Properties of photoactive nanomaterials. Applications and challenges.

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Photoactive materials are substances that can absorb light and then produce a physical or chemical response, such as generating an electrical current or emitting light of a different color. Some of the most common photoactive materials include:

1. Silicon - Silicon is the most commonly used material for making solar cells, which convert sunlight into electricity.
2. Organic molecules - Certain types of organic molecules, such as conjugated polymers and dyes.
3. Perovskites - Perovskite materials, which are a type of crystal structure, have gained interest in recent years due to their high efficiency in solar cells or photocatalytic systems.
4. Quantum dots - Quantum dots are nanoparticles made of semiconductor materials that can be used to make highly efficient light sources.
5. Transition metal oxides - Certain transition metal oxides, such as titanium dioxide, are used in photocatalysis or dye-sensitized solar cells.

These are just a few examples of photoactive materials, and there are many other types of materials that can be used for a variety of applications, such as photochromic materials that change color when exposed to light or photoluminescent materials that emit light when excited by a light source.

When it comes to photocatalysis titanium dioxide is still one of the most intensively studied material. Due to its negligible toxicity and high thermal and photochemical stability, TiO_2 is widely used for environmental and biomedical purposes, particularly for the air and water treatment, self-cleaning surfaces, surface disinfection, water splitting and CO_2 reduction. The activity of heterogeneous photocatalysts strongly depends on their physicochemical properties, such as band gap energy, potential of the conduction and valence band edges, phase composition, surface area, particle size, and facet exposition. Therefore, usually the characteristics of materials is focused on examining these parameters. Nevertheless, the influence of other factors on photocatalytic activity, especially the presence of various defects in the crystal structure, cannot be neglected.
In order to extend their photocatalytic activity for visible light, several strategies have been utilized, such as noble metal deposition, transition metal doping, or photosensitization. In the case of the infrared light utilization, one of the most effective approaches is to use lanthanide-doped materials that are able to harvest near-infrared (NIR) photons and convert them into UV and visible light.

In this lecture, many different aspects of photocatalysis phenomena will be discussed from mechanistic and practical perspectives, as well as methods for tuning the optical and redox properties of photoactive materials. These methods lead to a wide variety of practical applications, such as the photodynamic inactivation of microorganisms, water splitting, selective and efficient photocatalytic oxidation. Some aspects of nanototoxicity of these materials will be presented using biomolecules as models.