YOUR LOCAL DISTRIBUTOR TO ORDER A SAMPLE AND OBTAIN TECHNICAL/SAFETY DATA SHEETS

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T U B A L L
Materials have evolved