

T U B A L L

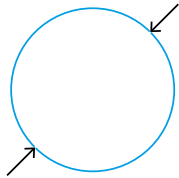
graphene nanotube

Wall thickness

1 atom

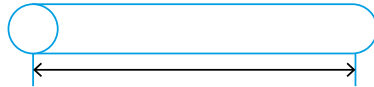
Specific surface area of 1 g

500–1000 m²



Range
of outer diameters

1.6±0.41. nm



Length >5 μm

Thermal conductivity
compared with diamond

3 times more

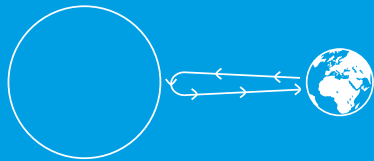


G/D
ratio

>90

Amount
in 1 g

10¹⁷



1 g of TUBALL™ nanotubes
contains enough to stretch from
the Earth to the Sun & back

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 – single wall carbon nanotubes. These tiny tubes provide us with a rare opportunity to create nanoaugmented materials that have extraordinary properties.

Single wall carbon nanotubes (SWCNTs) can also be called graphene nanotubes as they are essentially an extremely thin rolled up sheet of graphene. 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.

UNIQUE PROPERTIES OF SWCNTs

With these unique properties of nanotubes, many characteristics of materials are improved.

Excellent
conductor

**5 times
lighter than
copper**

Stronger
than steel

**up to
100 times**

Thermal
stability

**up to
2800°C
in a vacuum**

Length
to diameter
ratio

**about
3000 times**

SWCNTs — THE FIRST UNIVERSAL ADDITIVE FOR MATERIALS

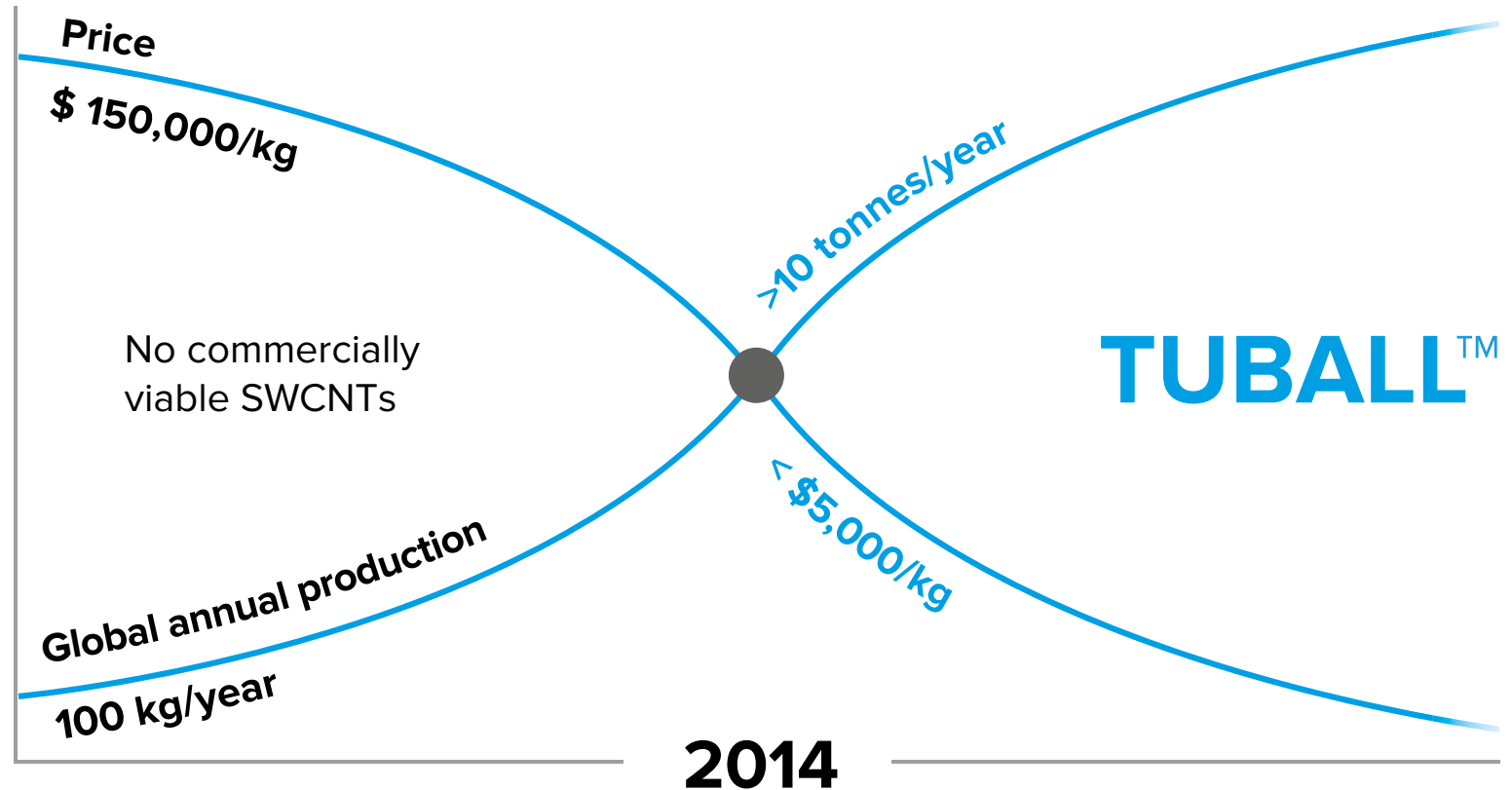
Owing to their extraordinary thermal conductivity and their mechanical and electrical properties, SWCNTs find applications as additives in an extremely wide range of structural materials.



WHY SWCNTs LEFT UNUSED

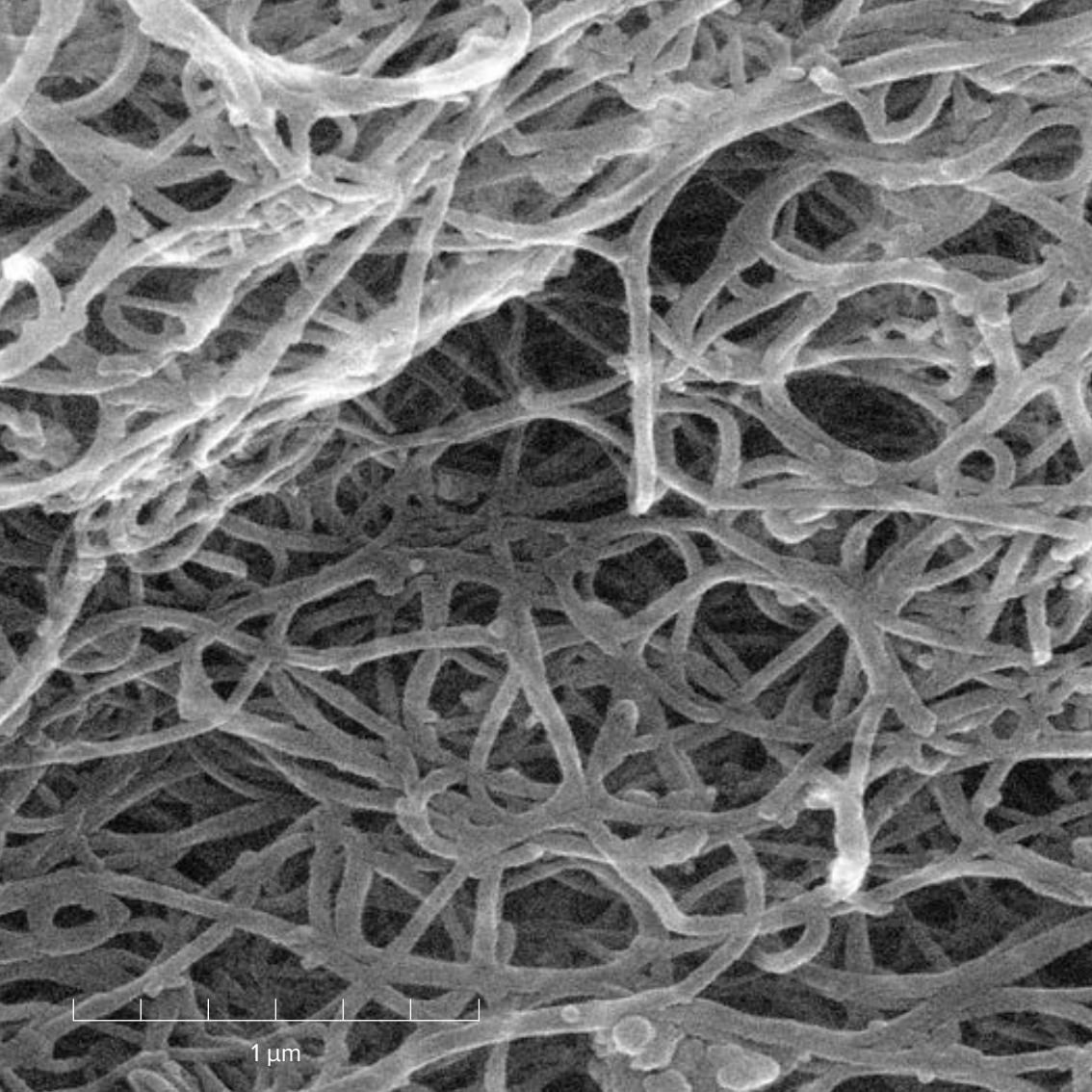
BY CIVILIZATION BEFORE?

In 2014 SWCNTs became available to the mass industry



The background of the image is a grid of circular containers, likely vials or small drums, arranged in rows and columns. Each container has a label that reads 'TUBALL' and contains a dark, granular substance. The containers are held in place by a metal frame with vertical and horizontal bars. The overall image has a dark, industrial feel.

FIRST MASS-PRODUCED SWCNT_s



TUBALL™

While the huge potential of SWCNTs 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 SWCNTs to be available for commercial applications in a wide range of industries. OCSiAl's breakthrough yet low-cost mass-production technology has made the widespread use of nanotubes economically viable while still preserving their high quality.

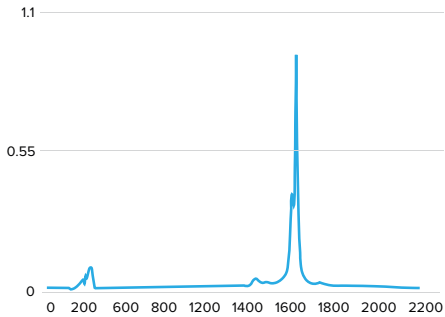
FEATURES

- High quality of SWCNT (G/D ratio >90)
- Best price-to-performance ratio compared with analogues
- Gains traction starting from extremely low concentrations
- Adds uniform electrical conductivity
- Enhances mechanical properties of materials
- Maintains colour, elasticity and other key properties
- Versatile for an extremely wide range of applications

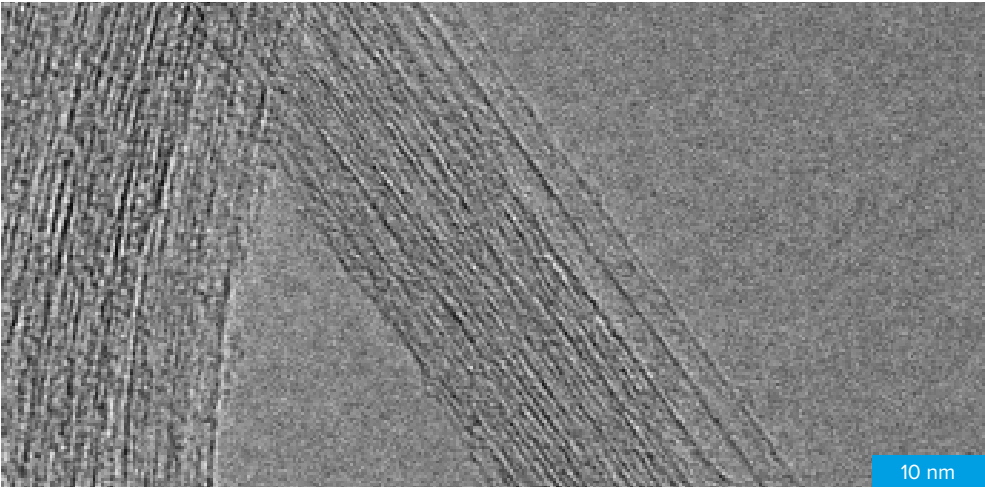
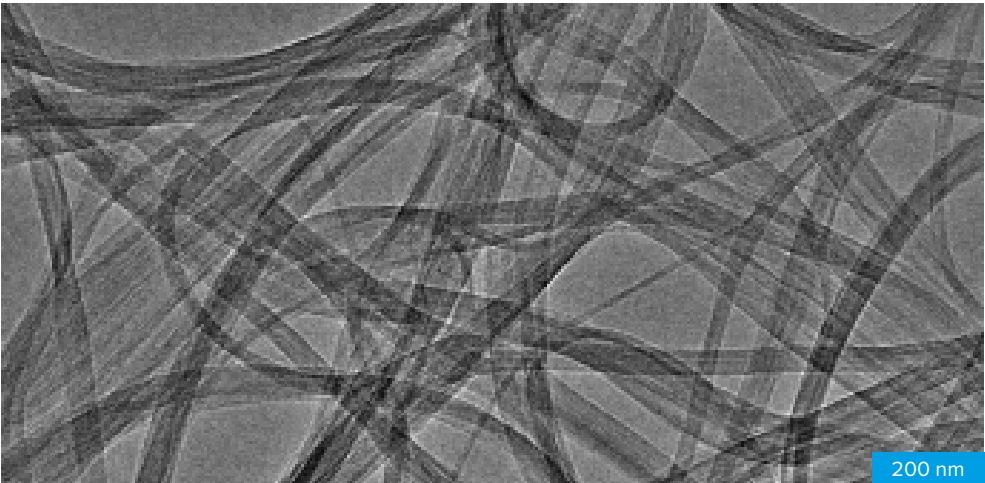
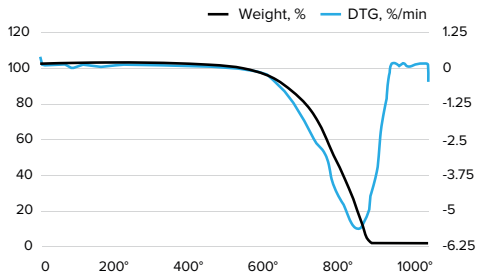
TECHNICAL INFO

	UNIT OF MEASURE	VALUE	METHOD OF EVALUATION
Carbon content	wt.%	>85	TGA, EDX, Ash residue
CNT content	wt.%	≥80	TEM, EDX, Ash residue
Number of layers CNT	unit	1	TEM
Outer mean diameter CNT	nm	1.6±0.4	TEM, Optical absorption
Length of CNT	µm	>5	AFM
Metal impurities	wt.%	<15	EDX, TGA, ash residue
Moisture	wt.%	<5	Infrared thermogravimetry

RAMAN SPECTRUM



TGA CURVES



PRODUCTION

tuball
production
installation

GRAPHETRON 1.0

started July 15, 2013



INDUSTRIAL PRODUCTION OF SWCNTs

OCSiAl is the first international advanced materials company to commercialise breakthrough technology for the synthesis of high-quality SWCNTs.

In 2013 in the city of Novosibirsk, Russia, OCSiAl launched its pilot industrial production facility with a capacity of 10 tonnes per year. Its unique production technology, which has unlimited scaling potential, brings OCSiAl to the position of the largest SWCNTs manufacturer in the world.

FACILITIES

2013

● **GRAPHETRON 1.0**

2019

● **GRAPHETRON 50**

2023

● **GRAPHETRON IN LUXEMBOURG**

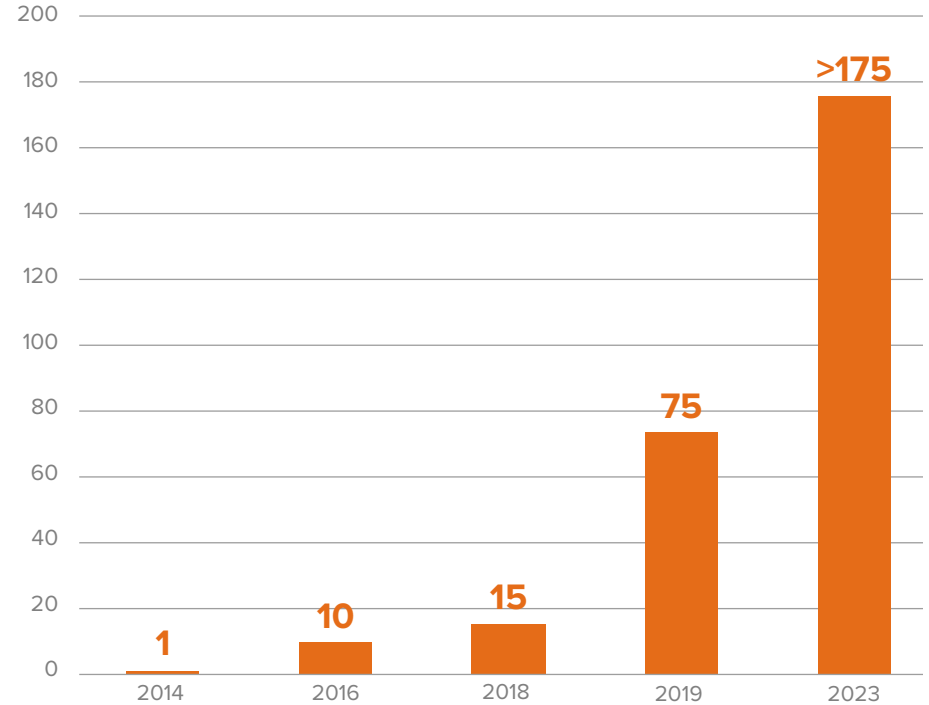
IN 2017 OCSiAl HAD MORE THAN

90%

OF THE WORLDWIDE
SWCNTs PRODUCTION CAPACITY

PRODUCTION CAPACITY: ROADMAP

tonnes/year





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 2019 is 75 tons per year. It is planned to expand existing capacity and launch a new facility in Luxembourg.



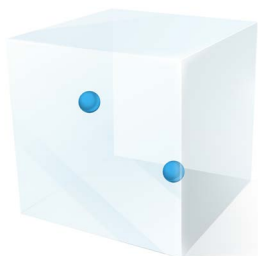
ISO certificates obtained in 2017 confirm the required high level of OCSiAl's quality control, environmental, health and safety management systems. Currently, OCSiAl is certified in accordance with ISO 9001, ISO 14001 and BS OHSAS 18001.

INDUSTRIAL APPLICATIONS

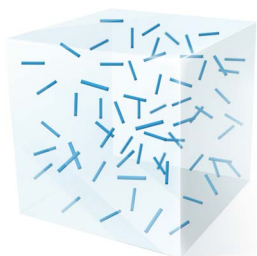


HOW IT WORKS

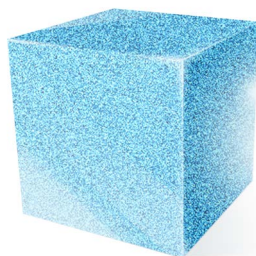
TUBALL™ provides significant improvements in material properties upon the addition of ultra-low loadings, starting from as little as 0.01%.



Microparticles



Nanofibers



SWCNTs

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

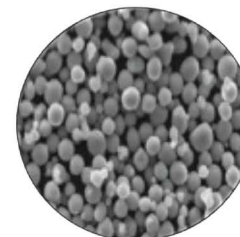
Unlike conventional additives such as multi wall carbon nanotubes, carbon fibers and most types of carbon black, which all disperse unevenly throughout the material's matrix, SWCNTs nanotubes create a uniform 3D reinforcing and conductive network.*

* 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.

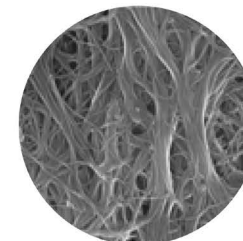
COMPARISON OF ADDITIVES THRESHOLD OF CHANGE



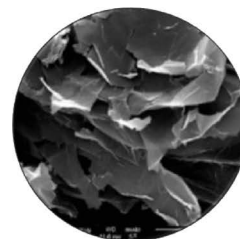
CARBON BLACK
20–40%



METAL FILLERS
15–35%



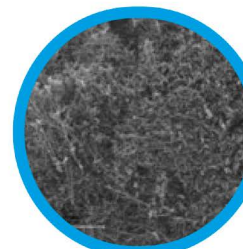
CARBON FIBERS
3–12%



GRAPHENE
1–6%



MWCNTs
0.5–5%



SWCNTs
0.001–0.01%

TUBALLTM PROTOTYPING CENTRE



SWCNTs



coatings



electrochemical power
sources



thermoplastics



elastomers



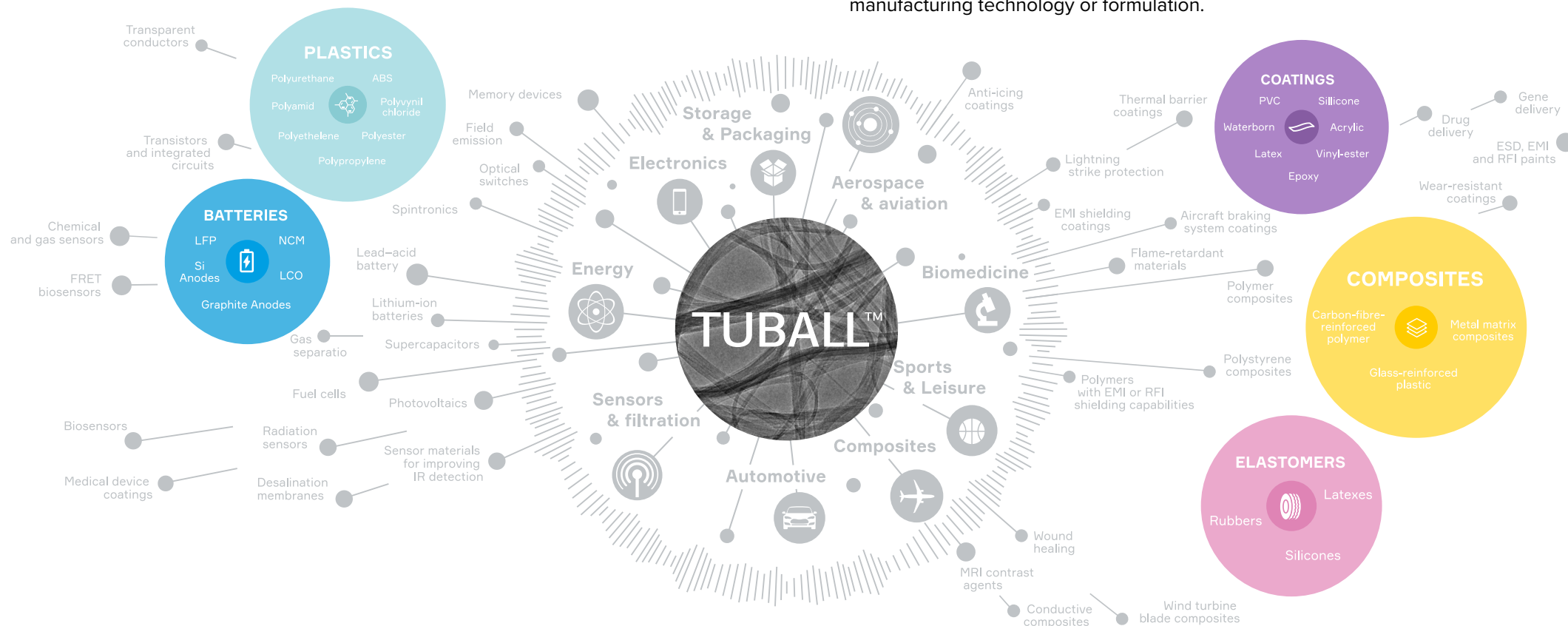
thermosets



others

TUBALL™ APPLICATIONS: 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. OCSiA 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 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 single wall carbon 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



FOR NUMEROUS INDUSTRIAL APPLICATIONS

MATRIX
201

MATRIX
202

MATRIX
203

Epoxy, polyurethane

MATRIX
207

MATRIX
208

MATRIX
301

MATRIX
202

MATRIX
205

Phenolic

MATRIX
204

Polyester, vinylester,
acrylic, melamine

MATRIX
302

Acrylic

MATRIX
601

MATRIX
602

MATRIX
605

LSR, RTV and HCR silicones

MATRIX
603

Rubbers

MATRIX
8XX

Thermoplastics

...and many
more to come

A scientist in a white lab coat is operating a large, complex industrial machine. The machine has a digital display showing a blue square, various gauges, and a large blue circular component on the right. The background shows a laboratory setting with other equipment and a clean, professional environment.

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

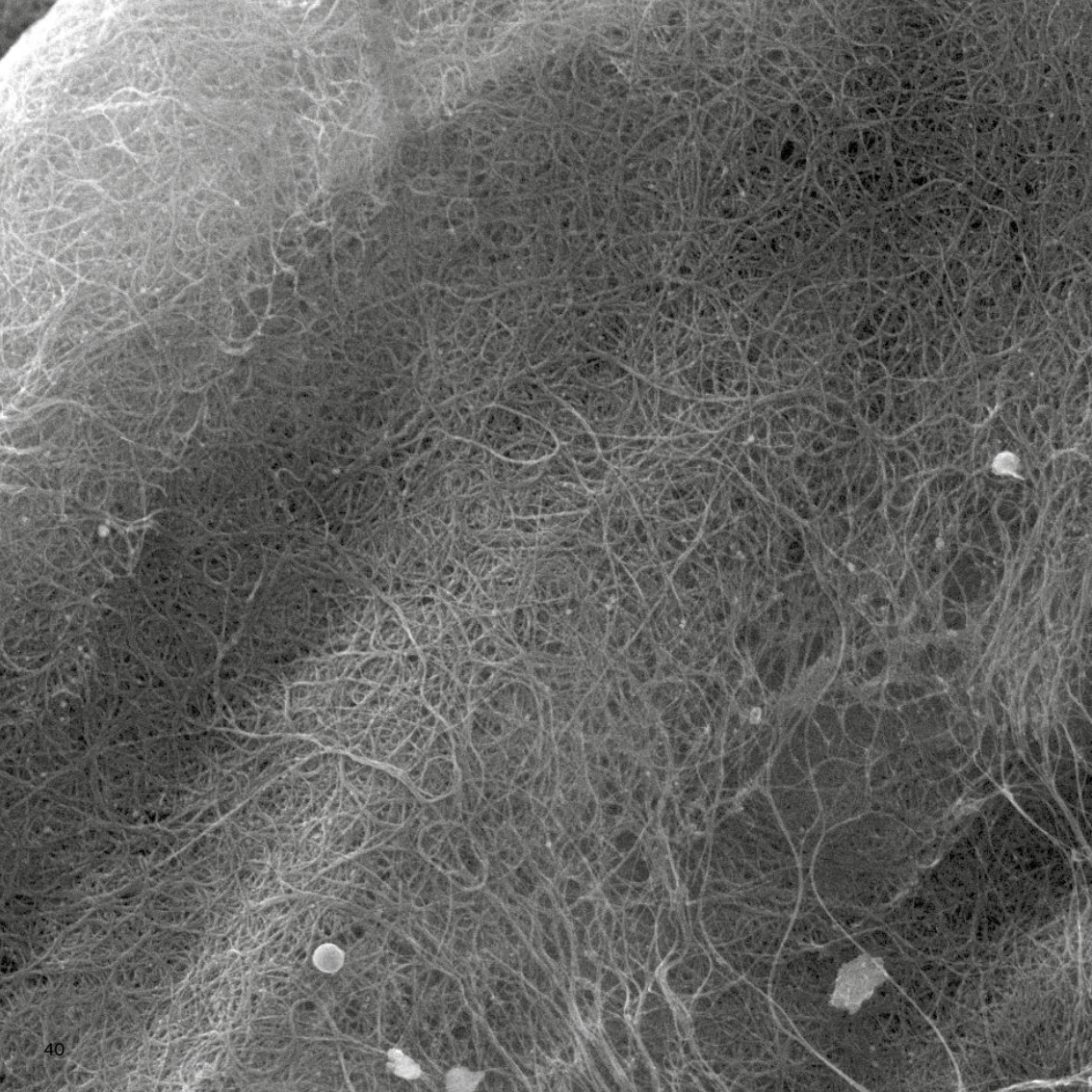
- First and only SWCNT completed (September 2016)
- TUBALL™ is registered under the number 01-2120130006-75-0000
- Allows OCSiAl to commercialise up to 10 tonnes/year in Europe



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.



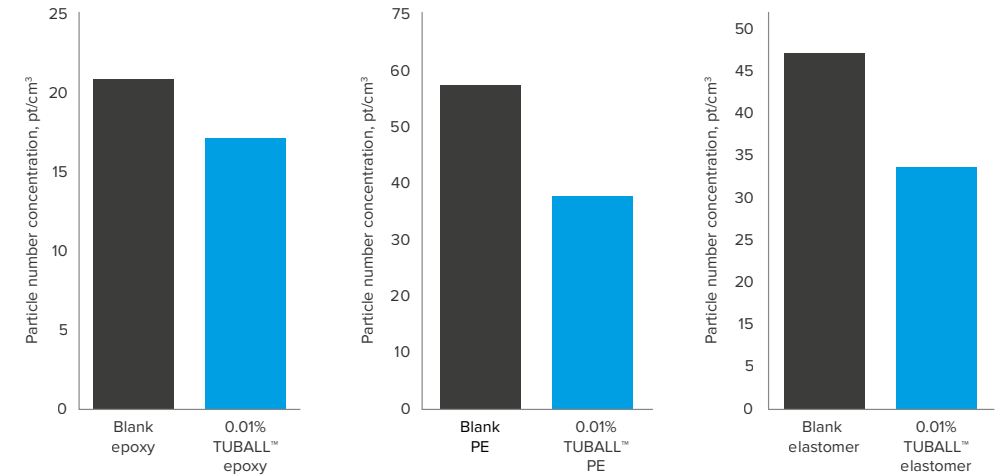
INDEPENDENT NANOSAFETY TESTINGS

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 SWCNTs 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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TUBALL

Materials have evolved