

**Course Name: Building Materials as a Cornerstone to Sustainability**

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**Lecture 01**

Mechanochromic,

Chemochromic

Hello, dear students. So, last class we saw a very important topic which is the smart material of titanium dioxide. Today we will look at yet another smart material which is mechanochromics and chemochromics. So, today we will see about mechanochromics and chemochromics. What is chromogenic material? So, chromogenic material is a class of material known as chromogenics, and this is capable of changing color. in response to various stimuli.

Every type of subgroup has a separate set of stimuli. Certain materials react differently to different stimuli, such as temperature, electric field, changes in their physical or chemical characteristics, etc. Investigating mechanochromic and chemochromic material in more detail is the agenda of today's class. Mechanochromic materials are a subclass of chromogenic materials that change color in response to mechanical stimulus.

This implies that the material's appearance can be altered simply by applying pressure, shearing, grinding, or employing other mechanical forces. The hue shift is caused by modifications in the molecular structure of the substance. These alterations could involve molecular rearrangements, the formation of new chemical bonds, or the breaking down of existing ones. These changes affect how light interacts with the material, which causes the noticeable hue shift. There exist multiple processes through which mechatronics can happen.

First is crystallization induced mechanochromism. Crystallization-induced mechanochromism. When a material is subjected to mechanical stress, its crystal structure changes, changing its optical characteristics, which is hue. So, mechanical stress causes a change in hue. Second is molecular arrangement.

The material's absorption or emission properties might alter as a result of mechanical stress creating alterations in the orientation or arrangement of the molecules. So, the mechanical stress will result in alteration in the arrangement of the molecules. The third

is phase transitions. Materials can undergo phase transitions due to mechanical force, which alters the material's optical characteristics. So, due to phase transition that is from solid crystalline to liquid or vice versa liquid to solid due to the impact of mechanical force.

This can result in optical characteristics. Say the material can become from transparent to translucent or opaque. Third is polymer chain conformation changes. When subjected to mechanical stress, polymers with particulate structural characteristics may experience conformational changes that modify their optical characteristics. Next is fracture induced mechanochromism.

When certain molecular arrangements are disturbed or imprisoned species are released, certain materials undergo color shifts near the fracture sites. So, this can be a very important and crucial property that we could use in identifying cracks in structures. Now, mechanochromic materials have potential applications in various fields, including structural health monitoring, flexible electronics, smart textiles, and anti-counterfeiting measures. There are certain pressure sensing films. So, pressure distribution may be seen and measured thanks to the use of mechanochromic materials in pressure sensing films.

These change the colour in response to mechanical pressure. These materials are used in tamper-evidencing applications that allow colour changes brought on by mechanical stress to visually indicate any effort to tamper with the product or surface. First one is the pressure sensing films as can be seen in this picture. The second is material force sensors. Made of mechanochromic composites and polymers, these sensors enable the measurement and identification of mechanical forces in a variety of applications.

The third is mechanochromic polymers. Now these have been used in electronic skin or e-skin technology which allows color changes in reaction to pressure or touch improving the artificial skin's sensory skills. Fourth are applications for flexible and stretchy mechanochromic polymers. Hydrogel foam is chromogenic rubber and fibre are examples of flexible and stretchy mechanochromic polymers. Let us now look at the uses of mechanochromic materials in buildings.

First use, Now the building construction that uses mechanochromic materials can receive immediate feedback on the structural integrity when we use this for structural health monitoring. Under stress or pressure the colour changes may reveal probable damage area enabling preventive maintenance and averting catastrophic failures. So, when there is a crack in a structural system and due to use of mechanochromic materials, if the crack changes its color and can be identified, Immediate correctives can be done to ensure that the structure does not fail. Second is energy efficiency. Mechanochromic

materials can be incorporated into building envelopes to enable architects to create structures that react to variations in temperature or sunlight.

Mechanochromic windows for instance could darken in reaction to sunlight lowering heat intake and glare and enhancing energy efficiency. So you can see how stretching can change the color from red to green to blue depending upon the extent of stretching. depending upon the extent to which the material expands. The third is interactive installations. So, mechanochromic materials can be used to provide interactive experiences for visitors and inhabitants in architectural projects and artwork.

For example, interactive walls or floors that react to touch or movement can pique users' interest and improve their entire sensory experience. Fourth is safety and security. Because they can reveal tampering or unauthorized access, mechanochromic materials can be used as security elements in structures. Mechanochromic coatings, for instance, can cause doors or windows to change color in response to forceful entry attempts, warning residents or security staff. Let us now look at chemochromic materials.

Materials known as chemochromic materials alter colour, transmission, or reflection qualities when they interact with other chemicals. the chemical reactions that occur within the materials help to allow this changing of characteristics. An electron that was a component of one chemical bond at one location moves to a different site within that molecule through the reaction phase. The molecule absorbs a specific colour of light depending on whether or not such an electron is present in its initial position. Now, chemochromic materials are available in various forms and they have a variety of applications.

The first one is a very simple application which we all are aware and that is the litmus paper. The material present in litmus paper that detects the acidity and alkalinity of solution is a type of chemochromic material. Second one- the second use is in the manufacture of dyes. These materials are used in the production of dyes for various purposes, such as coloring fabrics, paints, and other materials. Third is in pregnancy test kits.

Now, chemochromic materials are used in pregnancy tests to detect and respond to human chorionic gonadotropin. a hormone found in the urine of pregnant women. The fourth one is hydrogen leak detection in rocket engines. One of the primary applications of chemochromic materials is in the detection of hydrogen leaks in rocket engines. These materials change colour when they come into contact with hydrogen gas indicating the presence of a leak.

The fifth application is security inks. So, chemochromic materials are used in the production of security inks that change colour when exposed to specific chemicals or conditions, providing an additional layer of security for documents and other printed materials. Let us now look at the use of chemochromic material in buildings. First is smart windows. Smart windows that adapt to variations in temperature or light levels by altering their tint or opacity are made possible by the use of chemochromic materials.

By regulating temperature and light transmission in buildings, this technology enhances occupant comfort as well as energy efficiency. The basic idea is to use chemochromic coatings that change colour in response to certain stimuli, like hydrogen or oxygen gases. These coatings experience a chemical reaction that modifies their characteristics upon exposure to infrared radiation, resulting in variations in light transmittance. The second uses coatings for leak detection. Surfaces are coated with chemochromic materials to detect gas leak such as hydrogen leaks.

When certain gases come into touch with these coatings, they change colour giving a visual cue that leaks are present in storage tanks, pipelines or other vital building infrastructure. Third uses color-changing paints. Building components can be painted using chemochromic paints to show alterations in the surrounding environment. These paints, for instance, can alter colour when exposed to moisture, making it easier to spot areas that are vulnerable to leaks or water damage. In the construction sector, they can be used to prevent counterfeiting by verifying the legitimacy of materials or goods.

The fourth use is safety indicators. Chemochromic compounds can serve as safety indicators when added to construction materials. For example, these materials have the ability to change colour when dangerous gases are present, warning occupants of possible risks and enhancing building safety overall. So, in today's class we saw two important smart materials that are upcoming. One material is based on temperature thermochromic and another material is based on colour which is chemochromic.

Both these materials are upcoming smart materials. Their usage in architecture is yet to be explored in greater detail. Nevertheless, it is in the hands of architects and designers and young people like you to explore how these can be used in order to create a very positive impact on the environment. As of now, some of these are very functional such as to detect cracks in buildings, to detect structural failure and some of these are also used in architecture as a way of artistic expression. Further exploration of its uses needs to be delved into, as these are upcoming materials. I will stop today's class with this and we will continue our next class with yet another smart material. Thank you.