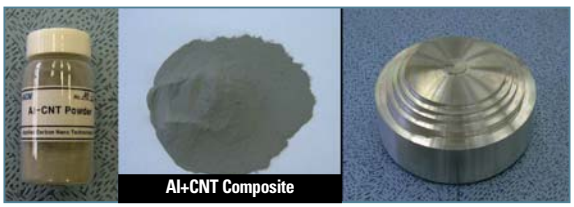
METAL+CNT COMPOSITE

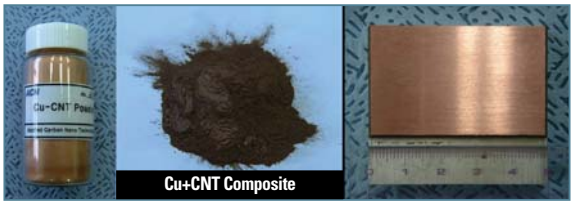
- ▶ Lowest Cost & High Productivity
- ▶ Excellent Mechanical Properties
- ▶ Low Weight Structure Material
- ▶ Base Metal : Pure & Alloy metal

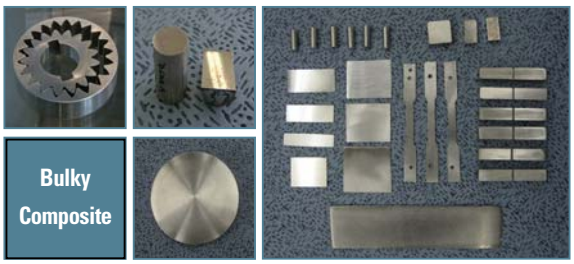
Generals

Features

- Excellent Dispersibility of CNT in Metal Matrix
- Improved Strength by Metal-based Nano-crystalline
- Improved Strength & Toughness by Mechanical Properties of CNT
- Improved Conductivity by Electrochemical Properties of CNT
- Improved Abrasion Resistance by Nano-crystalline & CNT
- Light weight compared with the Existing High-strength Composites
- Low Cost Metal+CNT Composite compared with High Strength Composite
- Various Grade can be Manufactured depending on Application Fields







Type

- Metal+CNT : Al+CNT, Cu+CNT, W+CNT etc.
- Alloy+CNT : Al Alloy+CNT, STS+CNT, W alloy+CNT etc.
- CNT Contents : ~20 Vol.%

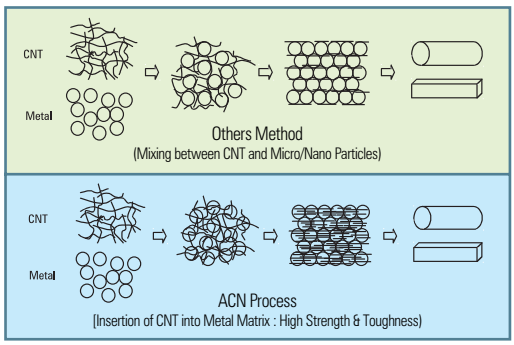
Applications

- **Light Weight Structures with High Strength & Toughness**
  : Aerospace, Automobiles, Vessels and Leisure/Sports Apparatuses
- **Abrasion-resistant Light Weight Materials**
  : Aerospace, Automobiles, Tools and Machine
- **Excellent Thermal and Electric Conductivity**
  : Electronics, Computer, Automobiles, Aerospace and Precision Equipment

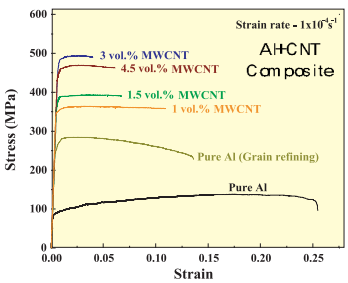
Characteristics

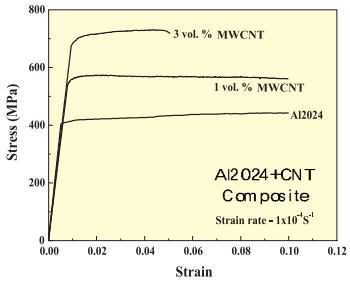
Comparison of Manufacturing Process

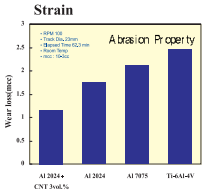
ACN Process : Lowest Price & Mass Production

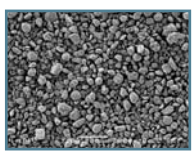


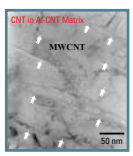
Excellent Mechanical Properties



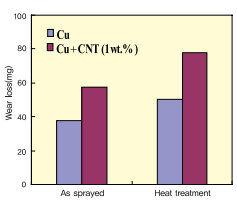


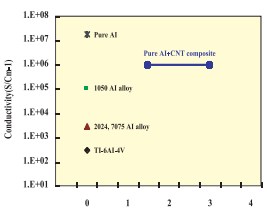






Electrical Conductivity of Metal+CNT





- Cold Spray Coating
  - As spraying : Cu < Cu+CNT
  - As heat treatment : Cu < Cu+CNT

Ti Alloy < Al Alloy < Al+CNT < Al

Comparison of Mechanical Properties

	Yield strength (MPa)	Tensile strength (MPa)	Elonga-tion (%)	Hardness (HRB)	Specific strength (MPa)	Electrical conduct. (IACS%)	Wear loss (10^3 cc)
2024 Al Alloy	324	469	19	70.5	174	12	1.74
7075 Al Alloy	435	505	13	80.5	181	9	2.13
Ti-6Al-4V	880	950	14	260~	198	-	2.45
Pure Al+CNT (CNT 3 vol.%)	440	475	5~10	83.2	176	55	-
Alloy Al+CNT (CNT 3 vol.%)	715	720	4	93.7	265	-	1.16

* Tension test :ASTM E8
* Wear test : RPM100, Track Dia. 23mm, Elapsed time 62.3min, Room Temp.

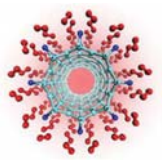
POLYMER+CNT COMPOSITE

- Uniform Dispersibility & Conductivity
- High Conductivity with Low Loading of CNT
- Excellent Physical Properties
- Maintain the Resin Physical Properties
- Extremely Low of Particle Sloughing

Generals

Features

- Improved Conductivity by Electrochemical Properties of CNT
- Improved Strength & Toughness by Mechanical Properties of CNT
- Uniform Dispersibility & Conductivity by using Metal+CNT Composite
  - Insertion of CNT into Metal particle : Control Length of CNT in Metal
  - Prevent Segregation of CNT in Extrusion
  - Role : CNT (Conductivity), Metal (Dispersibility & Conductivity)
- Realization of High Conductivity with the Minimum Addition of CNT
- Maintaining the Properties of the Base Material°Øs own
- Decreased Particle Sloughing
- Extended Lifetime



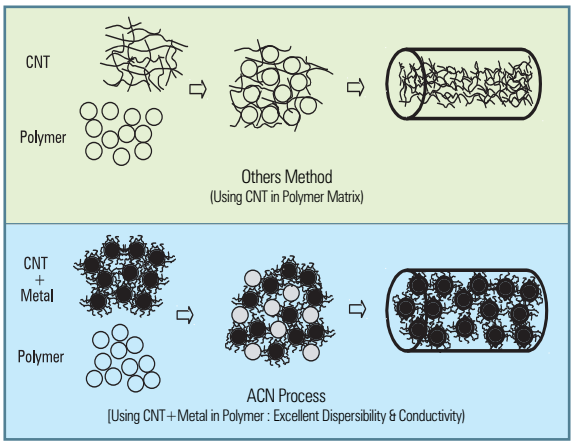
Type

- PC+CNT, Nylon+CNT, PET+CNT, PE+CNT etc.
- CNT Contents : ~20 wt.%

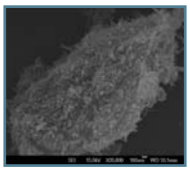
Applications

- **Shielding Material (ESD & EMI)**
  : Mobile, Cloth, Computer, Glove, Shoes, Matt, Tile, Tray, Tape, Box, Bag, Film etc.
- **Engineering Plastic, Heat sink**
  : Aircraft, Automobile, Aerospace, Electronic, Medical, Vessel Sports equipment, etc.

Comparison of Manufacturing Process



Al+CNT Composite

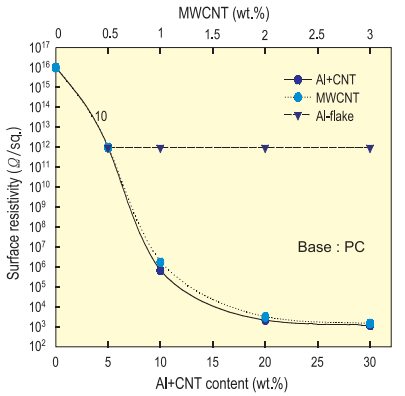


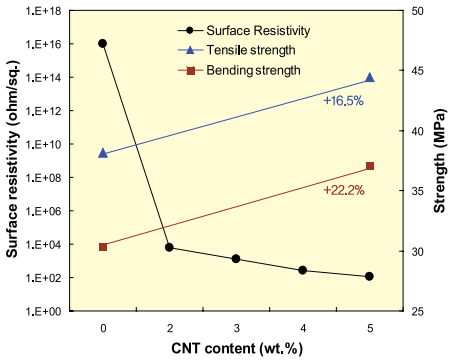
SEM Image of Al+CNT

Polymer+(Al+CNT) M/B

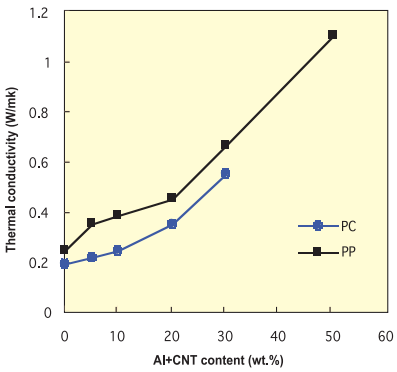
Characteristics

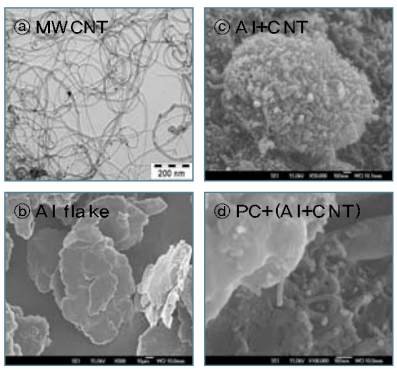
Surface Resistivity & Strength



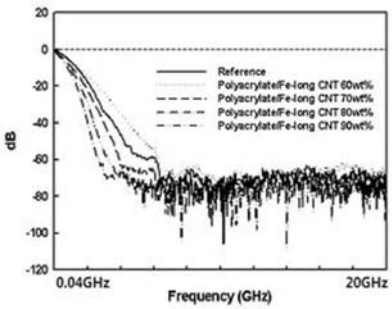


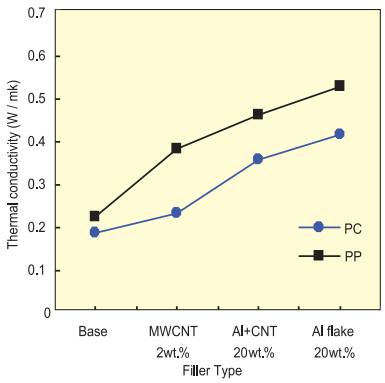
Thermal Conductivity





Electro Magnetic Absorption





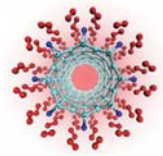
CERAMIC+CNT COMPOSITE

- Uniform Dispersibility & Conductivity
- High Conductivity with Low Loading of CNT
- Excellent Physical Properties
- Maintain the Ceramic Physical Properties

Generals

Features

- Improved Conductivity by Electrochemical Properties of CNTs
- Improved Strength & Toughness by Mechanical Properties of CNTs
- Improved Abrasion resistance by Appearance Properties of CNTs
- Realization of High Conductivity with the Minimum Addition of CNT
- Maintaining the Properties of the Base Ceramic's Own
- Decreased Particle Sloughing
- Extended Lifetime



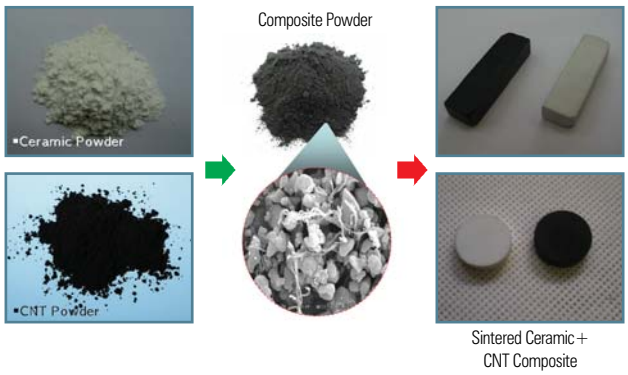
Type

- ZrO_2+CNT, Al_2O_3+CNT etc.
- CNT Contents : ~ 10 Vol.%

Applications

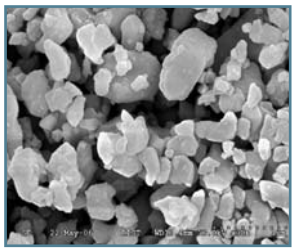
- Ceramic coating materials with high strength and high toughness
- Industrial materials requiring electric conductivity and heat dissipation
- Ceramics for shock absorption Abrasion-resistant ceramics

Manufacturing Process of Ceramic+CNT Composite

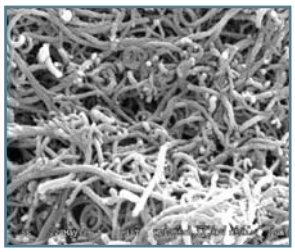


Characteristics

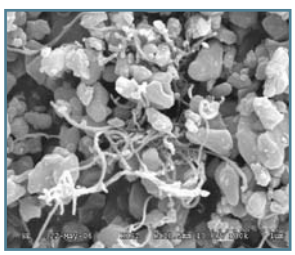
SEM Image of Ceramic+CNT Composite



Raw ceramic powder

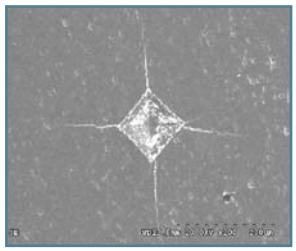


Carbon Nanotube (MWCNT)

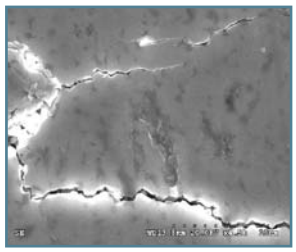


Ceramic+CNT Composite

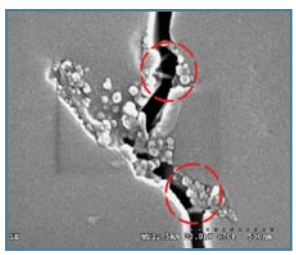
Crack Propagation Behavior of Ceramic+CNT Composite



Vickers hardness press mark

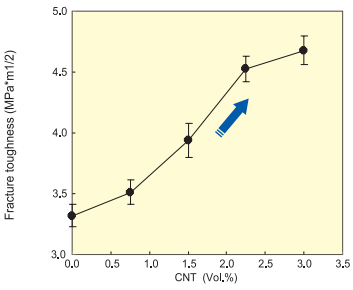


Prevent Crack propagation

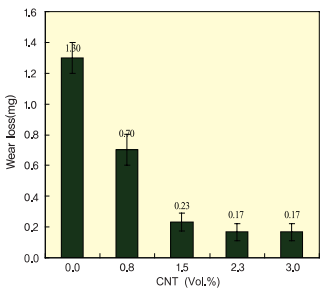


Crack bridging by CNT

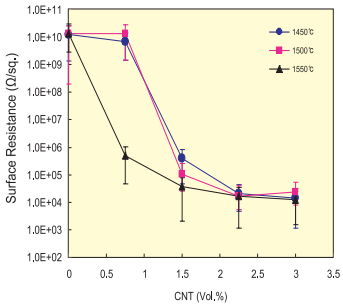
Fracture Toughness



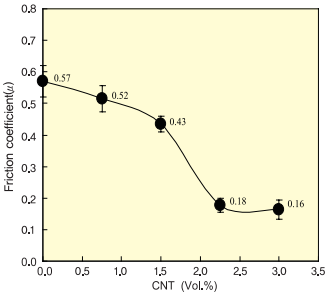
Wear loss



Surface Resistance



Fraction coefficient



LIQUEFIED CNT

- Uniform Dispersibility & Conductivity
- Highly Electric/Thermal Conductivity
- Excellent Dispersibility of CNT
- Highly Photocatalyst Property

Generals

Features

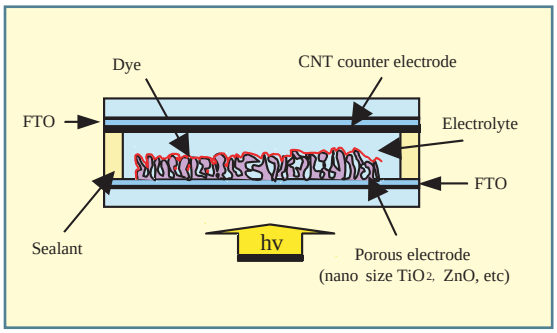
- CNT-used Liquid high conductive paste & ink
- Low cost CNT for expensive Pt & Ag
- Excellent electric conductivity & thermal emission property
- Environmental-friendly materials with conductivity & photocatalyst
- Various grade can be manufacturing depending on application fields
- Convenient usage : Spray, coating etc.

Type

- CNT Paste : 10^{1}~10^{2} Ω/sq.
- CNT Ink : 10^{1}~10^{4} Ω/sq.

Applications

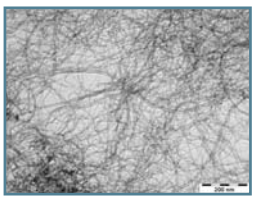
- ESD, EMI
- Dye-sensitized solar cell counter electrode
- Adsorption of harmful gas, Pollution decomposition



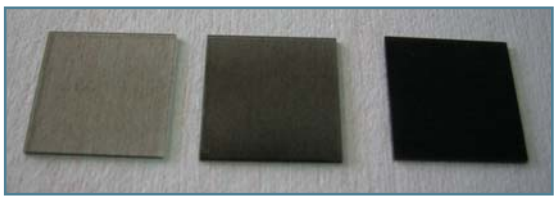
DSSC modules with CNT counter electrode

CNT Ink

CNT Paste



High Dispersibility CNT for Liquefied CNT



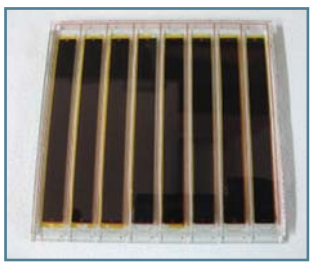
CNT Counter Electrode of DSSC

Dye-sensitized Solar Cell CNT Counter Electrode

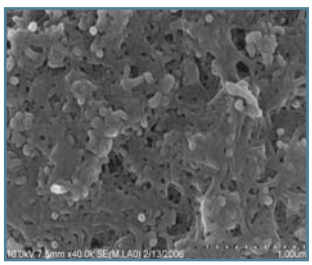
Features

- Low cost CNT counter electrode for expensive Pt counter electrodes
- High photo-electric conversion in low level illumination
- High efficiency and stability in comparison with Pt DSSC

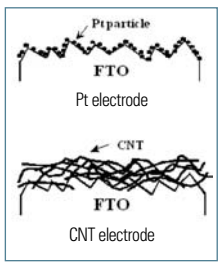
DSSC modules with CNT counter electrode (KERI-ACN)

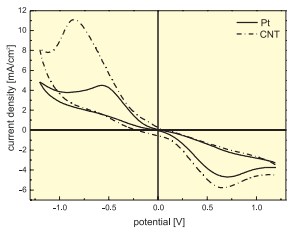


DSSC modules with CNT counter electrode



SEM image of CNT electrode

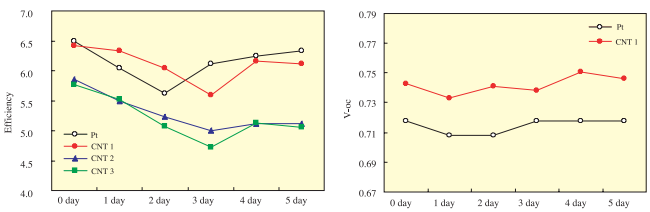




Cyclic voltammogram of Pt and CNT
(Scan rate : 100 mV/s)

Property

- Sheet resistance
  : CNT electrode ≒ Pt electrode (Excellent Conductivity)
- Electrochemical properties
  : CNT electrode > Pt electrode (CV & impedance spectrum)
- CNT Electrode
  : Excellent performance & Simple Process
  → CNT : Low resistance, Excellent electron emission
  Large surface area, Low cost



Comparison of efficiency & V-oc between Pt and CNT electrode

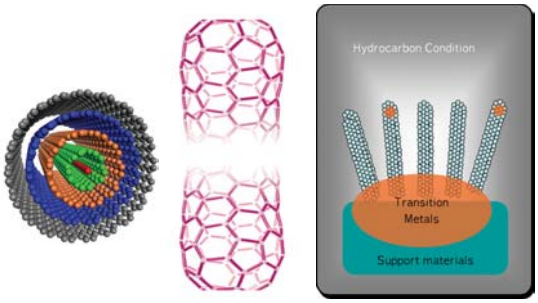
CARBON NANOTUBE

- Mass production and Lowest price
- Excellent mechanical/Electrical/Thermal property
- High chemical stability
- Various technological applications

Generals

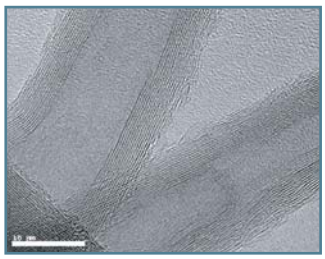
Features

- New dreamy material in the 21st century
- Tubular material with hexagonal honeycomb structure
- Remarkable electronic/thermal and mechanical properties
- Mass production and lowest price
- Wide use and various technological applications
- Environmental-friendly materials with conductivity & strength

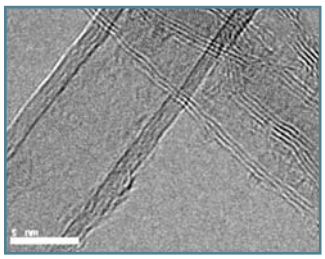


Typical Properties of MWCNT

Properties		Value	Remarks
Electrical Resistivity (Ω •cm)		0.1	Pure Cu (1.67)
Thermal Conductivity (W/m/K)		~2,000	Pure Al (236)
Elastic Behavior	Young's Modulus (MWCNT)	1.28 TPa	
	Maximum Tensile Strength	~100 GPa	SUS 304 (0.6 Gpa)



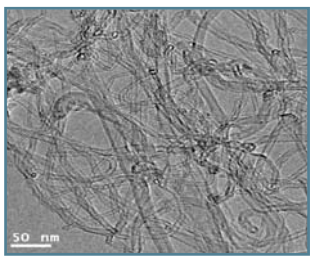
MWCNT



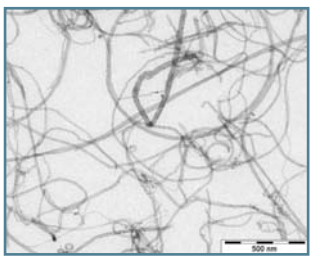
TWCNT

Properties and Qualities

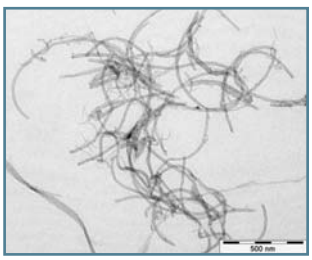
Type	Purity (wt.%)	Diameter (nm)	Length (um)	Remarks
CNT 85, CNT90	85, 90	5~20	~10	Catalyst CVD
CNT97	over 97	5~20	~10	Purified CNT90
Chopped CNT	85, 90, 97	5~20	~1, 1~3	Various Length
TWCNT	85, 97	5~10	~10	Thin Wall CNT



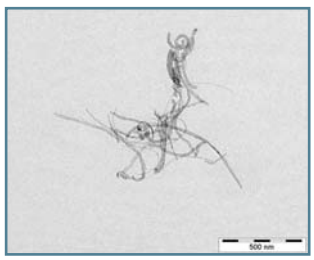
Normal MWCNT



Normal MWCNT



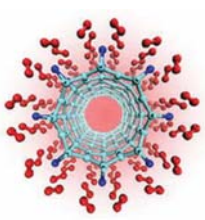
Chopped CNT (1~3 um)

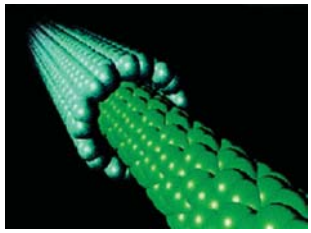


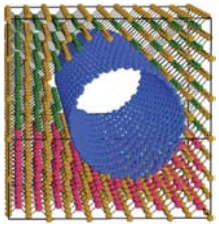
Chopped CNT (~1 um)

Applications

- Electron emitter, light source
- Electromagnetic interference (EMI), Electrostatic discharge (ESD)
- Solar cell electrode, Fuel cell electrode
- Rechargeable battery
- Metal/Ceramic/Polymer composite
- CNT paste & ink
- Removal sick house syndrome, adsorption of harmful gas, pollution decomposition







ENGINE OIL ADDITIVE(MISO-N)

- Chopped CNT, Nano Pt dispersed in oil
- Up to engine Power
- Saving the Fuel
- Superior thermal behaviors of Oil
- Can be used in all kinds of cars

Generals

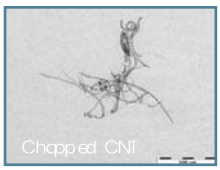
Features

- Nano Pt & Chopped CNT are uniformly dispersed in engine oil
- Nano materials are coated in scratched part of engine inner surface
- Nano Pt : Promote perfected combustion, decrease toxic waste gas
- Chopped CNT in Nano size : Improve Lubrication & thermal conductivity
- High performance engine oil additive
  : Decrease fuel consumption, Improve engine performance,
  Prevent wearing of friction surface of engine, Less noisy
- Application : Motor, Aircraft, Vessel, Motorcycle, Industrial Engine
- Patents : 3 (Miso-N, Chopped CNT, Nano Pt)

Features

- In common use for Gasoline, Diesel, LPG.
- After shaking several times, pour Miso-N into
- engine oil in any time, but after engine oil exchange is better.
- With one bottle, no need to change engine
  oil up to 15,000~20,000 km, but we recommend
  up to 10,000 km in order to get better effects.

Main Components



Chopped CNT
- Excellent electric & thermal
- conductivity
- Self lubricant
- Excellent chemical stability
- CNT length control (Patent)

Nano Platinum (Pt)
- Excellent electric & thermal
- conductivity
- Self lubricant
- Excellent chemical stability
- CNT length control (Patent)

Sort

- 60ml : Passenger Car, SUV
- 200 ml : Bus, Truck
- 5L : Mass consumption company

Characteristics

Effect of "Miso-N"

Differences of property

Classification	Miso-N oil additive	Other products
Main Materials	Carbon nanotube(CNT), Nano Platinum (Nano Pt)	PTFE, Metal Powder,Mo compound, Graphite, Ceramic powder etc.
Function	Recover engine as a optimal situation & help perfect combustion	Improve the quality of engine oil
Durability	No risk of oxidation and burning in any condition of temperature	In harsh condition, there is a risk of oxidation in main materials (severe negative effects in engine)
Applying	There is no limit, can be used in all kinds of cars and any time, it can be applied regardless the time of oil change	There are different applying method according to the kinds of cars, fuels, and it can not be applied in any time
Continuance	One time using, the effect is lasted till 10,000~20,000 km	In the beginning there is certain effects but in some time, the effects are disappeared

Differences of property

Classification		Before (km/ℓ)	After (km/ℓ)	Fuel Saving Rate (%)
Gasoline	Hyundai, 1500cc DOHC ('97)	11.03	12.90	+17.0
	Samsung, 2000cc ('01)	13.33	14.59	+ 9.5
	Hyundai, 2000cc DOHC ('99)	11.6	12.8	+10.3
	KIA, 800cc (2000)	13.23	14.99	+13.3
	Daewoo, 1800cc ('96)	6.87	7.74	+12.7
	Hyundai, 2500cc ('97)	7.96	9.12	+14.6
	Hyundai, 2000cc ('99)	8.71	9.33	+ 7.2
Dissel	KIA, SUV 2500cc ('04)	10.8	13.6	+25.9
	KIA, SUV 2500cc ('05)	11.4	13.5	+18.6
	Hyundai, 14Ton Truck ('99)	3.62	3.79	+ 4.7
LPG	Hyundai, 2000cc ('04)	9.94	10.84	+8.98
	Hyundai, 2000cc ('05)	9.89	10.88	+9.95

City Bus in Seoul	2008			2009		
	April	May	June	April	May	June
Normal Bus (3 avg.)	3.08	3.02	2.85	2.92 (-4.91%)	2.83 (-6.14%)	2.57 (-9.75%)
Test Bus (5 avg.)	Before (km/ℓ)			After (km/ℓ)		
	2.85	2.95	2.74	3.15 (+10.96%)	3.07 (+4.21%)	3.02 (+10.06%)

Test Result in the Army

Classification	Saving fuel (%)	RPM at 80km/h	Power	Noisy	Interval time to normal engine Temperature
K-131 (Jeep, Gasoline)	+25.9	2,800 (300 ↓)	Up	Reduce	Faster
K-311 (5/4T, Dissel)	+19.2	-	Up	Reduce	Faster
K-511 (2.5T, Dissel)	+26.3	2,300 (200 ↓)	Up	Reduce	Faster

Classification	HC (ppm)	CO (%)	NOx (ppm)	CO2 (%)
Before	50	0.0	212	15.0
After	14	0.0	218	15.0
Limited Value	190	1.2	1,440	-