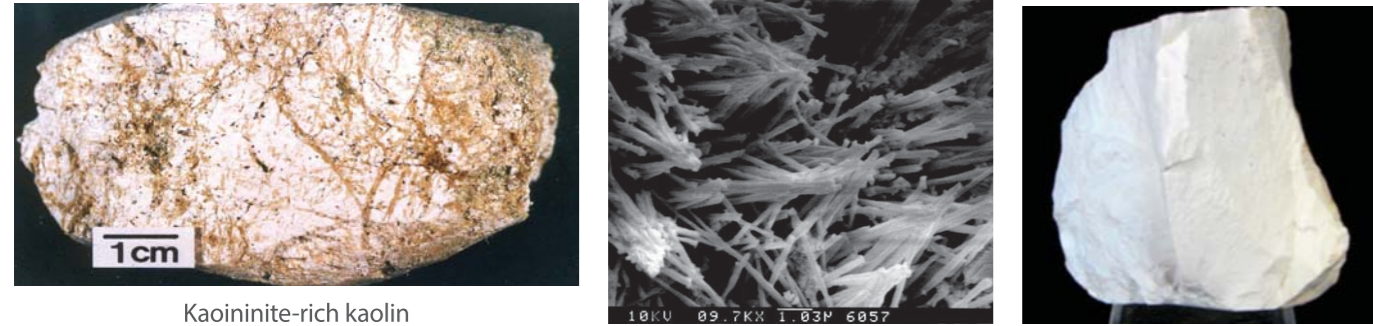


Mineral form of Halloysite

Halloysite-and kaolinit-rich kaolin



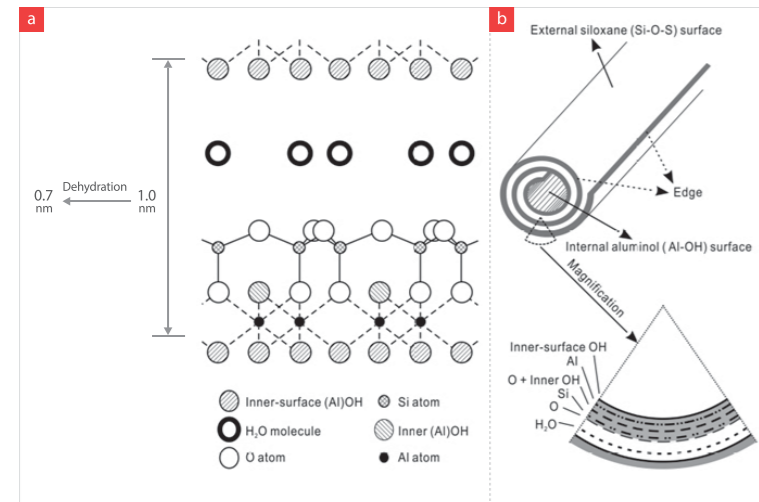
Kaolinite-rich kaolin

Structure of Halloysite Nanotube

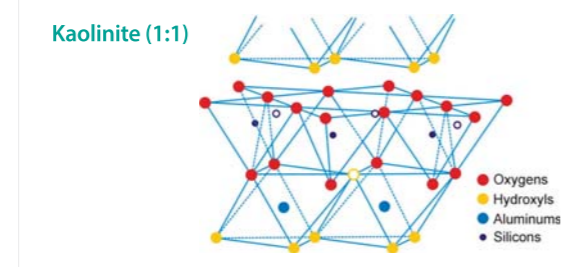
Halloysite

- $Al_4Si_4O_{10}(OH)_8$
- $4H_2O$
- Consist of SiO_4 tetrahedral(outside) and $Al_2(OH)_6$ octahedral units.
- Surface charge at pH 2-9 : Negative

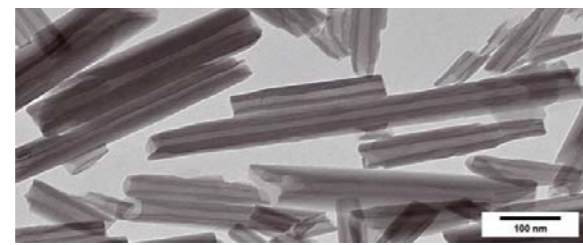
Crystalline Structure of Halloysite



Structure of clay mineral



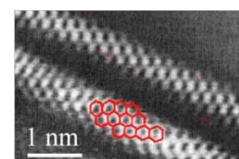
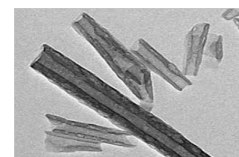
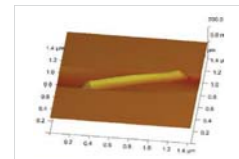
Inorganic Hollow Nanotube



- Lumen 10 % by volume / • Length : < 0.4 μ m
- Thickness : < 0.1 μ m

Clay Tube Nanocontainer

- Halloysite versus Carbon Nanotubes



Parameters	Halloysite Nanotube	Carbon Tubes
• Length	0.5 - 2 μ m	1 - 5 μ m
• External diameter	50 - 100 nm	2 - 10 nm
• Inner lumen diameter	10 - 20 nm	1 - 3 nm
• Surface area	70 - 300 m ² / g	70 - 300 m ² / g
• Water wettability	Hydrophilic	Hydrophilic
• Biocompatibility	Biocompatible	Health hazard
• Price/Availability	\$2 per kg / tons	\$10,000 per kg / kg
• Publications/Patents	693/23 (2013)	55,700/902 (2013)
• Researchers/Companies	2 companies in USA / LaTech, China	500 companies and labs

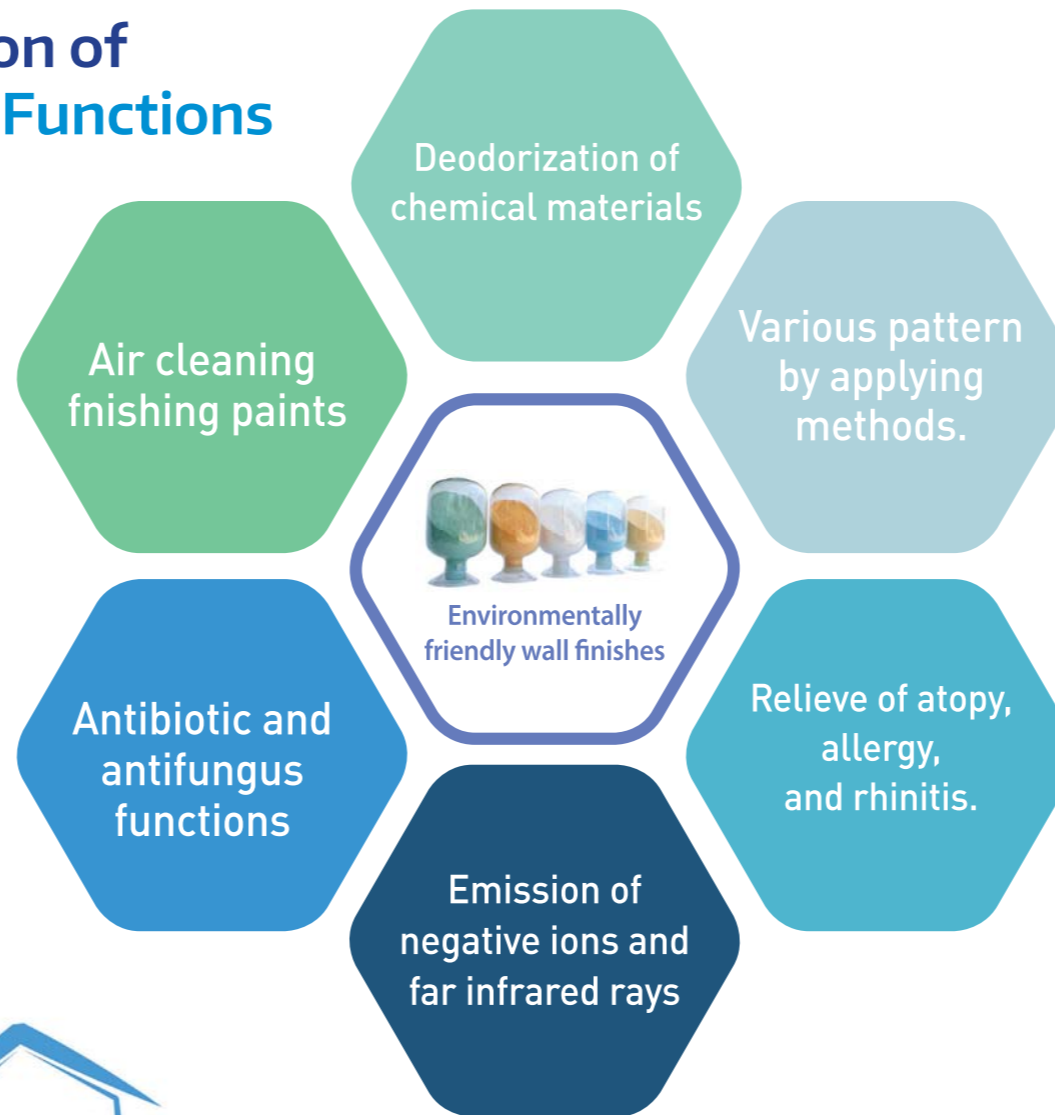
Relevant Products



Wall Coatings

It suppresses reproduction of molds by photo-oxidation reaction as eco-friendly natural ceramic materials contain photo catalysis and it can substitute for paint and wall paper.

Description of Products Functions



LW LAKWOO CO., LTD.

116-54 Sansu-ro, Sancheong-eup, Sangcheong-gun, Gyeongnam Province, Republic of Korea
Tel. +82-55-972-9922 / Fax. +82-55-972-9925 / Homepage. www.lakwoo.co.kr



hue(林) Dream HALLOYSITE NANOTUBE

Diagnostic Reagent, Paint Improving Atopic Dermatitis, Anti-Bacterial Paint, Corrosion Resistant Paint, Catalyst of spandex fabric



LW LAKWOO CO., LTD.

CEO Greeting

LAKWOO Co., Ltd. has been a valuable part in the industry of the new ceramic materials in the last half century. Since began supplying ceramic raw materials for pottery, sanitary ware and tile which served as the groundwork for the basic industry, we are currently supplying state-of-the-art ceramic raw materials such as extremely sensitive ceramic materials, petrochemical catalyst.

We, moreover, possess a government certified research institute, and completed developing a multi-functional and environmentally friendly paint by kaolin and 5 NANO grinding techniques after years of continued research and development, which is now on sale. LAKWOO intends to develop a diagnostic reagent, paint improving atopic dermatitis, anti-bacterial paint, and corrosion resistant paint for ships, etc by injecting functional components into Halloysite Nanotube in the crystal structure which shows characteristics of Korean Kaolin. We will strive to concentrate on strengthening the function of the catalyst supplied for BDO and developing the catalyst used in various petrochemical fields as a focal project.

We guarantee to become a reliable and recognized enterprise based on the management philosophy of "stable security of raw materials, stable production and stable supply of raw materials".

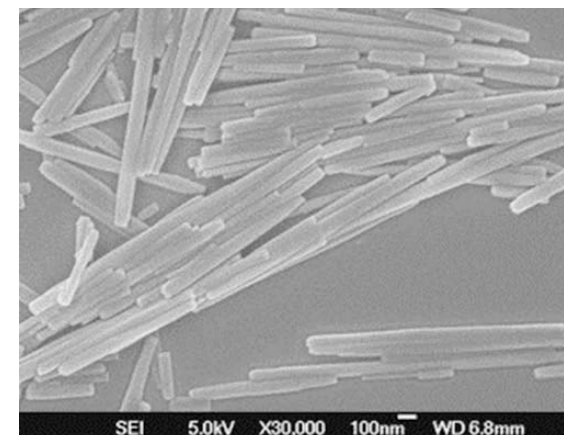
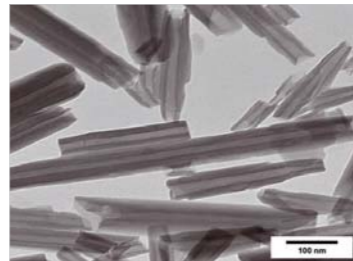
Halloysite Nanotube Features of industrial use



- Natural production** : Abundant Amounts, reasonable price
- Tube with hollow structure**
 - High aspect ratio : Strengthened plastic, elastomer, corrosion resistant coating
 - Large surface area : Catalyst, absorbent, carrier material, elastic material, foam cell
 - Internal hollow space : Controlled release, insulation, lightweight, reserve osmosis
 - Bound water : Fire retardant, thermometer, foaming agent
- High mechanical strength** : Improvement in physical properties of nanoscale composite
- Low surface Hydroxyl groups** : Easy dispersion in the polymer
- Fast adsorption** : Removal and purification of pollutants
- Biocompatibility** : Non-toxic, drug delivery system



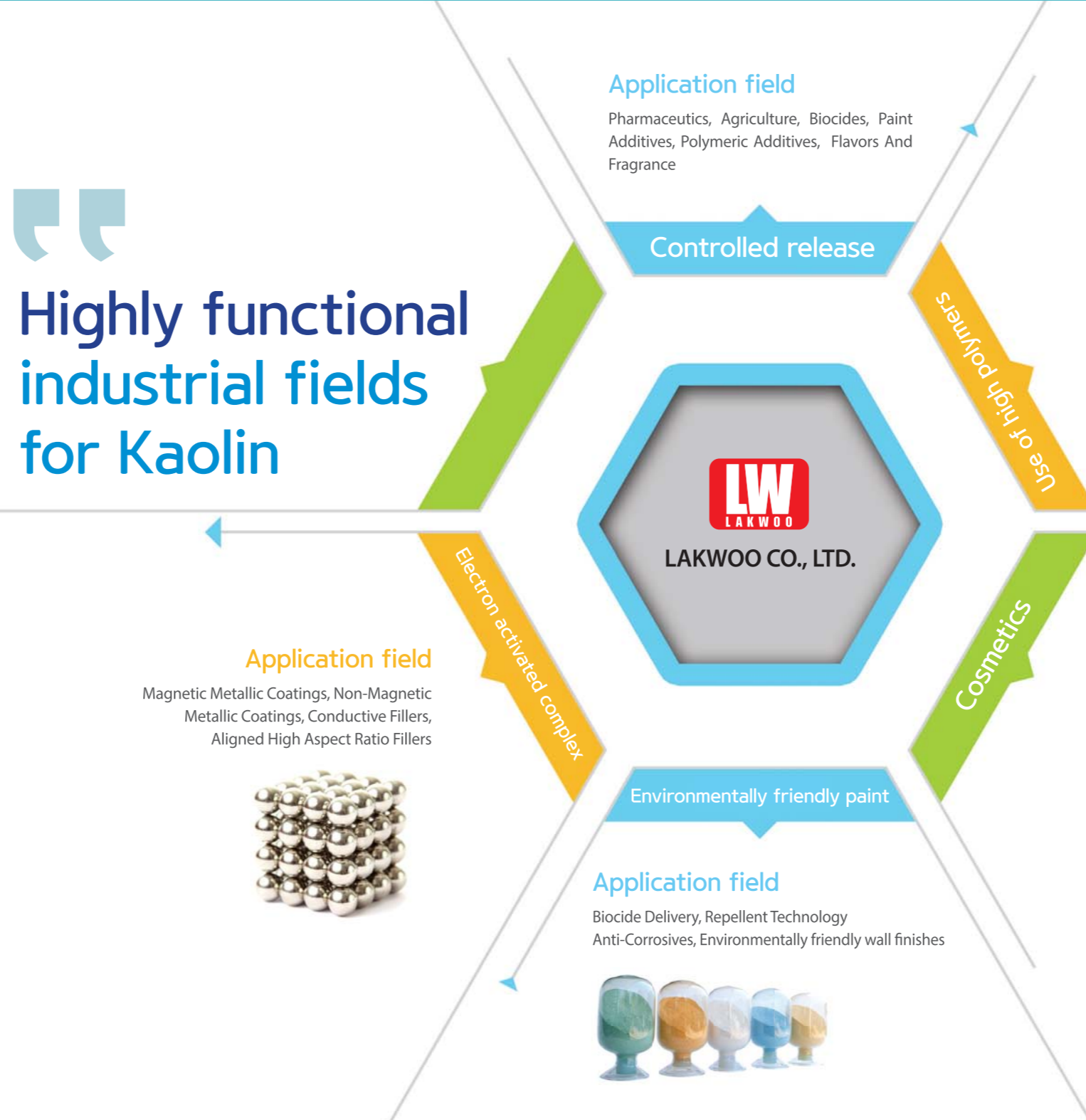
Kaolin mining in Sancheong(2015)
Area 4,297,250m²



Strengths of Halloysite Nanotube

- Easy disposal - Exfoliation is not necessary, Standardized processing equipment is in use.
 - Improvement of dispersion
 - Effective combination with high polymers
 - Use in many kinds of high polymers
- **Application**
- Plastic reinforcing agent(strength, ductility, thermal resistance)
 - Controlled release: Antimicrobial, air freshener, cosmetics, medicines

Highly functional industrial fields for Kaolin



Application field

Pharmaceutics, Agriculture, Biocides, Paint Additives, Polymeric Additives, Flavors And Fragrance

Controlled release



Application field

Dyes, Self-Healing Agents, Fire Retardant Fillers, Anti-Oxidants, Active Ingredients, High Performance Fillers

Application field

Containing Cosmeceuticals, Colorants Anti-Aging Additives, Optical Brighteners Insect/Mosquito Repellents



Environmentally friendly paint

Application field

Biocide Delivery, Repellent Technology Anti-Corrosives, Environmentally friendly wall finishes



Application field

Magnetic Metallic Coatings, Non-Magnetic Metallic Coatings, Conductive Fillers, Aligned High Aspect Ratio Fillers



Opportunity of utilizing HNT in the future market

NANO TECHNOLOGY



Application 1 HNT Nanocomposites

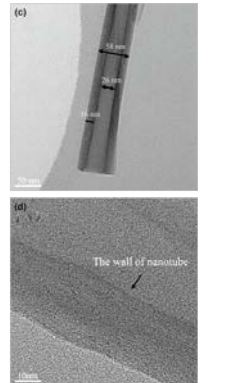
- Suitability with high polymers**
Respond strongly to highly polar biopolymers(polysaccharides, polyelectrolytes, proteins, DNA, and polyacrylates) and medium polar biopolymer(polyvinylchloride).
- Sustained release**
Nanocontainer(selfhealing high polymers, drug delivery, regenerative medicine, antimicrobial) is higher than existing nanoparticle(e.g. Porous Silica, Alumina, Titania, Amphiphile Vesicles And Liposomes) in terms of doping efficiency, chemical and mechanical stability.
- Easy disposal**
Small Surface Hydroxyl Groups → Easily Disposed
- Biocompatibility**
Biocompatibility → Release physiological activators constantly (10 hours to several months), Therapeutic agent (as it is not biodegradable, it is not available for use of the intravenous injection).



Conventional Filler	Nanoclay	HNTs
Features <ul style="list-style-type: none"> • High strength • Brittle • High weight 	Features <ul style="list-style-type: none"> • High strength • Not brittle • Lower High weight 	Features <ul style="list-style-type: none"> • High strength • Not brittle • Lower weight
Process <ul style="list-style-type: none"> • 40% to 50% loadings 	Process <ul style="list-style-type: none"> • 1% to 10% loadings • High viscosities at higher loadings • Limited compatibility 	Process <ul style="list-style-type: none"> • 1% to 40% loadings • Better packing and lower viscosities • Broad compatibility

Application 2 Nanocontainer

- Nano structure in a tube shape
- OD : ~200 nm / • ID : ~100 nm / • Wall of tube : Consist of dozens of layers
- Olume ratio for internal space : 10 ~ 30%
- ◆ Vary large specific surface area → Improvement of adsorption features
- ◆ Doping of differentiating agents in the Lumen → Improvement of thermal resistance
- ◆ Nanocontainer for storing activators → Improvement of corrosion resistance
- ◆ Control of releasing drugs → Use of drug delivery system



Application 3 Lumen

- Template** : Catalysts of metallic nanorods or nanoparticles
- Selective-etching** : Doping volume is improved (10% → 30%)
- Transplantation of selective hydrocarbon** : Absorbent
- Cheap Mesoporous Material** : Oil adsorption

