

## **The Fourth Green and Sustainable Chemistry Award**

Awarded by the Minister of Environment

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### *The Development of Strong Photocatalytic Fiber with Surface Gradient Structure and its Commercialization in the Field of Water-Purification-System*

The photocatalytic activity of titania ( $\text{TiO}_2$ ), which is one of the functional ceramics, has been noticed since 30 years ago, and using the properties, lots of products have been developed in the field of bacteria-sterilization, deodorant, air-purification. However, insofar as using former coated materials, for the great potential demand in the field of water-purification, many problems regarding peering of the titania layer coated on the substrate, and so forth, have prevented practical use. In order to solve the problem, the development of appropriate material and system with durability and good photocatalytic activity has been strongly desired.

To solve the aforementioned problems, an epoch-making “strong titania fiber” consisting photoactive surface layer with a nanometer-scale compositional gradient, which can effectively oxidize any kind of organic materials, has been newly developed and an effective water-purification system using this fiber has been also developed. The scientific paper regarding this fiber was published in the March 2002 issue of “Nature”. The basis of this technology is to incorporate a selected low-molecular-mass additive ( $\text{Ti}(\text{OC}_4\text{H}_9)_4$ ) into a precursor polymer from which the ceramic forms. After melt-spinning the resulting precursor polymer, thermal treatment of the spun fiber leads to controlled phase separation (“bleed-out”) of the additive; subsequent calcination stabilizes the compositionally changed surface region, generating a functional surface layer. This fiber (diameter: 5 micro-meter) consists of the silica-based core-structure and the gradient-like surface titania layer, which are strongly sintered. Accordingly, this new fiber solved the aforementioned difficult problems related to peering of the titania layer, and also achieved high strength (2.5 GPa). Furthermore, they developed a water-purifier using this fiber (felt material), which was designed to contact with organic pollutants effectively. The maximum treatment quantity of the purifier is 3, 12, 40, and 80 ton/hour. This system is very simple with a module composed of the cone-shaped felt material and UV lamp. Purification of the water of collective bathtubs and swimming pools was actively performed. Any bacteria (common bacterium, legionera pneumophila, colon bacillus, and so forth) and organic chemicals (dioxin, PCB, and so forth) were effectively decomposed into  $\text{CO}_2$  and  $\text{H}_2\text{O}$  using the above purifier. Furthermore, the muddiness of the pool water was remarkably improved by the passage through the purifier along with a decrease in the organic filth and chloramines. About 50 purifiers using the titania fiber have been adopted mainly in Japan and Spain, so far.

This technology is an epoch-making, safe water-purification system taking the place of chlorine-sterilization, which is poisonous to the human body, and can totally realize “Human health”, “Safe environment” and “Save energy”.