The Nanocoated Photocatalytic Active Adsorbent (PCAA)

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THEORY

Photocatalysis

Photocatalysis is based on the photo-induced process of charge separation at the illuminated surface of a semiconducting material (photo-catalyst). These charges can be transferred to adsorbed molecules like O_2 (Fig. 1). Hence very reactive radicals are formed that trigger further oxidation steps of all kinds of organic molecules. TiO_2 is regarded as the most common photo-catalyst which can be activated with light at a wavelength below 385nm (UV-A).

$$\text{organic} + O_2 \xrightarrow{SC, h\upsilon > E_{BG}} CO_2 + H_2O\ (+\text{mineral acids})$$

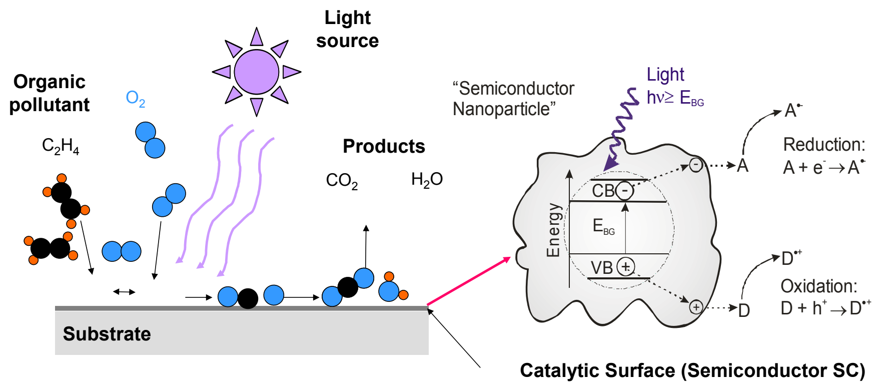

Figure 1: Principle scheme of the photocatalytic decomposition process on an illuminated catalyst surface: Adsorption – Transfer of electrical charges – Radical-reactions – Desorption.

CONCEPT

Requirements and Approach

Efficient photocatalysis requires a large accessible, illuminated active surface in a simple and compact reactor. Conventional concepts use powdered catalyst, which is non-transparent. Hence a uniform distribution of light is difficult.

Our approach is based on a coarse granular, UV-A light transparent, porous adsorbent with a large photocatalytic active surface (PCAA). Hence the material can be used in a fixed bed reactor (Figure 2).

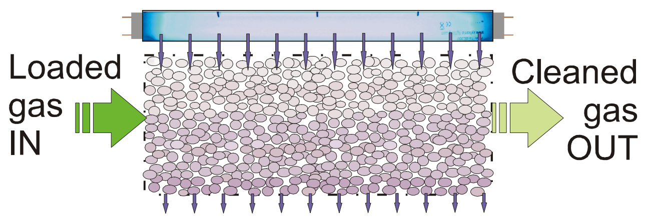

Figure 2: Concept of the fixed bed reactor with irradiated fill of photocatalytic active adsorbent (PCAA).

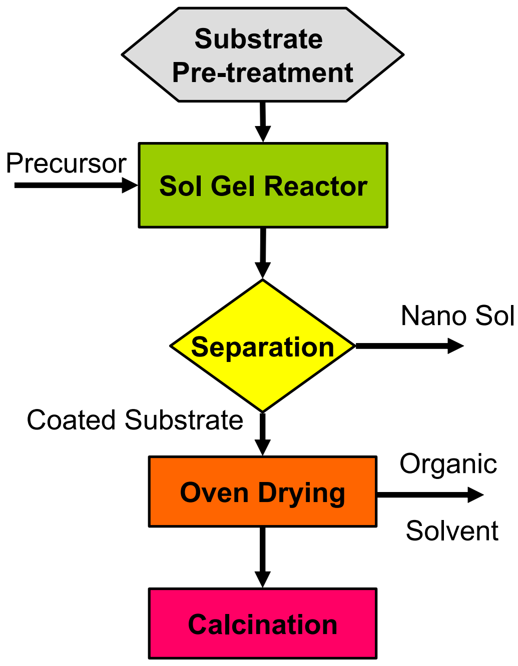

Figure 3: Scheme of the coating process.

Coating Process

A novel sol-gel process with rapid micro mixing of the precursors (titan-tetra-isopropoxide and water both in 2-propanol) is used to coat the porous silica substrate with TiO_2-based nano-particles. The nano-sol contains particles with approximately 6nm diameter allowing homogeneous coating of the inner pore system of the silica substrate (Figure 4).

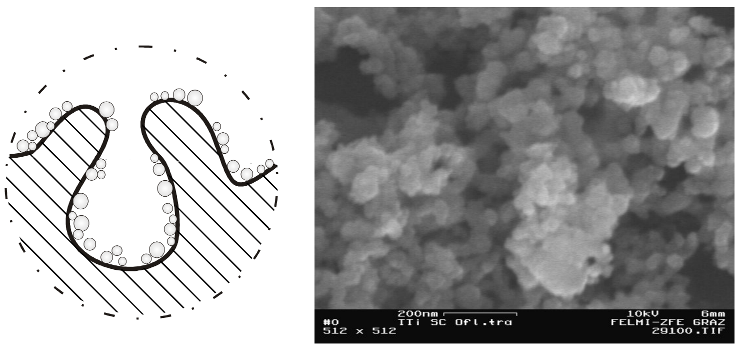

Figure 4: Sketch of a nano-coated pore (left) and scanning electron microscope image of a PCAA particle (FELMI Graz).

RESULTS

PCAA for Gas Cleaning

The photocatalytic performance of PCAA was studied by using a fixed bed plug flow reactor. Figure 5 shows the photocatalytic degradation of trichloroethylene (TCE) to CO and CO_2. Furthermore the adsorption behaviour of PCAA is visualized in sections without UV-A illumination.

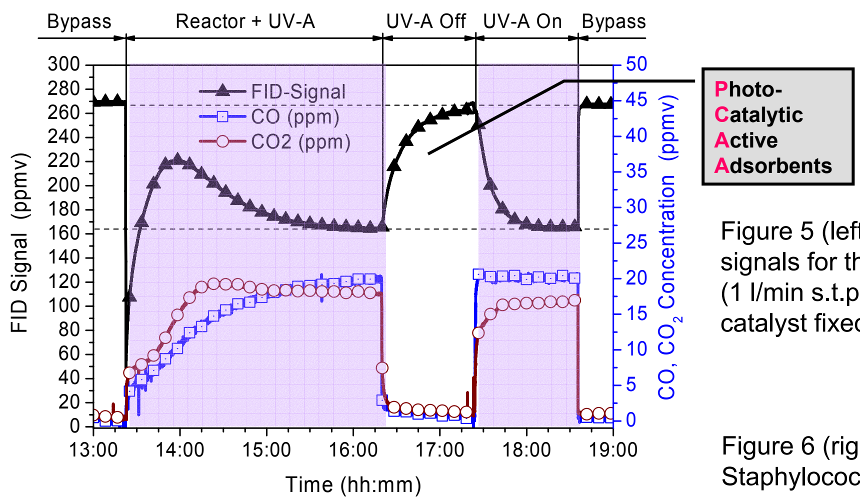

Figure 5 (left): Transient analyzer signals for the conversion of TCE (1 l/min s.t.p., UV-A, 30+/-2 cm³ catalyst fixed bed volume, 28°C)

Antibacterial Effect of PCAA

Preliminary test at the Institute of Hygiene at the Medical University of Graz verified the antibacterial potential of PCCA. Uncoated placebo material and coated glass beads showed no effect (Figure 6).

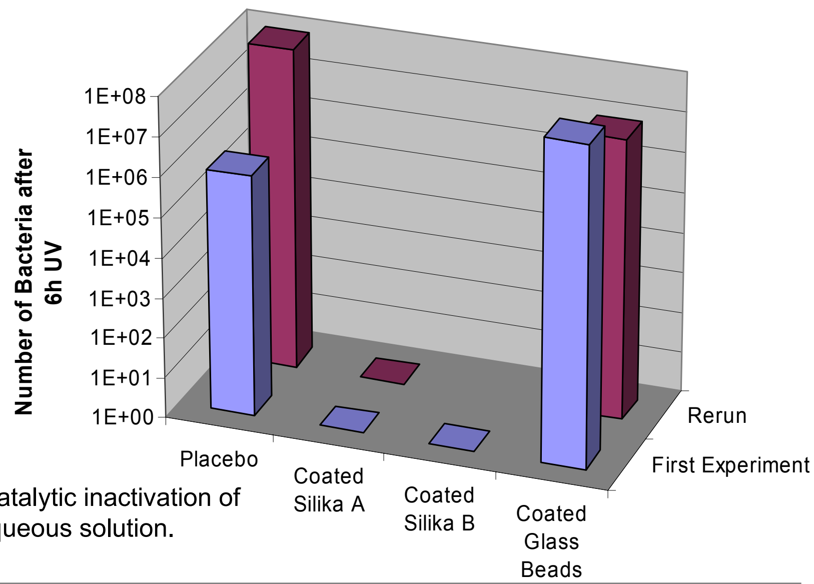

Figure 6 (right): Results of the photocatalytic inactivation of Staphylococcus Aureus bacteria in aqueous solution.

OUTLOOK

Prototype

Two tubular modules have been develop to carry out further tests for the bacteria elimination in room air on UV-A illuminated PCCA material.

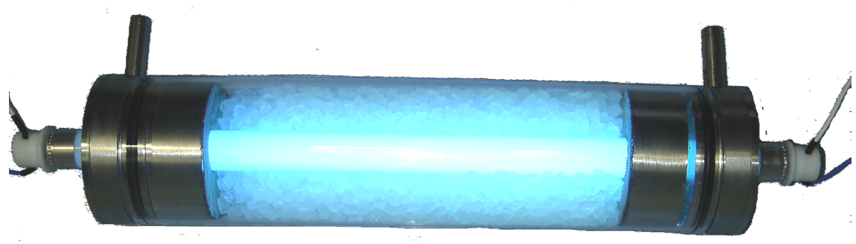

Figure 7: Tubular prototype module half filled with PCAA.

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