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## Eco- friendly glass materials for rational design of green buildings

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### ABSTRACT

During the last century, materials use increased 8-fold and as a result humanity currently uses almost 60 billion tons of materials per year. The construction industry alone consumes more raw materials than any other economic activity. However, research on construction materials still is excessively focused on their mechanical properties with minor concerns regarding environmental considerations and energy saving measures. By starting to focus attention on indoor air quality, water and energy efficiency and environmentally sound materials in particular eco friendly glasses, we will make an impact on our life and the world in which we live. Photo catalysis has recently become a common word and various products using photo catalytic functions have been commercialized. Among many candidates for photo catalysts,  $TiO_2$  is almost the only material suitable for industrial use at present and also probably in the future. This is because  $TiO_2$  has the most efficient photo activity, the highest stability and the lowest cost. This paper provides some insights on future construction materials which are essential for the rational design and reproducible construction of bio-inspired multifunctional self-cleaning surfaces in practical applications. © 2015 Trade Science Inc. - INDIA

### KEYWORDS

Titanium dioxide;  
Photo electrolysis;  
Eco-friendly glasses;  
Environmental;  
Application.

### INTRODUCTION

Eco-friendly literally means earth-friendly or not harmful to the environment. This term most commonly refers to products that contribute to green living or practices that help conserve resources like water and energy. Eco-friendly products also prevent contributions to air, water and land pollution. You can engage in eco-friendly habits or practices by being more conscious of how you use resources. Glass is a fascinating material. Manufactured from silica sand, soda ash, dolomite, limestone and salt cake at high heat in a furnace it is wonderful that the result is a transparent hard material that looks

like solid water. Glasses are non absorbent and have transparent properties make it eminently suitable for use in building construction. Even though ceramic is also a plentiful resource just like glass, it is surprisingly not as durable and long-lasting as a glass installation is with reference to wall cladding, not flooring of course; although I have done a feature glass floor for one client, I do not normally recommend it. In this day of environmental consciousness, it makes a lot of sense to consider alternatives<sup>[1]</sup>. Glass is the inexpensive, eco-friendly alternative to depleting wood resource or metal interior decorative installations in both homes and commercial buildings. With the advent of certain digital print

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process, consumers can now choose glass wall cladding printed with any full color image of choice and further enhance the beauty of their interior spaces.

I am glad to share those more Malaysian architects and interior designers are increasingly choosing to use printed glass for use in lifts, lift lobbies, and for pillar and wall cladding as an alternative to wood, stone, metal and ceramic tiles for the reasons stated above. There is also the fact that the radiant shiny reflective property of glass makes its use in these enclosed spaces most suitable as it considerably brightens them and often needs less lighting too. Green buildings are the ones that are analogous to all the normal buildings, but follows environmental friendly features in every nook and corner. Read on to know more about the green glass wonders in India and how it enhances the sustainability<sup>[2]</sup>. Improvements in modern home-building methods are helping to reduce the impact humans have on the environment. Eco-friendly building techniques include using materials that take less energy or require fewer resources to produce; designing homes to be more energy-efficient; and incorporating alternative energy and waste water management into home designs. We hope this review will stimulate interdisciplinary collaboration among material science, chemistry, biology, physics, nanoscience, engineering, etc., which is essential for the rational design and reproducible construction of bio-inspired multifunctional self-cleaning surfaces in practical applications<sup>[3]</sup>. It is also helpful that glass is a much more plentiful and cheaper resource than is the traditional wood and metal.

One of the most important features of eco-friendly houses is that they are designed for energy efficiency. Of course, it is essential to use high-efficiency appliances, heating and cooling equipment and water heaters. But green design can also include windows placed to allow ventilation throughout the house, south-facing windows that take advantage of the sun's warmth, and shade trees and awnings for summer. Skylights in interior rooms reduce electricity use during the day. Alternative energy sources are becoming more common in private homes. Some systems generate electricity directly, like photovoltaic (PV or solar electric) and wind power systems. Other systems, such as geothermal and

solar hot water, use the sun to heat or pre-heat water for domestic use or for space heating and cooling. Usually, the PV and solar hot water systems can be mounted on a roof, while wind systems have land requirements.

Managing water is an often overlooked component in an eco-friendly house project. It is important to reduce rainwater runoff, which can carry too many nutrients to nearby watersheds. Minimize impervious surfaces and use rain barrels to catch water running off the roof. Water can then be directed to gardens and lawns. Gray-water systems recycle water from sinks and showers for use in gardens. Installing low-flow toilets conserves water and reduces waste, while composting toilets go a step further by not using water at all. Green buildings can have tremendous tangible and intangible benefits. The immediate and tangible benefit is the reduction in operating energy and water costs from day one. The savings could be 25~40%. Other tangible savings include enhanced asset value. Increased productivity, health & safety benefits form a small part of the intangible benefits.

### ROLE OF GLASS IN GREEN BUILDINGS.

Glass is an excellent green material. Certain glasses like solar control glasses can trap the unwanted heat or UV rays and maintain optimal temperature inside the building. They let in great amount of natural lights to energize the interiors<sup>[4]</sup>. Thus glass in buildings substantially reduces the need for artificial lighting and allows day-light to light the interiors. Green glasses can be used both in residential condos and commercial edifices. They let in great amount of natural lights to energize the interiors. They have low reflection reducing the glare. They can trap the unwanted heat or UV rays and maintain optimal temperature inside the building. They have pleasing aesthetics and could have better panoramic views from interiors by blending interiors with exteriors. Green glasses are recyclable.

### Photo catalysis in construction

*As well as removing hazardous organic compounds, NO<sub>x</sub> emissions and air pollution, photocatalysts are very effective at killing a variety of bacteria and some viruses.* Titanium dioxide (TiO<sub>2</sub>) has his-

torically been widely used as a white pigment in paints, cosmetics and foodstuffs. It exists in three crystalline forms: rutile, anatase, and brookite. It is also a photo catalyst; a semiconducting material which can be chemically activated by light. Of the three crystalline forms, anatase shows the highest photo-activity. In modern industrial products  $\text{TiO}_2$  is almost exclusively used in the form of rutile crystals, however, and where it is used as a photo catalyst, It is always in the anatase form<sup>[5]</sup>. The principle of photo catalysis by titanium dioxide is described as follows:  $\text{TiO}_2$  is a semiconductor which when it is irradiated by photon energy ( $h = 3.2 \text{ eV}$  or  $\lambda = 385 \text{ nm}$ ), redox reactions start<sup>[6]</sup>. The band gap energy is excited and an electron is promoted from the valence band to the conduction band.

For most materials that are electrically conductive (metals), these two immediately recombine. However, for semiconductors, they survive for longer periods. The hole and the electron created can migrate and initiate redox reactions with water and oxygen and then degrade mineral or organic molecules adsorbed on the surface of the photo catalyst. If titanium dioxide of the anatase type is exposed to UV light at very low contact angles it gains the unique property of 'attracting' rather than repelling water (super- hydrophilicity). The water lies flat on the surface in sheets instead of forming droplets. Furthermore, UV illumination leads to the formation of powerful agents with the ability to oxidize and decompose many types of bacteria, organic and inorganic materials to their constituent parts ( $\text{H}_2\text{O}$  and  $\text{CO}_2$ )<sup>[6]</sup>. **Coatings and claddings** through photo catalysis, cement or concrete structures can destroy most organic and inorganic pollutants that come into contact with their surfaces, minimizing discoloration. The cement itself is often not photo catalytic. In fact it is usually only the final application of cement or a paint coat. This effectively makes the finish self-cleaning and helps in fighting air pollution and harmful emissions. Treated cement effectively destroys airborne pollutants, cutting down on urban organic pollution.

### Glazing

Self-cleaning glass uses thin film titanium dioxide coating. The film can be applied by spin coating of organo-titanate chelated precursor (for example, tita-

nium iso-tetrapropoxide chelated by acetyl-acetone), followed by heat treatment to burn the off organic residues and to form the anatase phase. The first stage of the self cleaning process utilizes the photo catalytic property, reacting with daylight to break down organic dirt<sup>[7]</sup>. The second stage utilizes the hydrophilic property.

### Waste water treatment

Pilot projects have demonstrated that photo catalytic detoxification systems can effectively kill faecal coliform bacteria in secondary wastewater treatment. Reactors, where the titanium dioxide is fixed on a glass, ceramics or metal surface, are the main component of thin-film fixed-bed reactors. In this reactor type industrial waste water is passed over  $\text{TiO}_2$  coated material (glass, polystyrene, methacrylate). The reactors trap and chemically oxidize organic compounds, converting them primarily to  $\text{CO}_2$  and water. These reactors operate at room temperature and under negligible pressure. Thus, they can be readily integrated into new and existing heating, ventilation, and air conditioning systems.  $\text{TiO}_2$  coated ceramic tiles are considered to be very effective against organic and inorganic materials, as well as against bacteria. These tiles are used in hospitals and care facilities to reduce the spread of infections, and in public and commercial facilities and schools to improve hygiene conditions. Furthermore, because these tiles show hydrophilic behavior, water forms a uniform sheet over the surface. Grease, dirt and other staining materials can easily be swept away with a stream of water. In exterior applications this characteristic makes these tiles self-cleaning. Products made of photo catalytic concrete are mainly achieved by cements that are doped with photo catalytic titanium dioxide, therefore only white and grey products are commonly available. Until now, the technology for colored photo catalytic concrete did not exist<sup>[8]</sup>. Recently, a method was developed to create a stable iron oxide/ $\text{TiO}_2$  compound, in cooperation with the University of Turin. Using this method a color range of yellow, red and black photo catalytic iron oxides has been created.

### CONCLUSION

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harmful to the environment. Eco-friendly products also prevent contributions to air, water and land pollution. Glass is a fascinating material. Manufactured from silica sand, soda ash, dolomite, limestone and salt cake at high heat in a furnace it is wonderful that the result is a transparent hard material that looks like solid water. Glasses are non absorbent and have transparent properties make it eminently suitable for use in building construction. Photo catalysis has recently become a common word and various products using photo catalytic functions have been commercialized. Among many candidates for photo catalysts,  $\text{TiO}_2$  is almost the only material suitable for industrial use at present and also probably in the future. This is because  $\text{TiO}_2$  has the most efficient photo activity, the highest stability and the lowest cost. More significantly, it has been used as a white pigment from ancient times, and thus, its safety to humans and the environment is guaranteed by history.

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