About Titanium Dioxide

www.tdma.info
www.tio2industry.org
Titanium dioxide (TiO₂) is a white solid inorganic substance that is thermally stable, non-flammable, poorly soluble, and not classified as hazardous according to the United Nations’ (UN) Globally Harmonized System of Classification and Labeling of Chemicals (GHS).

TiO₂, the oxide of the metal titanium, occurs naturally in several kinds of rock and mineral sands. Titanium is the ninth most common element in the earth’s crust. TiO₂ is typically thought of as being chemically inert.

What are the differences between TiO₂ as a PIGMENT and as a NANOMATERIAL (ULTRAFINE)?

Pigment grade TiO₂ is manufactured to optimise the scattering of visible light and consequently white opacity. This requires a primary particle size of approximately half the wavelength of the light to be scattered, that is half of 400 - 700nm for visible light.

TiO₂ nanomaterials (ultrafine) are transparent and more effective as UV absorbers or photocatalysts. The transparency and UV absorbance allow for effective use as a protective ingredient for sunscreens.

Titanium dioxide has been used for many years (ca. 90 years) in a vast range of industrial and consumer goods including paints, coatings, adhesives, paper and paperboard, plastics and rubber, printing inks, coated fabrics and textiles, catalyst systems, ceramics, floor coverings, roofing materials, cosmetics and pharmaceuticals, water treatment agents, food colorants and in automotive products, etc …
Pigment grade TiO₂ is manufactured in order to maximise the number of primary particles in this size range (approx. 200 – 350 nm). However as in all production processes of particulate materials, there will be a distribution of primary particle sizes around the average value and it is likely that a small fraction of the primary particles are < 100 nm, and therefore covered by the nanoparticle ISO definition (ISO/TC 229 Nomenclature system for nanoparticles). In practice, all these particles tend to agglomerate into the micron (µm) size range.

Due to the smaller size of primary particles and higher surface area, TiO₂ as a nanomaterial allows the manufacture of various catalysts of enhanced activity.

TiO₂ as a nanomaterial is engineered to have primary particles less than 100 nm in order to optimize such properties.

What are the benefits derived from TITANIUM DIOXIDE?

- As a pigment, TiO₂ has excellent light-scattering properties and is used in a variety of applications that require white opacity and brightness.
- It absorbs UV light. When TiO₂ pigment is incorporated in a polymer, it minimizes degradation of the system (embrittlement, fading and cracking). Surface treating of the TiO₂ can further improve this property.
- When used in paint or coating system, this effect ensures the longevity of the paint and the continued protection of the substrate.
- The use of light colored paints for interior applications provides an impression of openness and “space”. In addition, the high “luminosity” that comes from light colored paints reduces the energy needed to light the interior of buildings when compared to darker colors.
- In exterior applications the coolness conferred by TiO₂ colored surfaces leads to considerable energy savings in warm and tropical area by light reflectance thus reducing the need for air-conditioning.
- TiO₂ as a nanomaterial (ultrafine) appears transparent whilst still providing UV light absorption.
- Surface treatments allow dispersion in different media and efficient absorption of UV energy (e.g. in applications like sunscreens and light stabilization for wood coatings).
- When untreated, it can be used to decompose environmental pollutants by photocatalysis.
- TiO₂ as a nanomaterial (ultrafine) is used for example as a DeNOx catalyst support in exhaust gas systems in cars, trucks and power plants, thus minimizing their environmental impact.
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Are there any health concerns with \textbf{TITANIUM DIOXIDE}\textsuperscript{2}\textsuperscript{1}\textsuperscript{3}\textsuperscript{4}\textsuperscript{5}\textsuperscript{6}\textsuperscript{7}\textsuperscript{8}\textsuperscript{9}\textsuperscript{10}\textsuperscript{11}\textsuperscript{12}\textsuperscript{13}

- by oral intake

Pigmentary TiO\textsubscript{2} which meets appropriate purity standards is approved as a colorant for use in foods (E171 - e.g. candies, cookies, sweets, coffee whiteners, toothpaste, etc…) and pharmaceuticals (several Pharmacopoeias).

- by skin contact

TiO\textsubscript{2} in pigmentary and ultrafine forms is used in cosmetics applications (e.g. lipsticks, make-up products and sunscreens). It has been conclusively demonstrated that TiO\textsubscript{2} is safe for use in sunscreen products to protect skin from harmful effects of solar UV radiation. Comprehensive in vivo and in vitro dermal penetration studies have been performed.

Studies show TiO\textsubscript{2} particles (pigmentary or ultrafine) do not penetrate either intact or damaged skin \textsuperscript{6}\textsuperscript{8}. Even if the skin is sunburned the penetration of TiO\textsubscript{2} nanoparticles from representative sunscreen formulations is not enhanced \textsuperscript{7}.

The former European Scientific Committee on Cosmetic Products and Non-Food Products (SCCNFP) reviewed in 2000 data on TiO\textsubscript{2}. Based on the results, SCCNFP concluded that TiO\textsubscript{2} is "safe for use in cosmetic products at a maximum concentration of 25% in order to protect the skin from certain harmful effects of UV radiation. This opinion concerns crystalline (anatase and/or rutile) titanium dioxide, whether or not subjected to various treatments (coating, doping, etc.) irrespective of particle size, provided only that such treatments do not compromise the safety of the product" \textsuperscript{11}.

Based on existing safety information, it can be concluded that the use of titanium dioxide nanomaterial (ultrafine) as an ingredient in cosmetic sunscreen products at a concentration up to 25% poses no risks to human health\textsuperscript{12}\textsuperscript{13}.

New information obtained from research models should be put into a proper perspective by taking into account the relevance of the model used and the dose-levels or concentration tested that might not be representation of typical consumer exposure situation.
Life Cycle thinking

The value $\text{TiO}_2$ provides in product applications can often be equated with tangible environmental benefits. For example, $\text{TiO}_2$ is a potent opacifier, enabling thinner films and thus improved resource efficiency and avoided waste. In cradle-to-grave footprint analyses of products that contain $\text{TiO}_2$, both the upstream footprint of $\text{TiO}_2$ manufacture and the downstream environmental performance benefits facilitated by $\text{TiO}_2$ should be considered.

To support the development of accurate and consistent product carbon footprints, TDMA has developed a standard methodology to calculate the cradle-to-gate carbon footprint of $\text{TiO}_2$ and has published industry average $\text{TiO}_2$ carbon footprint data and the underlying method this year.

REGULATORY FRAMEWORK

Depending on the use of the titanium dioxide products, different legislative definitions for the purity of the raw material must be fulfilled.

A list of some key applications with relevant laws and provisions (depending on the country of use) can be found below:

Use as a colorant

- **Automotive**: Council directive 2000/53/EC (end-of life vehicles)
- **Contact lenses**: FDA 21 CFR § 73.3126
- **Electronic equipment**: Council directives 2011/65/EU and 2002/96/EC (Restriction of the use of Certain Hazardous substances in electrical and electronic equipment (RoHS))
- **Food**: E171 in the European directive 2008/128/EC, replacing 95/45/EC • FDA 21 CFR § 73.575 • Food Chemical Codex (FCC) • CODEX Alimentarius • FAO JECFA Monographs
- **Packaging**: Council Directive 94/62/EC • CONEG legislation (USA)
- **Paints**: Volatile Organic Compounds (VOC) according to the definition of the EU directive 2004/42/EC “decopaint directive”
- **Pharmaceuticals**: United States Pharmacopoeia (USP) • European Pharmacopoeia (EP) • Japanese Pharmacopoeia (JP) • Food and Drugs Administration (FDA) 21 CFR § 73.1575
- **Toys**: DIN EN 71-3 (Security of toys) • ASTM F963 – 11 Standard Consumer Safety specification for Toy Safety

Use without coloring effect

- **Cosmetics**: Council Directive 76/768/EEC • FDA 21 CFR § 352.10 (Sunscreen active ingredients)

Additional conformity with Good Manufacturing Practice (GMP), different ISO or other standards can be provided. Even the manufacture of Kosher or Halal titanium dioxide products can be achieved.

CONCLUSION

Titanium dioxide is a global product with many important applications that has been proven as safe in its intended uses over many decades.
11. SCCNFP (2000). Opinion of the scientific committee on cosmetic products and non-food products intended for consumer concerning titanium dioxide, Colipa No. S75, adapted by the SCCNFP during the 14th plenary meeting of 24 October 2000.

References

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