Development of Visible Light Photocatalyst with Superior Durability and High Catalytic Activity, 'Fresh Green'

- Background

Photocatalyst films with deodorant, antibacterial, antifogging, and self-cleaning effects are generally formed by titanium oxide solution spray coating or spin coating, or by dipping things in a titanium oxide solution. Therefore, photocatalyst films generally have poor durability and are consequently difficult to apply on surfaces subjected to a high degree of surface sliding or scratching. In order to use photocatalyst films indoors, it is important for them to be able to absorb visible light.

A titanium oxide film, super durable and in response to visible light, is able to available at the inaccessible location or in the room under weak-ultraviolet rays.

- Objectives

This study is intended to develop an innovative titanium oxide film with superior durability in response to visible light, and to characterize the film for practical use.

- Principal Results

(1) Carbon-doped Titanium Oxide Films and Characterization of Crystalline Structure

The carbon-doped titanium oxide films (hereinafter referred to as ‘Fresh Green’) were formed by oxidizing and carbonizing titanium surface (patent pending). The XPS analysis of Fresh Green film indicates a significant peak at the binding energy for Ti-C through the entire depth of the film up to the matrix boundary (Fig-1). The peak at the binding energy for Ti-C was observed in Fresh Green film with annealing process as well.

(2) Durability and Spectral Absorbance

Following features were found by durability tests and spectral analysis of Fresh Green:

- Hardness : higher than a hard chromium plating (Fig-2)
- Wear Resistance : no remarkable wear by SiC ball-on-disk test
- Scratch Resistance : higher exfoliation load than TiN
- Heat-Resistance : no degradation of photocurrent and wear at 470℃
- Corrosion Resistance : corrosion resistance with 1M H_2SO_4 and 1M NaOH aqueous solution
- Water Splitting : more than 6% quantum efficiency below 400nm wavelength
- Spectral Absorbance : absorbance up to 490nm, cf. 410nm for commercial products (Fig-3)

(3) Deodorant Effect and Anti-Contamination Effect

In order to assess sick house syndrome, a deodorant test was carried out. The decomposition rate of acetaldehyde by Fresh Green was more than two times higher than that by commercial products (Fig-4). In order to investigate specimen contamination, Fresh Green and commercial product specimens were placed in a room for smokers for 145 days. The surface was illuminated by a fluorescent light, but free of direct sunlight. After the test, the commercial product was stained with fat and had a pale yellow color. The surface of Fresh Green, however, remained unchanged and was clean (Fig-5). The fact clearly indicates that Fresh Green can oxidize and decompose the stains.

- Future Developments

We are developing the Fresh Green process further to have higher photocatalytic activity for the purpose of practical use.

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- Reference

M. Furuya *et al.*, 2004, “Development of Visible Light Photocatalyst with Superior Durability and High Catalytic Activity, 'Fresh Green',” CRIEPI Report T03067, *in Japanese*.

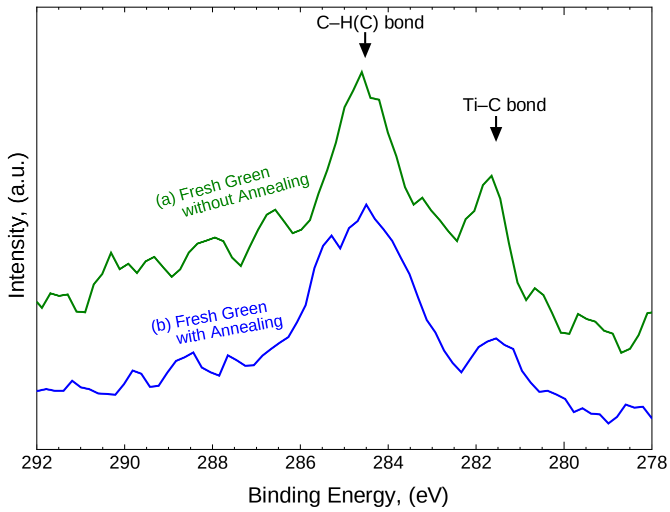


Fig-1 XPS Analysis of Oxide Films

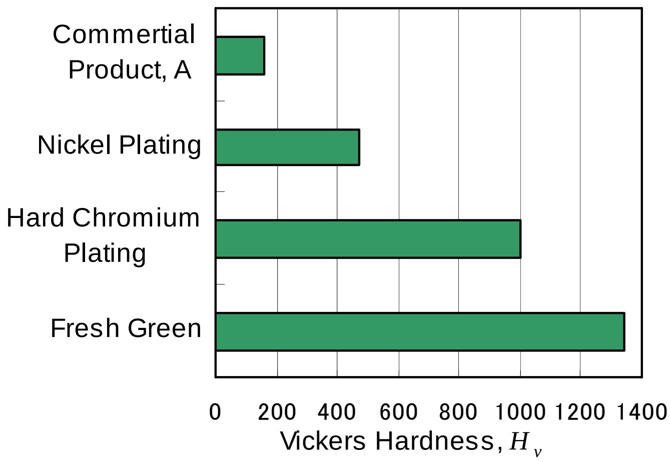


Fig-2 Comparison of Hardness

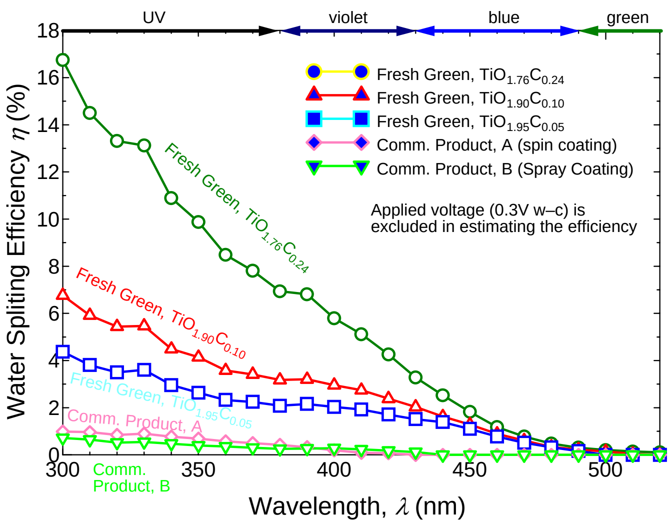


Fig-3 Wavelength Dependency of Water Splitting Efficiency

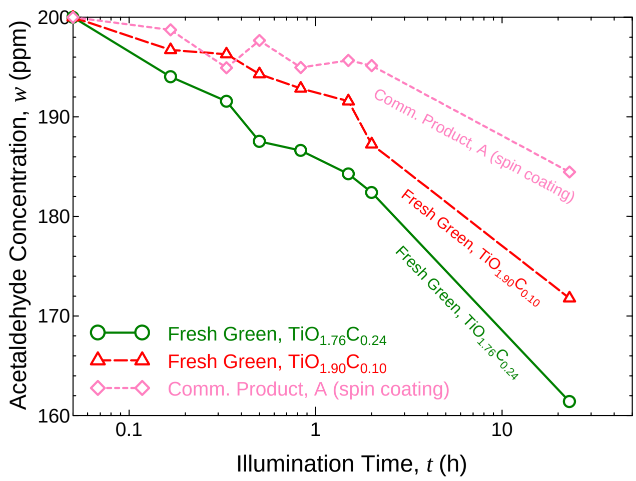
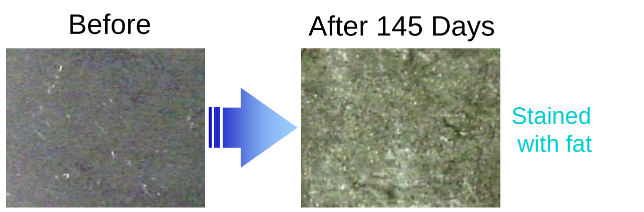
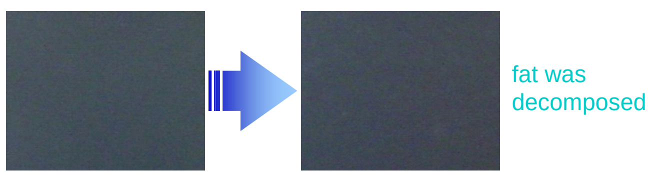


Fig-4 Deodorant Effect under Visible Light Irradiation



(a) Commercial Product, A (spin coating)



(b) Fresh Green

Fig-5 Surface Appearances after Field Contamination Test