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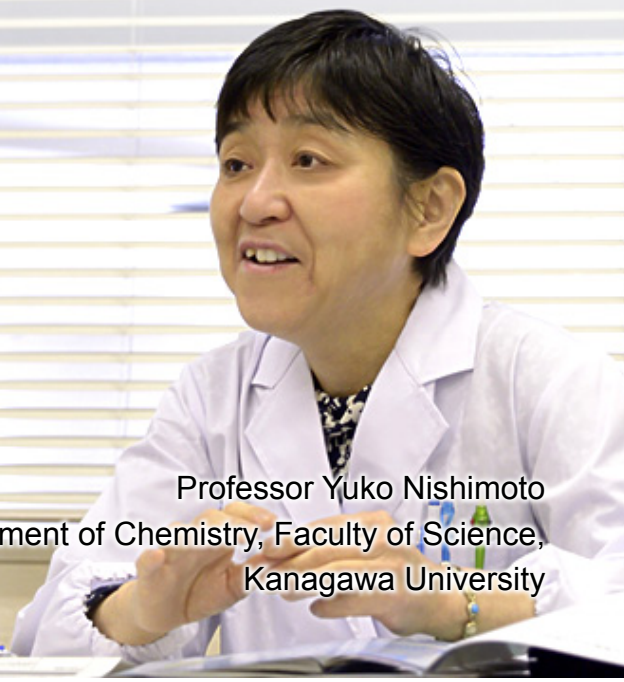
Hitachi High-Technologies Case Studies

Vol.1

Searching for new possibilities in water and in the air

Analytical chemistry looks for power in things around us

"Let's do what we can in analytical chemistry to protect our future!"
This is the slogan Professor Yuko Nishimoto came up with for her research laboratory at Kanagawa University in Kanagawa. She looks for answers to the mysteries in everyday things and searches for clues that tell us about the future.



Professor Yuko Nishimoto
Department of Chemistry, Faculty of Science,
Kanagawa University

Reexamining the ordinary from the perspective of chemistry

If we take a good look at the everyday, ordinary phenomena around us from a chemical perspective, we can find the reasons behind them.

Take eggs, for example. How are we able to boil them differently, like onsen (hot spring) eggs with firm yolks, and soft-boiled eggs with firm whites? When we examine the eggs chemically, we see that their proteins have different components, so that the yolk firms at a temperature of 70 degrees Celsius, while the white firms at 80 degrees Celsius. Therefore, empirically-known cooking methods are taking excellent advantage of these properties. Onsen eggs are gently placed in 70-degree water so their yolks firm first but their whites stay soft. On the other hand, soft-boiled eggs are heated at a higher temperature so that the surrounding white firms first, while the yolk inside stays soft.

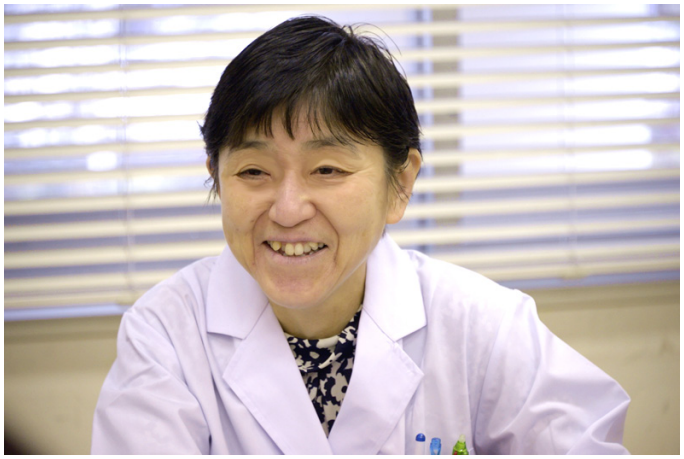
Taking a fresh look at the world around us, we see that all matter is made of atoms and molecules. How are these atoms and molecules contained within different kinds of matter, and what special characteristics do they generate? The field of science that seeks answers to these questions is called analytical chemistry.

"Analytical chemistry is solving one riddle after another. The process of finding unknown answers one by one makes it fun."

Sharing the joy of that process is Professor Yuko Nishimoto, a researcher in analytical chemistry at the Department of Chemistry, Faculty of Science, Kanagawa University. Through analytical chemistry, once the reasons matter is given certain characteristics are found, they can be applied in various ways. From development of new materials for industry to advancements in medical technology to solving the mysteries of life, analytical chemistry is contributing to developments in a wide range of fields.

Professor Nishimoto is focused on the role played by water and air in our lives, and she aims to take analytical chemistry beyond “protecting the environment” toward “improving the environment.” It’ s about more than just avoiding a negative impact on the Earth; it’ s about finding the features in nature that benefit the environment, and putting them to work. She believes analytical chemistry can be applied to make this happen.

“I'm looking for ways to make life more comfortable and convenient using the power of nature, from a scientific point of view.”



Professor Yuko Nishimoto
Department of Chemistry, Faculty of Science, Kanagawa University

Searching for limits of “functionality” to keep from harming the environment

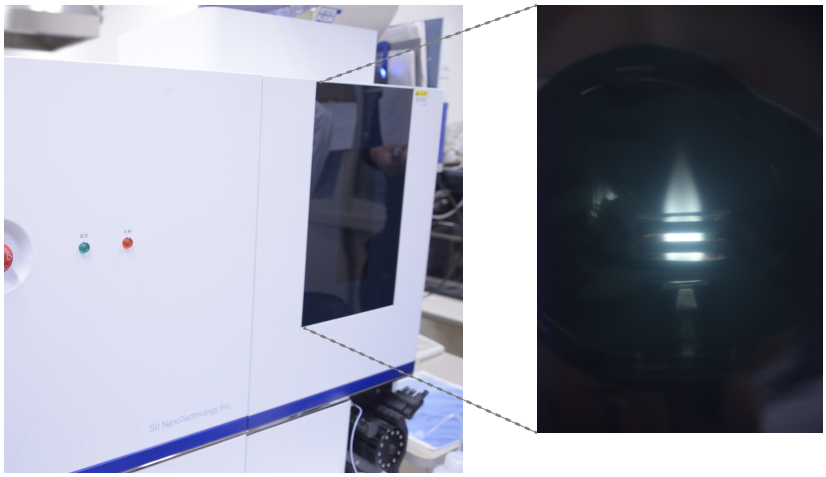
Professor Nishimoto practices analytical chemistry with a focus on the environment around us. One of the subjects of her research is water. She is particularly interested in what she calls “functional water[1]” . This is water that that is treated by humans and changed in nature to give it some sort of function. It is currently being used in medicine and healthcare for such purposes as finger disinfection, sterilization of pathogenic microbes, and relief of stomach ailments. There are also hopes for its use in agriculture to prevent diseases in crops.

The fact is that humans have known for many years that water can be treated to generate various kinds of effects. For example, electrolysis applied to water with just a little salt added can produce a sterilizing effect. However, the reasons for such effects have been unknown for a long time.

“A magazine reporter once handed me an electrolysis device that was supposed to make ‘water good for the skin,’ so I analyzed the water from that device. I found out that it was the chlorine that appeared at the time of electrolysis that was the reason for its sterilization power. And it turns out that the sterilization capability of water with salt added was also a result of chlorine!”

Chlorine has a reputation of being harmful to the body, but Professor Nishimoto says, “It's all about the limit – keeping it within a certain amount. It's important to look for the ‘level’ at which no harm is done to the environment as we make something functional.”

Professor Nishimoto uses a variety of analytical instruments to learn more about the nature of water. One of these is an ICP optical emission spectrometer. ICP stands for inductively coupled plasma. When a sample is introduced inside high-temperature plasma, it emits light, and the wavelength of this light varies depending on the type of element involved. This instrument measures the strength of the wavelength to



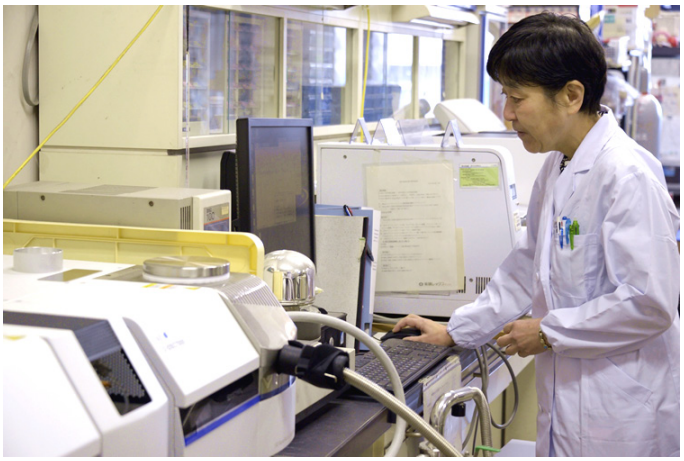
At left, an ICP optical emission spectrometer in use at Kanagawa University. At right, a sample emitting light with plasma.

1: The Japanese Society for Functional Water defines functional water as “an aqueous solution that has acquired a useful function that is reproducible through artificial process, for which clear scientific basis regarding treatment and function has been obtained or will be obtained.” Typical varieties of functional water include ozone and alkaline ionized water.

determine what element is inside and how much is contained. When analyzing water, it can measure the elements dissolved within the water.
Moreover, since the dissolved substance alters the boiling points and other properties of the water, a method called differential scanning calorimetry (DSC) is used, which can measure the melting point and other properties of a sample being studied by looking at the difference between the heat quantity of the sample and a substance that serves as a reference.

These are the methods by which Professor Nishimoto has found the reasons for the empirically-known functions of water. Now she is focusing on water containing sodium ions, and water with potassium ions.

“The cells inside our bodies have many sodium ions on the outsides, and many potassium ions on the insides. There should be a reason for that difference. If we can thoroughly investigate the nature of water, we can probably create even higher-quality water in the bodies of humans and other mammals.”



Professor Nishimoto works with differential scanning calorimetry.

Objects from the trash can benefit the environment

Another subject of Professor Nishimoto's research is the air. It's such a commonplace thing for us that we usually give it little thought, but sometimes it influences people and other living things.

One of the areas studied in analytical chemistry is volatile organic compounds (VOCs), which are found in building materials and other products. VOCs are organic compounds that drift into the air even at room temperature from liquids such as paints, adhesives, and gasoline. The VOCs that are emitted by building materials may lead to sick building syndrome, which can cause health problems such as headaches and asthma. Professor Nishimoto began her research alongside construction companies that are working on VOC countermeasures.

“We developed a method that detects VOCs thought to be emitted by building materials in a shorter time than conventional methods,” said Professor Nishimoto. This research has resulted in development of a rapid VOC measurement method that combines devices for thermo gravimetry (TG), evolved gas analysis (EGA), and other instruments.

Professor Nishimoto is also analyzing the functions of materials that absorb VOCs. She uses a gas chromatograph-mass spectroscopy (GC-MS) to measure the remaining amount of VOCs in the air and determine how much VOCs the materials are absorbing. One of the materials known to have a high absorption capability is charcoal, especially bamboo charcoal.

Professor Nishimoto once accepted a proposal from the Aomori Prefectural Industrial Technology Research Center to determine whether or not the residue generated from the huge amounts of apples used to make juice could be used as a VOC absorbent. When she analyzed the “apple charcoal” they provided, she found that it exhibited superb VOC absorption rates, including 80% of the benzene used as solvent for paint, and 95% when treated with steam. “I'd like to make efficient use of this material that is usually thrown in the trash,” says Professor Nishimoto.

“If we can increase the added value of these materials through analytical chemistry, I believe we can put them to even wider use.”

Apple charcoal and Hiba charcoal provided by the Aomori Prefectural Industrial Technology Research Center. A large number of samples have been collected in the laboratory.

Broader and deeper knowledge of matter can generate new possibilities

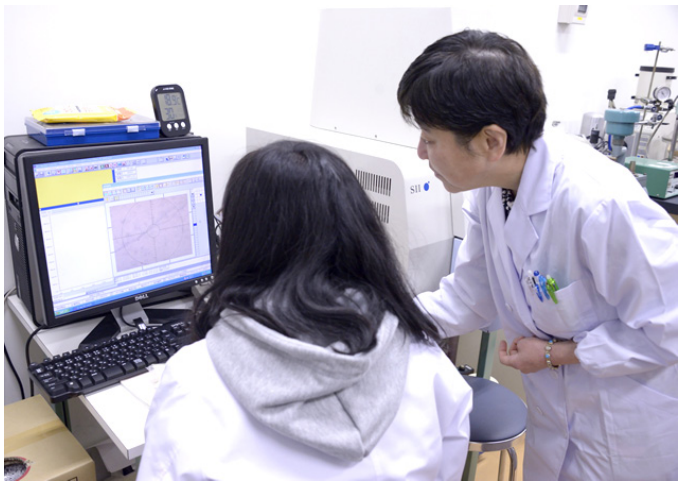
As Professor Nishimoto continues her research in analytical chemistry, she arrives at the thought that “utilizing the power of nature itself is important.” Things made through a combination of two substances often results in a stronger interaction, which could pose harm to the environment, she says.

“I want to effectively bring out the actions that substances in nature have. Therefore, rather than mixing or combining various substances, I want to try using individual substances – just water if it's water, or just apple charcoal if it's apple charcoal.”

Through careful analysis of the nature of substances, methods to better utilize their functions begin to emerge. Eliciting these functions one by one will generate new technologies. And from there, says Professor Nishimoto, she gets so excited that she can't stop! She is starting from a broader, deeper knowledge of matter, with her eyes on the future.

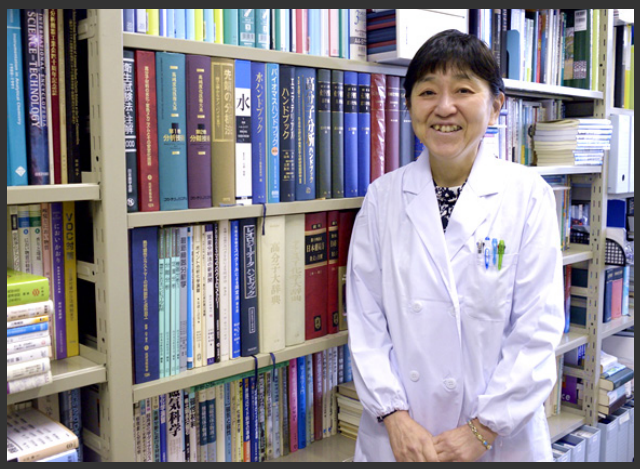
“Let's keep doing what we can in analytical chemistry to protect our future!”

Those lessons will be handed down to Professor Nishimoto's successors studying at her laboratory. Hitachi High-Tech will support the insatiable curiosity of scientists with the latest technologies.



The process of learning unknown facts one by one is similar to a detective novel. Professor Nishimoto wants to convey this fascinating process to her students.

Professor Yuko Nishimoto
Department of Chemistry, Faculty of Science, Kanagawa University



A graduate of the Chiba University Faculty of Science, Department of Chemistry, she completed her master's program at the Chiba University Graduate School of Science. She was employed by Seiko Instruments and worked on making applications for analytical instruments in the company’ s Scientific Instrument Division, Application Laboratory.
She joined Kanagawa University when its Faculty of Science was established. She served as a Faculty of Science assistant, lecturer, assistant professor, and associate professor prior to her current position. She is also a Doctor of Science. With the slogan “Let's do what we can in analytical chemistry to protect our future!” she is engaged in production and analysis of functional water, environmental sample analysis methods, and analysis of samples related to cultural properties.

Website:
Kanagawa University http://www.kanagawa-u.ac.jp/english/
Kanagawa University Faculty of Science http://www.sci.kanagawa-u.ac.jp/english/

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