Gwangju Institute of Science and Technology

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Professor Bong-Joong Kim's research team identifies growth kinetics of individual spiky gold nanoparticles by using liquid cell transmission electron microscopy

☐ GIST (President Kiseon Kim) School of Materials Science and Engineering Professor Bong-Joong Kim's research team is the first to identify the growth mechanism, kinetic characteristics, and morphology of spiky gold nanoparticles in real-time by using the principle of electron beam radiation decomposition with a transmittal electron microscope * in a liquid phase with liquid cells.

* transmission electron microscope: a microscopy technique in which a beam of electrons is transmitted through a specimen to form an image

- The results of this study are expected to benefit such fields as surface plasmon resonance sensors, biosensors, pharmaceuticals, drug delivery, renewable energy, and catalyst by identifying the principle to control size and morphology that determines the physical properties of gold nanoparticles.

☐ The spiky gold nanoparticles have a plasma resonance characteristic that can coordinate a wide range of light waves in the ultraviolet region from visible rays according to the sharpness of the spines located on the surface of the particles, enabling various fusion studies. In addition, this research has been urgently required to observe the entire process of growth of gold nanoparticles produced in liquid phase in real-time as the size of gold particles thorns also affects the light wavelength.

- For this purpose, real-time liquid transmittance electron microscopy, which enables real-time monitoring of nanoscale particles in a liquid crystal, has been developed and utilized. However, it was difficult to identify the source and process of producing pointed gold particles due to problems with the imaging technique because it was impossible to remove bubbles and single particles from the liquid cells in the microspheres.

☐ By using the real-time liquid cell transmission electron microscopy technique, the research team was able to completely remove bubbles by circulating water and by adjusting the electron beam size, dose *, and HAuCl4 solution concentration to create a single gold nanoparticle growth environment. The use of bright field imaging ** enables continuous electron beam to be administered to the liquid phase.

> * Electron beam dose rate: the number of electrons reaching a unit area (e.g. 1 nm2) in 1 second
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> ** Bright field imaging: a technique for imaging by selecting the beam transmitted as an aperture of the diffraction imaging

- The results showed that spiky gold particles turn into roughened shaped particles when faceted, and that they change in a wide range of wavelengths (530-1120 nanometers) through the UV-violet spectrophotometry. In addition, the theoretical modeling was able to quantitatively determine the gold concentration on the particle surface over time. Furthermore, the time to change the morphology of gold particles into a completely pointed form was inversely proportional to the density of the particles, and the density of the particles was found to be proportional to the density of the beam but not highly dependent on the liquid concentration.

☐ Professor Bong-Joong Kim said, "This research achievement is the first to quantify through homogenous nucleation * the generation, growth, and morphology of spiky gold nanoparticles used in a wide range of fields such as optics, energy, catalysts, and biotechnology. This is of great significance in revealing the fundamental principles of producing materials through nuclear generation along with developing new applications."

☐ This research, which was funded by the GIST-Caltech Research Collaboration fund and the National Research Foundaion, was led by GIST School of Materials Science and Engineering Professor Bong-Joong Kim with GIST School of Materials Science and Engineering Ph.D. student Wan-Gil Jung and was published by the *Journal of the American Chemical Society*, the most prestigious journal in chemistry, as its cover on July 10, 2019.