Course Name: Building Materials as a Cornerstone to Sustainability

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Lecture 04

Titanium di oxide products

Hello everyone. In our last class we saw a little bit about titanium dioxide as a coating on glass with an example too. In today's class we will look at titanium dioxide products in slightly greater detail. It's a smart material. And we will look at its introduction, its applications, its photocatalysts of titanium dioxide, the advantages and the limitations, and we will also look at some building examples where this product has been used. So, titanium dioxide is also known as titanium oxide or titania.

It is the inorganic compound with the chemical formula TIO. When used as a pigment, it is called titanium white, pigment white 6, or PW6. It is a white solid that is insoluble in water, although mineral forms can appear black. As a pigment, it has a wide range of applications, including paint, sunscreen, and food coloring.

When used as a food colouring, it has E number E171. World production in 2014 exceeded 9 million tonnes. It has been estimated that titanium dioxide is used in two-thirds of all pigments, and pigment based on the oxide has been valued very highly in the market. One aspect of self-cleaning glass. If we look at the applications of titanium oxide, then its self-cleaning characteristics dominate all the others.

So, one aspect of self-cleaning glass is coated with unique hydrophilic and photocatalytic material that is triggered by daylight ultraviolet radiation. Anything that falls on the surface of the windows is broken down by the photocatalytic activity which keeps objects from adhering or sticking to the glass. Now this glass that cleans itself comes in two varieties. One is hydrophobic glass. and another is hydrophilic.

Water droplets rolls down the panes of both types of windows to keep them clean on their own. Hydrophilic coatings, on the other hand, are based on titania and include an extra characteristic that enables them to chemically decompose absorbed dirt when exposed to sunshine. Let us look at the various glazing type specifics. You would have heard of the word lotus effect. That refers to hydrophilic self-cleansing glasses

exceptional water repellency.

This is akin to that of lotus leaves. At this point, the titanium dioxide coating on the glass combines with UV light to produce electrons that disintegrate organic debris into tiny particles that may be washed away by rainwater. In stage 1, as you can see here, the coating reacts with natural daylight. So you have this coating here. And as the sun rays fall, the coating reacts with natural daylight to break down and loosen the organic dirt.

In stage two, which is here, there is a coating again. When it rains, instead of forming droplets, the water spreads evenly over the surface of the glass forming a thin film and this film combines with the dirt. It becomes heavy and it gets washed away because of sliding over the surface. Either way, both of these do not leave any streaks, and they wash away the dirt. Now, what are the advantages of glass that cleans itself? The first advantage is it is long lasting.

It is a long-lasting, self-cleaning coating that stays on windows. Longer glass retention results in cleaner glass. There are economic savings from lower window cleaning expenses in very high-rise skyscrapers. They employ glass cleaners who hang on the facade and clean the glass. But when you have a glass that self-lenses itself, it can result in a lot of economic savings.

Because of the sheeting effect, there is a clear view outside even when it is pouring. It is kinder to the environment by using less detergent, chemicals, water. So it becomes environment friendly. Because less dirt and grime sticks to the glass, cleaning is simple and quick. There is hardly any human intervention at that point.

This is ideal for the roof of a conservatory and other challenging-to-reach and unclean spots. So, architecture where you have weird or extremely fanciful and dramatic building forms. This is a good way to keep the surface clean because sometimes it may be very difficult for humans to enter that place, enter and clean it. Let us now look at the applications. First is paints and coatings.

Titanium dioxide nanoparticles can be incorporated into paints and coatings for building exteriors. This can result in surfaces that are resistant to dirt, mould and pollutants. Additionally, these coatings may contribute to air purification when exposed to sunlight. The second application is in concrete and cement products. Titanium dioxide can be added to concrete and cement formulations.

This may lead to self-cleaning properties and the ability to reduce air pollutants when these materials are exposed to ultraviolet light. The third is roofing materials. Titanium

dioxide coating roofing materials can harness the self-cleaning effect, helping to maintain the appearance of the roof over longer periods of time. Third are tiles and flooring. Tiles and flooring materials may incorporate titanium dioxide for self-cleaning benefits.

This is particularly useful in areas where cleanliness and hygiene is important. The next application is facade panels. Titanium dioxide can be applied to the surface of facade panels to create a self-cleaning effect. This is advantageous for maintaining the aesthetics of building exteriors. They can be used in air purification systems.

Building materials with titanium dioxide can contribute to air purification. When exposed to light, titanium dioxide generates reactive oxygen species that can break down and neutralize pollutants in the air. These can also act as photolytic concrete. Some manufacturers produce photocatalytic concrete that incorporates titanium dioxide. This type of concrete can help reduce air pollution and resist the growth of mold and bacteria.

So, in total, the applications of titanium dioxide are in pigments, where they can be used in paint, paper, plastics, ceramics, glass, leather, printing inks, and bitumen flooring. They can be used in the medical field. So this is an architecture. or paint field. In the medical field, they can be used in bone implants and in biosensors.

Titanium dioxide can be used in sensors such as gas sensors and lambda sensors in automobiles. They can be used for wear resistance. So, coatings on propeller shaft bearing sleeve of boats and on pump seal. They can be used for corrosion resistance as coatings on steel petroleum tanker trucks. They can be used for UV protection from inner sunblock or textile fibers.

As architect and designers, this area is what we will be interested in though titanium dioxide has multiple other applications. Let us look at the photocatalyst of titanium dioxide. Photocatalysis is a chemical reaction that is initiated by light in the presence of a photocatalyst. Titanium dioxide is a well-known photocatalyst with a wide range of applications, particularly in environmental and industrial processes. The photocatalytic activity of titanium dioxide is primarily attributed to its ability to absorb light energy, creating electron-hole pairs that can participate in various chemical reactions.

Here is an overview of photocatalysis of titanium dioxide. where the titanium dioxide absorbs UV rays on its surface. The strong oxidizing agent OH is produced and this surrounds and destroys the germ cells. They disintegrate harmful substance and allergens and in this process release carbon dioxide and water.

Let us look at the advantages. First is the photocatalytic properties. So, titanium dioxide

exhibits photocatalytic activity especially in the presence of ultraviolet light. This becomes important in a tropical country like India, where light is available in plenty. This property allows it to break down organic pollutants and can be harnessed for self-cleaning and air purifying applications. The second advantage is the whitening and opacity.

Titanium dioxide is a widely used white pigment in many products, including paints, coatings, plastics, and papers. It provides excellent whitening and opacity, enhancing the visual appeal of these materials. Third advantage is the UV absorption capacity. Titanium dioxide has the ability to absorb ultraviolet radiation, making it useful in sunscreens, coatings, and other products that require protection against UV rays.

Fourth is its chemical stability. Titanium dioxide is chemically stable and resistant to degradation contributing to its durability in various applications. Fifth is its biocompatibility. In its pure form, titanium dioxide is generally considered biocompatible and is often used in medical and cosmetic applications such as dental implants and sunscreen formulations. What are the limitations of titanium dioxide? First are its environmental concerns. There are environmental concerns associated with the production and disposal of titanium dioxide nanoparticles.

Nanoparticles, if released into the environment, may have unknown effects on the ecosystem. Second is energy-intensive production. The production of titanium dioxide, particularly through the sulphate process, is energy intensive and can contribute to higher greenhouse gas emissions and higher embodied energy and embodied carbon concerns. They have potential health concerns. Inhalation of fine titanium dioxide particles in industrial settings may pose health risks, and there are ongoing studies to understand the potential long-term health effects.

Fourth is the cost. titanium dioxide especially in its high quality pigment form can be relatively expensive. This cost factor can influence the overall expense of products that heavily rely on titanium dioxide. Next is its limited photocatalytic activity in the dark. The photocatalytic activity of titanium dioxide is effective in the presence of ultraviolet light. In the absence of light, its ability to catalyze reactions diminishes, and it has a limited self-cleaning effect in shaded areas.

Materials incorporating titanium dioxide for self-cleaning benefits may not perform optimally in shaded areas where exposure to sunlight is limited. Let us now look at a case study. This case study is called as PROSOLVE 370E. The Prosolve 370E system is made up of modular titanium dioxide-coated architectural tiles that, when exposed to light, neutralize nitrogen oxides in the surrounding air. Nitrogen oxides are bad for the

respiratory system, acid rain and ozone depletion.

Although titanium dioxide has long been known to have antibacterial and air purifying properties, prosolve's formulation and use are specially novel. The pollution-fighting technology is activated by exposing a larger surface area of the tiles to daylight as they are engineered for maximum material efficiency. ProSolve is designed to be installed on an existing building facade as a functional and highly topographical element, allowing the building to function in ways beyond what was originally envisioned. The most recent installation of ProSol 370E was an external facade on a Mexico City hospital. The elegant organic form becomes a memorable signifier on the building's reminding passersby of the city's air pollution problem.

Despite its absence of conceivable form and little association to construction, air pollution remained to be a key architectural consideration in many urban areas, one of which is the Mexico City, to which the United Nations declared as the most polluted city in 1992. Its lowered oxygen levels due to altitude and emissions from older vehicles led to this challenge that persisted for decades. Within the context of combating air pollution, a hospital in Mexico City, the Torre de Espalachades, is extended and redesigned to convert air pollutants into harmless chemicals. The Berlin-based design firm Elegant Embellishments installed a 2,500-square-meter depolluting façade made from quasi-crystal grid of Prozor 370E modules. three-dimensional modules with photocatalytic depolluting technology inspired by fractals in nature.

This facade is coated in superfine titanium dioxide that reacts with urban air pollutants upon exposure to ambient ultraviolet light. These pollutants are then broken down to less noxious compounds such as water and carbon dioxide, neutralizing chemicals produced by 8750 cars per day. That is a fantastic application of titanium dioxide despite all its disadvantages. The rippling morphologies of this facade also maximize the surface area of its active covering, simultaneously diffusing light, air turbulence, and particulates. The manifestation of the synergy between its design form and molecular technology proves that facades can work as natural receivers of new technologies over large urban areas.

By promoting activity in dormant surfaces, This building promises better performance in tuning against the invisible criteria of air pollution. Composed from two injection molded pieces, the X and the I. Utilizing innovative material like ABSP6, they achieved both strength and ductility to resist the high seismic forces common in the region. Additionally, the surface is treated with titanium dioxide, which is a white powder pigment that sterilizes, deodorizes, and neutralizes fouling and polluting properties when added to paints. Also, as rainwater runs down its surface, a magnetic reaction with the paint neutralizes toxic radicals.

So, in today's class, we saw what titanium dioxide is, its applications, its advantages, its limitations, and its application in architecture. With this, we will stop today's class and we will continue with yet another smart material in the next class. Thank you.