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\degree
  - Corrosion Resistance : corrosion resistance with 1M H2SO4 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.

- **Main Researcher**: Masahiro Furuya, Research Scientist, Sector, Nuclear Power Generation Technology, Nuclear Technology Research Laboratory

- **Reference**
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

Fig-5  Surface Appearances after Field Contamination Test