

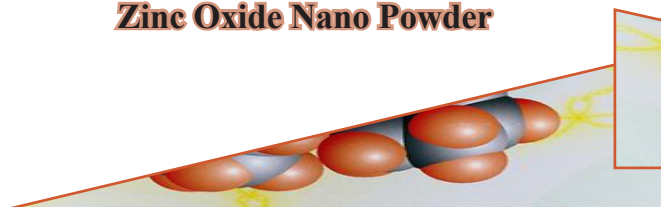
Technology Cooperation Office of the Presidency

A world map is shown in a light blue color, centered on the Atlantic Ocean. The word "IRAN" is written across the map in large, bold, stylized letters. The letter 'I' is green, 'R' is white, 'A' is orange, and 'N' is red. The map has a grid of latitude and longitude lines.

IRAN

Technological Potential

Zinc Oxide Nano Powder



By introducing the Bulletins of “Iran Technological Potential” provided by Technology Cooperation Office of the Presidency (TCO), we intend to encourage international cooperation aiming at sharing technological resources with others. We would put forward more publications of such bulletins in different arenas of science and technology in near future.

As a matter of fact, science and technology has a global nature rather than local or even national, so geographic boundaries has been crossed and as a result, exchanging ideas and maintaining joint research activities has become crucial to many scientists and researchers all over the world. In addition, developments of electronic communication tools as well as IT advances facilitate this process as never before. The main objective of these bulletins is to improve the international community’s knowledge about recent advances of Iran capacities and capabilities in Science and Technology and to facilitate technological collaborations with other countries.

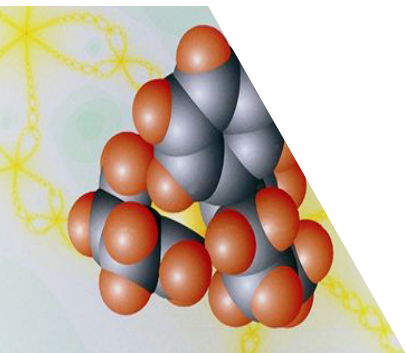
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Institute Of Catalyst Innovations

Preparing technological knowledge by do researches activities in addition of expensive and time-consuming, may have not favorable result; but using scientific capability of foreign expert is a suitable method to prepare technological knowledge in order to short of time, less expensive and necessity of result.

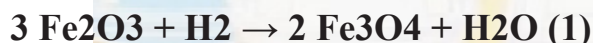
For this” Institute of Catalyst Innovations” believes that can use the scientific potential of expert in the country to develop existence technological knowledge that cause to increase capability and develop of lateral research activity & confidence of used capability for development too.

In this field, this institute in addition to prepare necessary bed to profit of scientific and research centers from scientific capability of foreign experts , has been a field to transport technical knowledge of **ZnO catalyst** as the first manufactured catalyst & edit technical science & produce **Nano powder ZnO**.

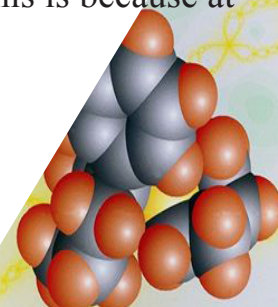
Then, the firm with several years’ record of cooperation to scientific centers out of country declare its preparation in order to invent the experts to removal technological – scientific requirements, planning and manufacturing research and scientific pilots with technological knowledge.

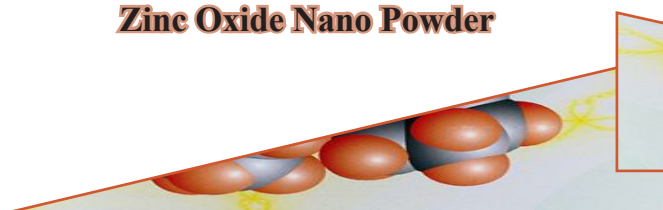
Background to Zinc Oxide

For many years hydrogen sulphide was removed by absorption in beds of iron oxide. This was loaded in the form of Fe₃O₄ and then converted in the presence of hydrogen at temperatures above 175°C into Fe₃O₄ as in reaction (1). Absorption of hydrogen sulphide was carried out at 350-400°C according to reaction (2).

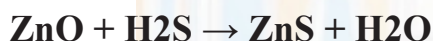


Iron Oxide is a low-cost material and has a high absorption capacity, but it is not a suitable absorbent to use for desulphurizing the feed to a steam reformer. This is because at





equilibrium the partial pressure of hydrogen sulphide is too high. In addition, hydrogen sulphid is relatively easily stripped by hydrogen and steam under conditions, which may arise during start-up and shutdown of the plant. The final absorption stage in modern synthesis gas plants is carried out using beds of zinc oxide. Zinc oxide reacts almost completely with hydrogen sulphide to form zinc sulphide as shown in equation (3).



Zinc Oxide Nano Particles:

Nano particle Zinc Oxide occurs as white or Yellowish-white hexagonal crystal powder. In normal pressure it sublimates and absorbs atmosphere carbon dioxide.

Among all commercial pigments, ZnO is the broadest spectrum absorber of ultra violet rays. The ZnO enthalpy of melting is 52/3 kj/mol.

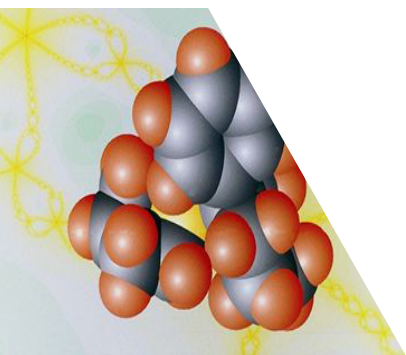
Because it absorb UV rays, zinc oxide can be used in ointments, creams and lotions to protect against sunburn and others damage to the skin caused as evaporative material, with 99/9% and 99/99% purity in sensors, as sputtering target in dielectrics, veristores and sensors.

It is soluble in acids and alkalis and used as an ingredient in manufacture of rubber goods and as filler in some rubber's mixtures.

Physical features:

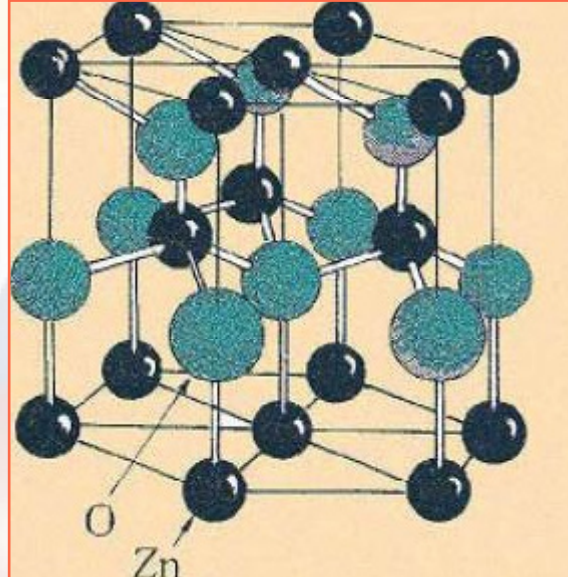
This white powder is able to absorb ultra violet rays in 366 waves – length. ZnO has a large band gap ($E_g = 3.37\text{eV}$) and thin layers of ZnO exhibits strong piezoelectric & piezoptic effects along “C” axis.

Molar mass	1/39 g/mol
Melting point	975° c
Heat conductivity	5/2w/mk
Thermal expansion coefficient	0/000004° c
Thermal conductivity	25/2w/mk
Crystal structure	hexagonal
Hardness	4 - 4/4 mohs
Refraction index	1/95 - 2/1



Zinc Oxide structure:

This material can describe as several alternative layers which consist of oxygen and zinc ions which are alternatively placed across “c” axis. ZnO is an amphoteric material which is soluble in organic and nonorganic acids and alkalis. Zinc oxide occurs in nature as the mineral zincite.

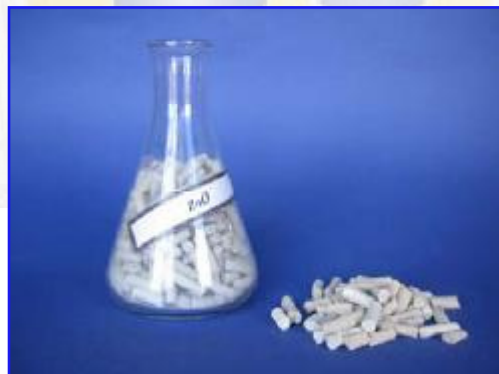


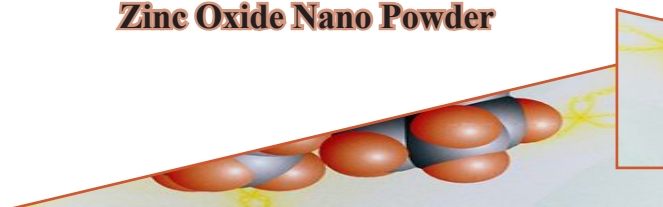
ZnO Applications in Industry:

Oil and Petrochemical Industries:

□ ZnO catalyst:

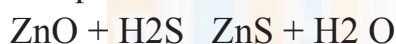
ZnO is a solid absorbent material used to separate slight amounts of hydrogen sulphide and sulphur organic compounds with low molecular weight. This catalyst usually comprise of approximately 90% ZnO in the form of spherical or cylindrical strings.





ZnO react with the existing Sulphur in hydrogen sulphide, carbonil sulphide, disulphide, light merkaptan and turn into zinc sulphide and higher temperature increases this activity.

Zinc Oxide reacts almost completely with hydrogen sulphide to zinc sulphide as shown in equation:



Zinc Oxide crystals are in compact hexagonal form.

Benefits of using ZnO absorbent in desulphurizing process:

- Desired equilibrium of H₂ S in less than 400° c
- Stability against reduction and oxidation
- No undesired side reaction

Key factors in determination of ZnO catalyst quality:

- The amount of sulphur absorption:

Whatever the ZnO catalyst absorb more sulphur, desulphurization of gas streams or hydro carbon feed would be better.

- Mechanical residence: high residence of ZnO catalyst caused to decrease the pressure changes and increase the catalyst durability.

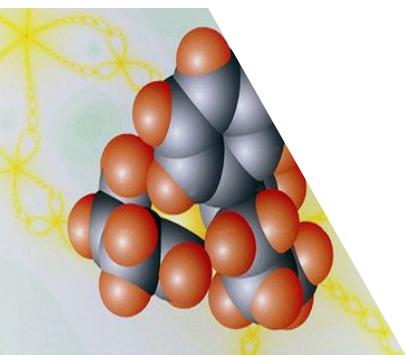
Therefore in according to mentioned key parameters of ZnO particles, such as absorbance rate and mechanical resistance, we can have ZnO catalyst in Nano scale. Decreasing in particle size of ZnO, results in surface and strength increasing, that is one of important advantages of nano- ZnO catalyst.

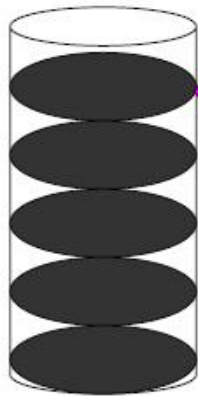
Electricity industry:

- Varistors:**

A varistor is an electronic component which is known as Voltage Dependent Resistor or VDR. Varistors are often used to protect circuits against excessive transient voltages by incorporating them into the circuit in such way that when triggered they will shunt the current created by the high voltage away from the sensitive components.

The preference of varistors which use nanosize zinc oxide is denser than those that use ZnO particle in micro size (0/5mm).





ZnO Micro Size
 250 gr
 5 Varistores
 $5 * 250 = 1250 \text{ gr}$
 $1.250 \text{ Kg} * 5 \text{ S} = 7.250 \text{ S}$
 Each Voltage : 5.5 K.V
 Total Voltage : 27.5 K.V



ZnO Nano Size
 180 gr
 3 Varistores
 $180 \text{ gr} * 3 = 540 \text{ gr}$
 $0.54 \text{ Kg} * 10 \text{ S} = 5.4 \text{ S}$
 Each Voltage : 11 K.V
 Total Voltage : 33 K.V

Health and beauty industry:

☐ Sunscreens

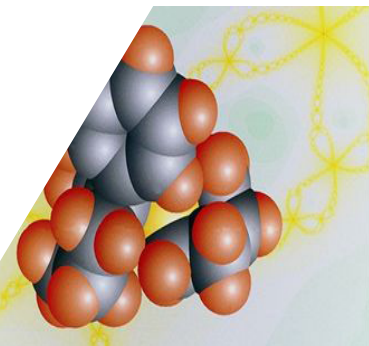
The use of sunscreen is an important way to reduce the risk of developing skin cancer and premature skin ageing.

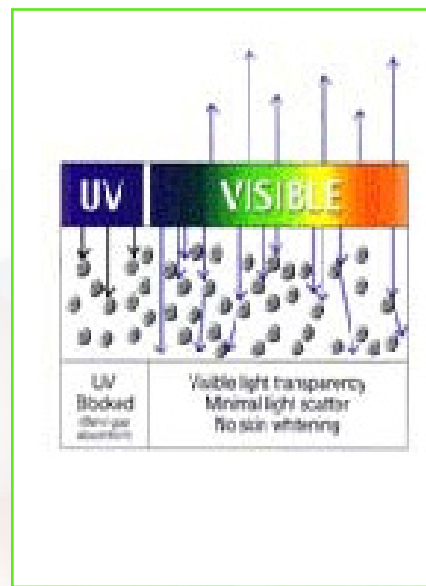
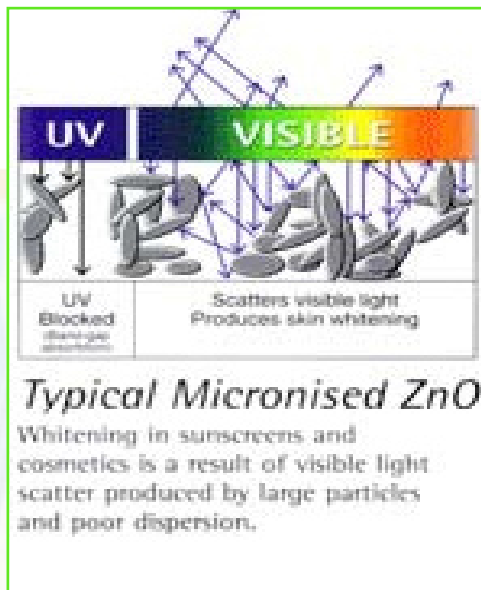
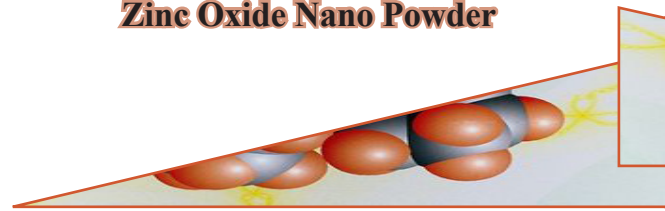
Zinc Oxide and titanium dioxide have been used as sunscreens for many years. They are particularly valuable because of their ability to filter UVA as well as UVB light, giving broader protection than other sun screening agents.

One disadvantage of zinc oxide and titanium dioxide is that they are visible, giving the skin a white color.

This effect can be reduced by decreasing the particle size of the material. When used in 'nanoparticle' form (less than 100 nanometers, or one millionth of a millimeter), they can't be seen on the skin but still retain the sun screening properties of the coarser material. There is no evidence that sunscreens containing these materials pose any risk to the people using them.

Zinc Oxide is non-toxic, and compatible with skin, making it a suitable additive for textiles and surfaces that come in contact with humans. Zinc Oxide's UV attenuation properties also make it effective additive to packaging plastics to prevent UV damage.





Rubber industry

In the various stages of rubber production, Zinc Oxide is used for various purposes, such as:

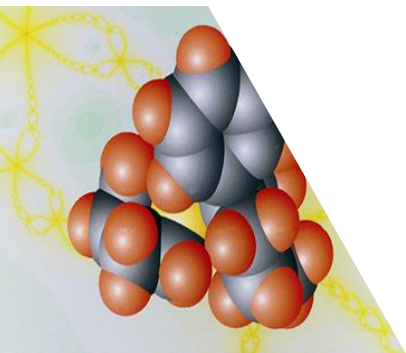
♣ **As an activator for sulfur vulcanization:**

- ♪ Increasing vulcanization velocity
- ♪ Enhancing quality of cross links

♣ **As a filler and removal of materials that have bad effects on reaction products**

♣ **Processing help before formulation**

- ♪ Decreasing contraction in molded products
- ♪ Increasing of molds durability



Beside these industrial and technological applications of zinc oxide, it can be used to improve physical properties of rubber in such ways:

- ♪ Decreasing heat production while working
- ♪ Improvement of erosion resistance
- ♪ Improvement of dynamic characteristics
- ♪ Improvement of aging properties

Zinc Oxide is used in activator/accelerator systems for various purposes. It committed with accelerator in reaction to produce active zinc derivates.

Studies showed that ZnO affect reaction velocity and vulcanization reaction products as an activator. It enhances reaction velocity and changes products distribution and this leads to changing reaction mechanism.

In conventional systems, in rubber processing formulation apply 5-8 phr (parts by weight per hundred parts of rubber') ZnO. In recent years a reduction in this quantity has occurred. According to conducted researches in rubber field, quantity of utilized ZnO in vulcanization reaction could be reduced to 2 phr, while product properties do not weaken in comparison with 5-8 phr.

Existence of nano- zinc oxide in primary composition of rubber leads to heat decreasing during working with rubber.

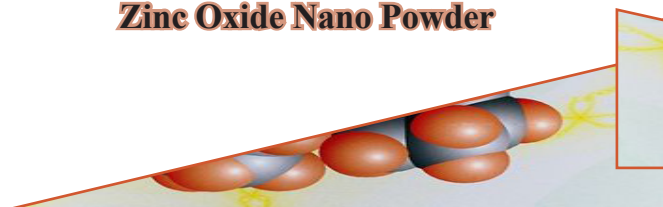
Conducted experiments showed that utilizing of nano- zinc oxide in rubber formulation increases erosion resistance, heat vulcanization resistance and resistance to dynamic loading.

One of the benefits of nano- ZnO refers to its heat distribution and transition properties. This characteristic is due to high heat conductivity of ZnO. Concentration of produced heat has undesirable effects on final product, that blocked by applied ZnO.

ZnO decreases molded rubber contraction, this leads to product homogeneity ,facilitate control of rubber sizes, and fixation of cleaning lines of molds, thus mold become more durable.

As mentioned above ZnO has a significant and effective role in rubber manufacturing processes, and improve final properties of end product, so ZnO usage is inevitable in rubber industry.

In according to ZnO in rubber vulcanization process, in ZnO reduction, we should increase ZnO activity while rubber properties remain desirable.



Parameter that determine activity rate of ZnO is specific surface. This parameter is affected by particle size and other different factors, but the role of particle size is more significant.

In common rubbers, red seal Zinc Oxide is used. Red seal zinc oxide particle size is 0.6 μm approximately with 6 m^2/g specific surface, while nano ZnO particles have a specific surface equal to 30-70 m^2/g , this causes higher activity in comparison to RS ZnO, and we can decrease ZnO usage to one tenth of normal condition.

So, this production has three important qualities: High mechanical strength, High longevity, Beauty and elegance.

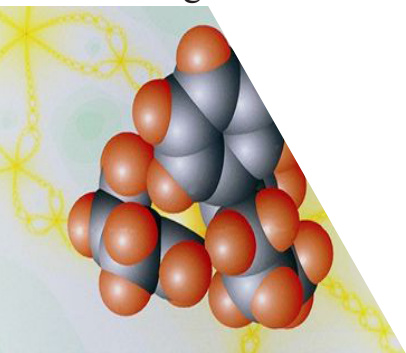
Ceramic and tile industry

Ceramic tiles and tiles with a high diversity in glaze resistance can be used in various sites such as factories and laboratories that encounter to different chemical materials.

Tile glazes are produced in various types such as dull, semi shiny, shiny, white, colored or flourished. A glaze is generally considered to be a thin, glassy coating fused to the surface of a clay form in the firing process. Glaze is a glass wear layer or hard finish, sometimes with added color, applied to the surface of ceramic tiles. Every glaze is made of the following 3 materials:

1. Silica – Creates glass. Examples: quartz, flint, pure silica
2. Alumina – Stiffens the glaze so it doesn't slide off the clay. Examples: clay (kaolin, all clay, or fire clay), alumina hydrate
3. Flux – Causes the glaze to melt at a low enough temperature to be used in ceramics. Examples: feldspar, whiting

In order to melt silica at lower temperatures other materials must be mixed in with the silica. The melting point of silica may be lowered by introducing 'fluxes' into the mix. If other materials containing fluxes are mixed with silica, in the correct proportions and within certain limits, the melting point of the mixture will be lower than that of its constituent parts. If materials which contain a third category of oxides commonly called glass stiffeners or stabilizers are added to the glaze recipe the melting range of the mixture is extended such that it gradually softens passing through a treacle-like or highly viscous stage before eventually becoming water-like and too fluid to hold its position. Viscosity is



the term used to describe the fluidity of the molten glaze. The more viscous the melt the more treacle-like it is with a tendency to move very slowly on sloping or vertical clay surfaces. A normal glaze mix can be represented theoretically as:

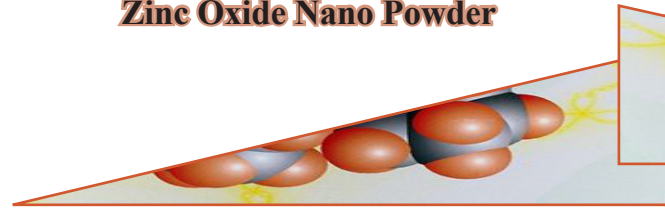
Flux (es) + Stabilizer(s) + Glass Former(s)

Each glaze oxide can be classified in terms of the role it plays in the melt i.e. flux, stiffener, or glass former.

Some oxides commonly found in glazes are:

Flux		
K ₂ O	potassium	oxide
Na ₂ O	sodium	oxide
Li ₂ O	lithium	oxide
CaO	calcium	oxide
MgO	magnesium	oxide
BaO	barium	oxide
ZnO	zinc	oxide
PbO	lead	oxide
SrO	strontium	oxide

Stabilizer	
Al₂O₃	aluminum oxide



Glass Former	
SiO₂	Silicon oxide

The glazing process enables the best possible results in color, weight, viscosity and density of the ceramic tile flooring. A glaze is a smooth, glassy coating applied to ceramic object in order to add color and decoration to the surface or to vary its texture. The glaze forms a hard, nonporous surface that is easily cleaned.

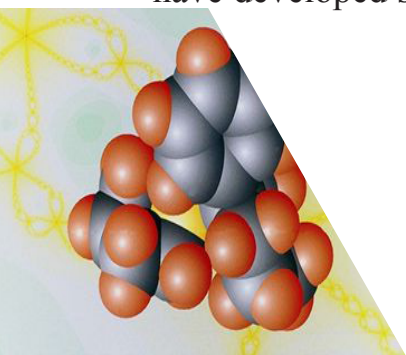
These are some important properties of glazed tiles:

- Water absorption
- Erosion resistance
- Impact resistance
- Breaking strength
- Stain resistance
- Visual quality

1. Stain Resistance: The ability of ceramic tile to withstand permanent staining by a variety of substances is also important. The stain resistance of ceramic tile varies depending on its capacity to resist moisture. Glazed ceramic tiles and even some unglazed tiles resist all types of stains and can be cleaned easily with some guidance.

2. Slip/Skid Resistance: One practical consideration is the level of slip resistance your ceramic tile floor requires. Slip resistance involves two factors - your ceramic tile floor's likely exposure to spills and your environmental requirements. The more your floor will be exposed to spills, the higher your need is for a slip-resistant floor tile. Also, homes with younger children, disabled or elderly people need to have floor tiles with slip resistant characteristics.

Ceramic tile manufacturers with the use of various glazes, glaze additives, and patterns have developed slip resistant tiles. Also, the ceramic tile size, grout joint spacing, and



slope of the floor will affect the slip resistance. In addition, unglazed ceramic tiles have greater slip resistance than glazed tiles and are recommended for areas subjected to frequent water spills or heavy foot traffic.

3. **Dirt Resistance:** Ceramic tiles do not retain dust or residues as easily as many other flooring surfaces. They can be easily cleaned with common household materials. Additionally, they do not need polishing or buffing to maintain their finish. A day-to-day cleaning procedure retains the look of the finish and shine on ceramic tile flooring.

4. **Color Permanence:** Because color is fired into a tile's clay body (in the case of unglazed tiles) or onto a tile's glazed surface (for glazed tiles), fading cannot occur. The colors in ceramic tiles do not fade even if exposed to direct sunlight (and its color-leaching UV rays). They remain permanently color fast.

5. **Hygiene:** The surface of ceramic tiles does not easily retain antigens or allergens, nor do they absorb fumes, odors or smoke. This feature enables good hygiene and makes ceramic a suitable flooring material for any environment where hygiene is essential.

6. frost resistance

7. heat shock resistance

8. acid and alkaline resistance

9. resistance to humidity and heat

Utilization of ZnO in ceramic tile industry results in:

- Improvement of surface quality
- enhancement and improvement of viscosity factor
- Decreasing of heat expansion factor
- Improvement of glaze whitening
- Improvement of glaze to ceramic tile body attachment

General Information:

Institute of Catalyst Innovations is capable to produce nano Zinc Oxide in industrial scale to 20000 kilograms in a year.

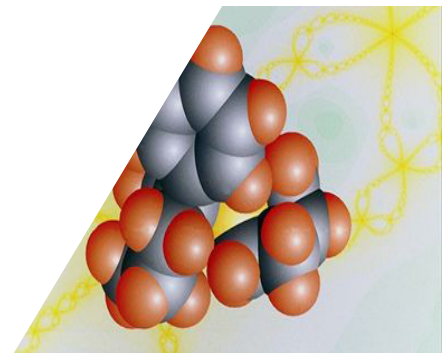
Cooperative companies categorize into two different types:

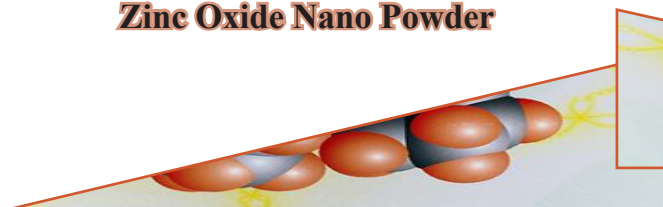
a- Nano ZnO consumer companies

These companies utilize ZnO, and categorize in two:

1- request quantity is less than Institute of Catalyst Innovations production capacity

In reciprocal financial contracts, Institute of Catalyst Innovations can afford consumer





needs.

2 Request quantity is more than Institute of Catalyst Innovations production capacity this company is capable to exchange technical information.

b- Investor Companies that can afford buying technical information in nano ZnO production, announce their capability for technical information exchange.

Nano ZnO has special utilizations in different parts of industrial uses. Nano ZnO consumers are commonly large companies that formulate nano ZnO in their R&D sections. Utilization of Nano ZnO is less than its common form; this gap will be filled in corporation with R&D section.

Institute of Catalyst Innovations has registered nano ZnO innovation in Iran.

World marketing of this product is active in American and Asian countries (especially Thailand);

“Nano phase” and “nano Amorph” are two American companies in this field.

One of the strongest Chinese companies is Yaocao that have wide advertising activities.

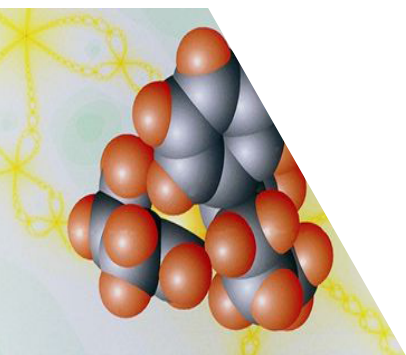
Benefits of this Production:

A great advantage of this nano- product in Iran is its low prize of production and it is cost benefit in according to import tariff. This Institute is capable to change nano ZnO properties in according to consumer requests and needs priorities and produces various grades of nano ZnO as well.

Opportunities for Cooperation:

One of the most extensive fields in Nano technology that is the newest area of science and technology in today world that can create major and stable evolutions and improvements in many sections of market is Nano particles area that encourages many researchers to produce and use them and have created many applications in different fields.

Now, Nano particles are manufactured from the extensive material spectra that Cerami-cal Nano Particles are one of their most common cases. **Zinc oxide**, Titanium oxide, Aluminum oxide & Ferric oxide, as important examples, categorized in this group.



Hence , this Institute with cooperation of ”**Iranian Nanotechnology initiative** ” , while preparing the ability to produce **Nano ZnO** in industrial scale , announced its readiness to **supply Nano** materials , the laboratory equipments and offering necessary scientific services of this centers, too.

We wish to promote and encourage the growth and development of the science of catalysis and those scientific disciplines ancillary thereto; to provide educational services to members and other interested individuals; to organize and participate in professional meetings of scientists; to report, discuss and exchange information and viewpoints in the field of catalysis; to provide liaison with foreign catalysis societies and clubs, with the international congress on catalysis and with other scientific organization and individuals.

We do welcome any interested company all around the world to establish and strengthen cooperation in joint R&D, marketing and manufacturing.

