Clarification of photocatalytic reaction mechanism by single particle microspectroscopy

Dr. Yoshiyasu Matsumoto
Fellow of Toyota Physical and Chemical Research Institute

Purpose of research:

Photocatalysts are expected to play a major role in solving energy and environmental problems, but the understanding of photocatalytic reaction mechanisms at the molecular level is still quite insufficient. Photocatalytic reaction rates at the surface of catalyst particles depend on various factors including the shape, aggregation degree, and surface orientation of facets of particles, etc. Because conventional researches have been conducted targeting an ensemble of catalyst particles with broad distributions in these factors, it is difficult to obtain how reaction rates are correlated with these factors. In this study, we perform microspectroscopic measurements of photocatalyst single particles and clarify how the spatial distribution and reactivity of photocarriers are influenced by these factors of photocatalyst particles. With this single particle microspectroscopy we aim to clarify the complex photocatalytic reaction mechanism based on information that cannot be obtained by conventional methods.

Method:

Focusing on a primary and a secondary particle, we measure systematically how the spatial distribution of photocarriers in a single particle depends on size, aggregation degree, and surface orientation of the particle. Furthermore, we extend the observation time long enough for the oxidation reaction of water actually to occur (operand measurements) to clarify the dependence of the reaction rate on the structures of photocatalyst particles and their surfaces.

Expected results:

Because catalytic reactions are generally quite complex and various factors are involved, catalysts have been developed on the trial and error basis. Development of semiconductors having an appropriate band structure is very important for improving the light conversion efficiency of photocatalyst, but it is also important to note that the light conversion efficiency depends greatly on the shape and aggregation degree of semiconductor particles. This study clarifies the shape and aggregation degree dependence of reaction in a single particle which has not been elucidated in the past. Thus, it is expected that this study leads to a guiding principle of optimizing the photocatalytic activity of microcrystalline catalyst particles.