Oxygen-deficient films prove to be highly photo-reactive, efficient for decontaminating water, harnessing solar energy, and self-cleaning surfaces

Background

Notably, metal oxides, particularly titanium oxides, often exhibit high chemical and physical stability, durability, and photo-reactivity that can be utilized in many applications. However, until now there have not been many successful attempts to utilize light as a sole energy source using titanium oxide-based materials, to a level that will enable the decontamination of toxic materials such as benzoic acids and other difficult to treat organic compounds.

We have demonstrated that hybrid organic/inorganic thin films produced through a specialized MLD (molecular layer deposition) process, allow comprehensive control over the titanium-oxide properties and their stoichiometry, and enable the production of exceptionally high photo-reactive coatings.

The hybrid films undergo a thermal annealing process at specific temperatures, causing the organic components to decompose and the inorganic components to crystallize while maintaining pre-designed defects, thereby yielding controllable oxygen-deficient titanium oxide film with high photo-reactivity and other unique electronic properties.

We have applied two different methods for producing high-photocatalytic films, both exhibiting reactions not typically attainable by titanium oxide materials. The first method enables photo-degradation of organic molecules at room temperature after annealing the film in an optimal temperature of 650°C, while the second method anneals the film at 520°C, resulting in the direct production of H₂O₂ (hydrogen peroxide) during photo-catalysis.

Thus, we have found a direct correlation between the oxygen-deficient titanium, the film's unique electronic properties, and its enhanced photo-reactivity, enabling its tailoring to specific applications.

Our Innovation

We have developed a novel technique for producing thin titanium-oxide coatings that are highly-photo-reactive, and can be utilized in varied applications such as self-cleaning surfaces; coatings that decontaminate building surfaces; decontaminating water; harnessing solar energy, and others. The films comprise a layered hybrid of organic and inorganic components that are transformed by thermal treatment to super-photo-reactive oxide material. These photocatalytic films, when exposed to UV light, prompt chemical reactions of oxidation and reduction processes at the film's surface, resulting in the decontamination of organic and chemical pollutants adsorbed on the surface.
Diagram a: Coating's production process scheme
Applications

The growing interest in recent years in photocatalytic thin film coatings comprising metal oxides has prompted the development of thin photocatalytic films suitable for such applications as:

- Coatings containing self-cleaning powdered paint additives that decontaminate urban building surfaces, graffiti-repellent coatings.
- Self-cleaning coatings for windows and building exteriors, solar panels, marine and aircraft vessels
- Decontamination of polluted water and air
- Self-cleaning coatings for sterilizing lab equipment, filtration membranes, and medical devices.
Highlights

- Customizable films suited to each specific application
- Innovative technique yielding film that is five times more reactive than other TiO₂ films
- Versatile usages of the coatings on glass, metal, or plastic
- Low-cost materials that do not contain toxic substances
- Materials are designed at the molecular level, enabling close control over catalyst composition

Development milestones

- Process was optimized for direct implementation on solid surfaces and for the decomposition of organic materials, proven to perform better than conventional TiO₂
- Additional investment would be required for future R&D and scaling up for the production of a new type of coating containing powdered additives that decontaminate urban building surfaces, paints, as well as water containing toxic chemicals or sewage water for large scale applications requiring bulk quantities.

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