

Course Name: Building Materials as a Cornerstone to Sustainability

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Lecture 01

Photochromics

Hello students. So today we will look at yet another smart material called photochromics. Today we will look at the introduction of photochromic. What are these materials? their installation of photochromic film on windows or facades, their characteristics, the benefits these could offer, their limitations, applications, and applications in buildings. So, what is chromism? Chromism involves materials that can change their color, radiation, or even erase color, making them like chameleons in the material world. This reversible color change or chromism is triggered by external factors.

Imagine them as chameleon materials that adapt to different stimuli. Chromic materials encompass substances that undergo changes in colour, radiation, or erasure of colour. The term chromosome denotes the reversible alteration of colour and, more broadly, the reversible change of other physical properties. These materials are often referred to as chameleon materials due to their color-changing characteristic.

The color transformation is induced by external stimuli, leading to various classifications based on the nature of the stimulus. Photochromic, for example, is responsive to light. Thermochromic is responsive to heat. Electrochromic is responsive to electricity. Piezochromic is responsive to pressure.

Solvatochromic, it is response to liquid. Carousel chromic is responsive to an electron beam. Photochromic materials are in a way like magic. They change color based on light. In low light, they are clear.

But when exposed to sunlight or UV rays, their molecules transform, revealing a visible color. It's like a chemical superhero story with two forms, A and B. Form A turns into B in the presence of light and when the light goes away the colour disappears. This reversible transformation either through heat or light is like a science trick happening at the molecular level. So, photochromics are like color changing wizards bringing a touch

of magic to material.

Let us look at the installation of photochromic film on windows or facades and what does it involve. There is a systematic process to ensure its successful application. First is to cut the film to the correct size of the specific window or facade for installation. Second step is thorough glass cleaning. the glass on which it has to be attached must be cleaned thoroughly, meticulously.

Stains beneath the film; those cannot be cleared once the film is applied, and then removing is another challenge, and therefore it has to be cleaned thoroughly. Third is water spraying. Spray a thin layer of water onto the glass surface before applying the film. Fourth is protective film removal. Before applying, remove the protective film by peeling off the clear backing from the film's corner.

You could use a tape if needed. Then the adhesive side wetting. Spray a thin layer of water on the adhesive side of the film. The film is then applied to the window surface using a squeegee to eliminate air bubbles between the film and the glass. After this heat is applied.

After applying, use a dryer to heat the film, ensuring proper adhesion and a smooth finish. What are the characteristics of photochromics? The photochromic glass offers benefits like improved performance in lower temperatures and enhanced visual response, making it potentially ideal for windows, especially in settings like airport control towers. However, a notable drawback is its high cost, estimated to be around 10 times more than simple absorbing glass. Although it holds promise for applications where visual requirements are paramount, such as control towers, its widespread use in buildings is limited due to the prohibitive cost hindering its adoption on a large scale, especially on buildings that have a huge amount of glass on their facade. Let us now look at the benefits of using photochromics.

Photochromic systems allow for shading whenever needed, thanks to its inherent chemical properties that turn them proportionally dark to the intensity of UV light. However, this technology remains subject to great challenges, one of which is the economic factor that renders these systems impractically expensive. Tinting our high-rise glazed buildings all in photochromics simply sounds unreasonable. On the other hand, environmental analysis and simulation tools today are quite advanced and allow for accurate calculation of solar radiation and lighting received by any surface of almost any material in a particular location of the world. The dynamic behavior of color-changing materials can even be simulated given the right algorithm that can feed the looping system with updated real-time data.

Photochromic window film provides valuable benefits for enhanced comfort and efficiency. Its automatic light control adjusts transparency based on sunlight, ensuring visual comfort in varying lighting conditions. By blocking 80% of infrared radiation, the film contributes to energy efficiency, resulting in substantial summer energy savings. Glare reduction creates comfortable living spaces with vibrant screens, removing the necessity for heavy blinds. Moreover, the film blocks 99% of harmful UV rays, preserving valuables and promoting skin protection.

Its safety features include impact resistant layers offering protection during accidents, storms or potential break-ins. In summary, photochromic window film combines comfort, energy efficiency, and safety, making it a versatile solution for various needs. Let us now look at the limitations of photochromics. Photochromic glass, while offering benefits, comes with certain limitations. Its colouration mechanism triggered by solar radiation involves a reversible and intense colouring process that is influenced by the spectral absorption difference in glass layers.

However, the response time to environmental changes is a few minutes, and the transition from tinted to clear states takes longer, resulting in uneven lighting in sudden brightness changes or cast shadows. Post-transition, photochromic glass becomes absorbent, risking overheating and potential thermal shock rupture during intense solar radiation. Current usage is mainly in optics and cars due to high cost, technological complexity, and control limitations hindering widespread architectural adoption. Recent advancements address some challenges but cost, user control and substance distribution uniformity remain areas of improvement. So, in general the limitations of photochromics include first its coloration mechanism.

So, photochromic glass reacts to solar radiation and causes an irreversible, intense coloring process. The difference in spectral absorption between the glass layer and additional substances drives this colour change. The response time and transition—this is the major limitation. The response to environmental changes takes a few minutes. There is a particular transition time.

So the transition from tinted to clear state takes twice as long. Sudden brightness changes or cast shadows can create uneven light and shadow areas. Second is the absorption and reflectivity changes. Post-chromatic transitions, photochromic glass can become absorbent rather than reflective. The risk of glass pane overheating potentially leading to thermal shock rupture during intense solar radiation can also happen.

Third is due to its very high cost. This is currently used in optical and car industries.

Hindered adoption in architecture is due to its high cost, technological complexity and user control limitations. So, its challenge includes achieving uniform distribution of photochromic substances and gradual loss of reversibility over time.

Fourth is the technological advancements. Despite technological advancements, recent years have seen a reduction in technological challenges. This allows for extended slab sizes and improved stability over time. Yet, due to its cost and user control and substance distribution uniformity, it still remains a big challenge on usage of photochromic. Let us now look at the applications.

So photochromic glass is widely used and marketed as smart optical material. Over 30 years of existence, it has numerous patents too. So its application is beyond glass. It is used in lenses, it is used in paints, inks, mixed with various materials, textile applications for decorative effect in fabrics, embroidery, prints, etc.

It is used in textile threads. So threads made with polypropylene and photochromic compounds. UV light activates colour change and returns to white when removed. This lasts for about 2000 alterations equivalent to a garment's life. Second is the interactive textile innovation. So, Swedish Interactive Institute develops UV sensitive color changing curtain dynamically illuminated by computer controlled UV lamp for dynamic patterns.

It is connectable to a computer as a display. Third is commercial fabric application. So, Super Textile Corporation in Taiwan offers high-tech photochromic fabrics and microcapsule dye technology for color change with sunlight and UV radiation. This is non-hazardous and suitable for general applications like knapsacks and warning signs. So, the photochromics extend beyond just applying it superficially to glass, and over the years it has found many uses.

Whether it is textile, it appears in threads made with polypropylene and photochromic compounds. These enable colour change, which gets activated due to UV light and lasts for about 2000 alterations. That is a good enough life of a garment. Then the innovation also includes UV-sensitive or color-changing curtains or dynamically illuminated by a computer-controlled UV lamp, and so on. So, some companies are also using it on fabric with microcapsule dye technology for color change with sunlight and UV radiation, which is suitable for general applications.

Let us look at the applications of photochromics in buildings. Now, photochromics find versatile applications in buildings, notably through smart windows that dynamically adjust transparency in response to sunlight, contributing to enhanced energy efficiency. Beyond energy conservation, these materials regulate light and heat transmission,

reducing the need for artificial lighting and heating. They are integrated into screens or partitions to provide adaptive opacity, serving as effective privacy solutions.

Applied in interior design, elements such as wall coverings and furniture and photochromic materials create responsive and visually engaging environments. Furthermore, their potential use in building exteriors, security applications, and contribution to occupant well-being makes them valuable tools in shaping innovative and dynamic architectural spaces. To be more specific, photochromic glass can be used on smart windows. That is, photochromic glass adapts transparency in response to sunlight, enhancing energy efficiency in buildings. For energy efficiency, it contributes to energy conservation by regulating light and heat transmission, reducing reliance on artificial lighting and heating.

When it comes to helping or aiding privacy solutions integrated into screens or partitions for adaptive opacity, providing privacy and openness as needed, photochromic glass is a good option. For interior spaces, apply interior design elements like wall coverings and furniture, creating responsive and visually engaging environments. Safety and security, potential use in security applications like adapting opacity to enhance building safety measures. They can be used on innovative facades by being applied to building exteriors for ever-changing architectural aesthetics and dynamic visual impact. They can also be used for health and well-being, as they contribute to occupant comfort by optimizing natural light levels and reducing glare, supporting the circadian rhythm.

So, here we see the various architectural applications of photochromics in buildings. So, photochromics is nothing, but in conclusion, photochromics is nothing but the reaction of a particular glass or material to light. in architecture this can be used effectively as this material becomes dark when light falls on it. In a hot tropical country like India, this becomes a very effective tool to save energy. However, its use in architecture is limited and hindered as of now because of its high cost.

its application starts increasing in architecture over a period of time as more and more people use this material simply because it cuts off a lot of heat, due to which the load on HVAC gets reduced and also glare gets reduced, resulting in energy efficiency and As the usage of this material increases in buildings, its cost would eventually come down. As of now, since that is the main hindrance, we as architects must consider and reconsider the use of photochromics in buildings. I will stop today's class with this. And we will look at yet another interesting smart material in our next class. Thank you.