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Factsheet:

Titanium dioxide

Forms of titanium dioxide

Titanium dioxide (TiO_2) 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).

TiO_2 occurs naturally in several kinds of rock and mineral sands. Titanium is the ninth most common element in the earth's crust. TiO_2 is typically thought of as being chemically inert.

TiO_2 is manufactured in different forms with different properties:

- Pigment grade TiO_2 has primary particles mainly in the size range of 200–350 nm and is not considered a nanomaterial. It has excellent light-scattering properties and is used in applications that require white opacity and brightness. It absorbs UV light. When TiO_2 is incorporated in a polymer, it minimises degradation of the system (embrittlement, fading and cracking).
- TiO_2 as a nanomaterial (ultrafine) is engineered to have primary particles less than 100 nm. It appears transparent whilst still providing UV light absorption. Production levels of ultrafine TiO_2 comprise only one hundredth of the total TiO_2 production.

The production processes for pigmentary TiO_2 as well as TiO_2 as a nanomaterial have not changed significantly over the last three decades.

The primary particles in TiO_2 are strongly bound or fused together by chemical bonds to form aggregates. They further agglomerate to form particles in the micron size range (µm).

Applications

Pigment grade titanium dioxide has been used for decades 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, food colorants, etc. Most of the surfaces and items that are white in colour contain pigmentary TiO_2.

Certain grades of pigmentary TiO_2 which meet appropriate purity standards are approved as a colorant for use in foods (E171, e.g. candies, cookies, sweets, coffee whitener, toothpaste, etc.) and pharmaceuticals (several Pharmacopoeias).

Select grades of TiO_2 in both pigmentary and ultrafine forms are used in cosmetics applications, e.g. in lipsticks, make-up products. Pigmentary TiO_2 is used to provide opacity and brightness e.g. in sunscreens. Ultrafine TiO_2 is used to provide transparency and UV absorbance as the protective ingredient in sunscreens. It contributes to high sun protection factors (SPF) and has been used for many years to provide protection from the harmful ultraviolet radiation from the sun.

Ultrafine TiO_2 has been used since the 1950s to reduce the environmental emissions of nitrogen oxides. It is used in "Selective Catalytic Reduction (SCR)" systems that convert nitrogen oxides into harmless nitrogen and water. Commercial SCR systems are typically installed in large industrial boilers, combustion plants and stationary or automotive diesel engines. Another application uses the photocatalytic properties of ultrafine TiO_2 to provide self-cleaning surfaces e.g. on glass and cement.

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Use scenarios

- Occupational exposure: Workers at titanium dioxide manufacturing plants and downstream users can be exposed to TiO_2 dust. Protection measures, including engineering controls and personal protective equipment, are applied for exposure control and worker risk mitigation in accordance with existing regulations.
- Consumer exposure: Consumer exposure to TiO_2 dust by inhalation will be very low because TiO_2 is typically incorporated into a product matrix where it is tightly bound, such as in paints or plastics. Oral intake of select grades of pigmentary TiO_2 is approved and occurs in the case of food and pharmaceuticals. Skin contact in cosmetics applications is also approved and is a longstanding practice.
- Environmental fate: In many product applications, TiO_2 offers downstream environmental benefits (e.g. photocatalysts to decompose pollutants). In cradle-to-grave footprint analyses, both the upstream footprint of manufacture of TiO_2 and the downstream environmental performance benefits should be considered. Since TiO_2 is inert, non-hazardous and occurs naturally in rocks and minerals, eventual release back to the environment should not be a major concern.

Safety assessment

Since the introduction of TiO_2 as a commercial product in 1923, there have been no identified health concerns associated with its exposure among consumers or the general population. The product has been proven as safe in its intended uses over many decades.

Key findings from scientific studies:

- Four large epidemiology studies involving more than 20,000 workers in the titanium dioxide manufacturing industry in North America and Europe indicate no association with an increased risk of cancer or with any other adverse lung effects.[1,2,3,4,5,6] These studies did not specifically differentiate between the ultrafine and pigmentary TiO_2.
- In 2006, the International Agency for Research on Cancer (IARC) evaluated TiO_2 as "possibly carcinogenic to humans" (Group 2B) based primarily on studies in rats. However, it is generally recognized that the rat is uniquely sensitive to the effects of "lung overload" which is not observed in other species, including humans.
- It has been conclusively demonstrated that TiO_2, at a concentration of up to 25%, is safe for use in sunscreen products to protect skin from harmful effects of solar UV radiation. Studies show that TiO_2 particles (pigmentary or ultrafine) do not penetrate either intact or damaged skin.[7,8,9,10]

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