



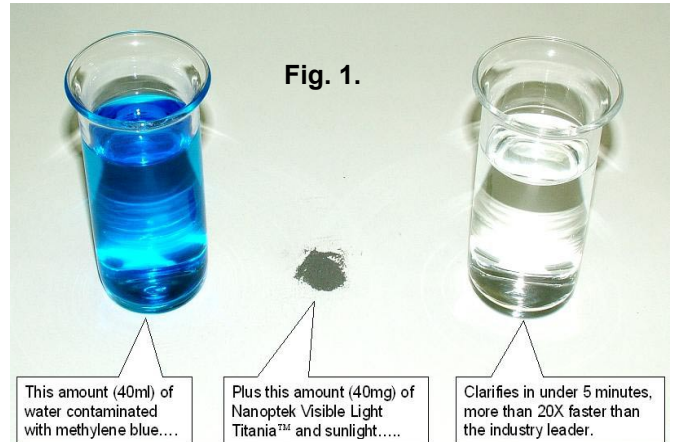
NEW CATALYST FOR WATER AND AIR PURIFICATION:

# NANOPEK Visible Light Titania™

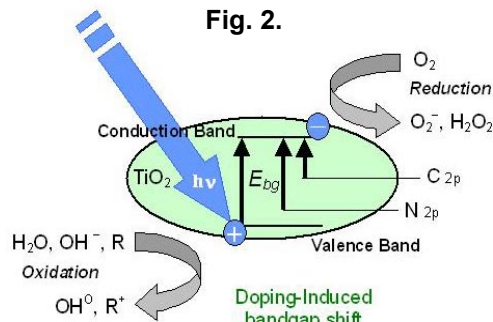
*More than 20X Faster Kinetics than Industry Leader in Sunlight;  
Continues to Work Even with Indoor Lighting*

**Nanoptek Visible Light Titania™** is a new photocatalyst that reacts with light and humidity to break apart many organic pollutants on surfaces, in air, or in water. It is engineered to absorb and use significantly more of available light than normal titania can and as a result is many times more effective in the same applications in which titania is presently used (Fig. 1).

**The market.** Titania (titanium dioxide or  $\text{TiO}_2$ ) is effective for water and air purification, as well as odor reduction and self-cleaning surfaces such as buildings and roadways. The global market, \$900M in 2009, is growing at 14.3% CAGR and is expected to reach \$1.7B in 2014.<sup>1</sup> Even so, many agree that a solution to the slow reaction kinetics of normal titania in visible light would result in a much larger market.



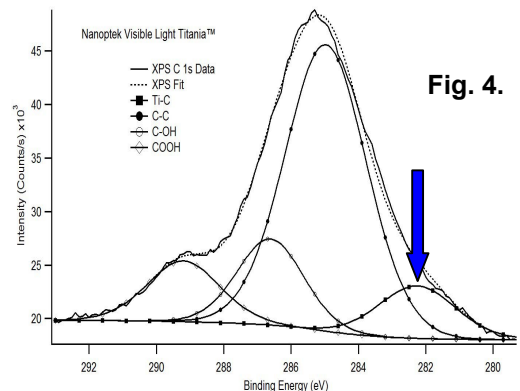
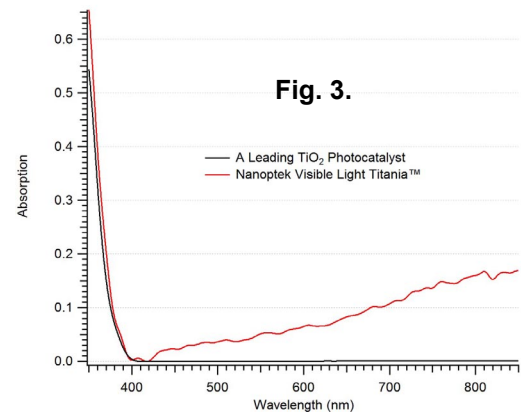
**Titania** is a semiconductor that, when illuminated with ultra-violet (UV) light, produces positive and negative surface charges. These dissociate water molecules from even ambient humidity into *hydroxy* ions ( $\text{OH}^-$ ) that are adsorbed on the titania, and hydrogen ions. Hydroxyl radicals ( $\text{OH}^*$ ) form when the positive charge accepts an electron from the adsorbed hydroxy ion (Fig. 2).



These highly reactive  $\text{OH}^*$  radicals are powerful oxidizing agents, second only to fluorine and many times stronger than concentrated bleach. Hydrogen peroxide ( $\text{H}_2\text{O}_2$ ) and oxygen radicals ( $\text{O}_2^-$ ), also powerful oxidizers, are

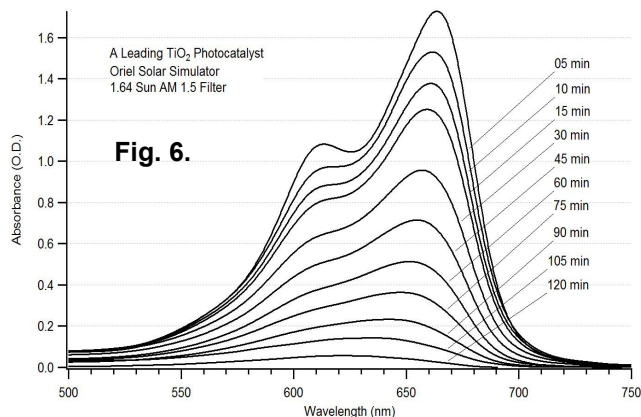
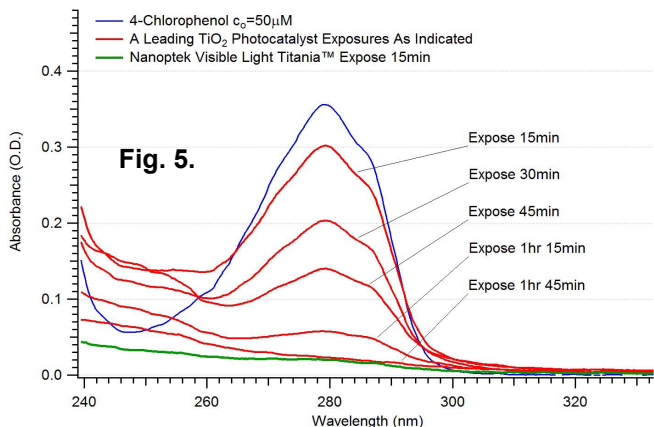
also formed. These agents have been shown to act together or separately to dissociate many organic molecules and other pollutants into harmless compounds, such that they can be used to remove contaminants from air and water, killing even drug-resistant bacteria and viruses on surfaces or in air and water, and reducing  $\text{NO}_x$  and other pollutants in air.

**However...** Sunlight contains less than 5% UV light, and indoor illumination has little to none, so titania has limited effectiveness outdoors. And indoor use requires artificial ultraviolet light sources that add capital expense, must be shielded from skin and eyes, or require expensive vacating downtime during purification. And "germicidal" UV sources can create ozone pollution. Typically, UV sources are expensive to operate because of their inefficient conversion of electricity to UV light.



<sup>1</sup> Margareth Gagliardi, M.; "Photocatalysts: Technologies and Global Market" BCC Research Report (AVM069A), March 2010. This does not include the market for non-catalytic titania, which is used as a pigment in many industries and products. Major producers for both pigment and photocatalytic titania include Evonik Degussa, Cristal Global, St. Gobain, Kronos, and Sachtleben Chemie. DuPont is the largest titania producer, but not for photocatalysis. "Downstream" users include Purifics, Photocat, Oxytitan, Pureti, Carrier, Trane, and Siemens

**Nanoptek's advantage.** VLT™ is band-gap-engineered using our proprietary process for stable carbon (TiO<sub>2</sub>:C) doping to absorb not only UV, but also visible light into the near IR, as shown in the absorption spectrum (red line) in Figure 3 and its light gray color (inset, Fig. 1). The carbon doping is indicated by the titanium-carbon bond peak, absent in normal titania, in XPS data (arrow in Fig. 4). The additional light absorption from this bonded carbon results in VLT™ **acting over 20 times faster** than the leading titania for chlorophenol (Fig. 5) and dye remediation (Fig. 6), for example. Each of these is an important indicator for two large classes of pollutants.

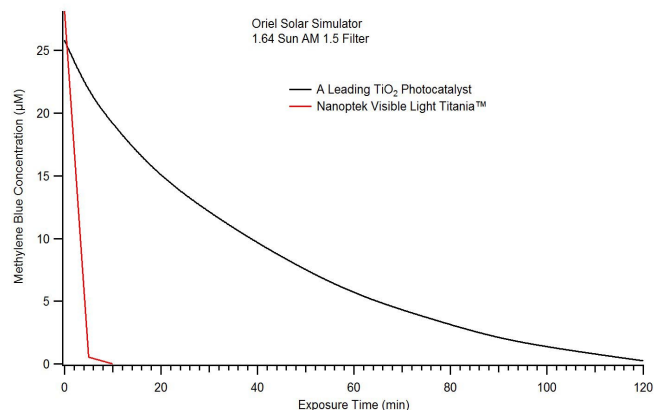
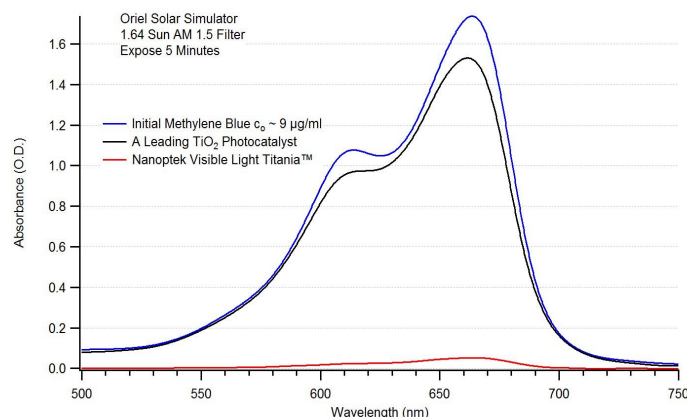


**Applications.** For water remediation, Nanoptek's VLT™ can be added directly, with the mixture exposed to sunlight, or at the focus of an optical concentrator (See Nanoptek CSHGs). Processing can be batch type, where water is held until completely detoxified and/or disinfected and then released, or flow, or a combination of the two. The VLT™ is reclaimed by either filtration or simply by allowing it to settle out of the liquid. Alternatively, it can be bound to a surface over which the liquid is flowed while illuminated.

For air and surface disinfection and detoxification, Nanoptek's VLT™ powder can be adhered to HVAC filters, facemasks, protective clothing, even stationary. VLT™ can be added to concrete, plaster, stucco, paint, ceramic, ceramic glaze, floor surfaces,

*“More than 20X faster remediation  
in sunlight of dyes in water,  
and works even without UV”*

wallpaper, food-handling surfaces such as countertops and cutting boards, hospital interiors, bathroom fixtures, as well as automotive, marine and aeronautical surfaces including cabin interiors, exterior paint finish, and any surfaces that are frequently touched such as keypads and screens on personal digital devices.....even shopping cart handles.



**For samples, or to discuss licensing opportunities:**

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