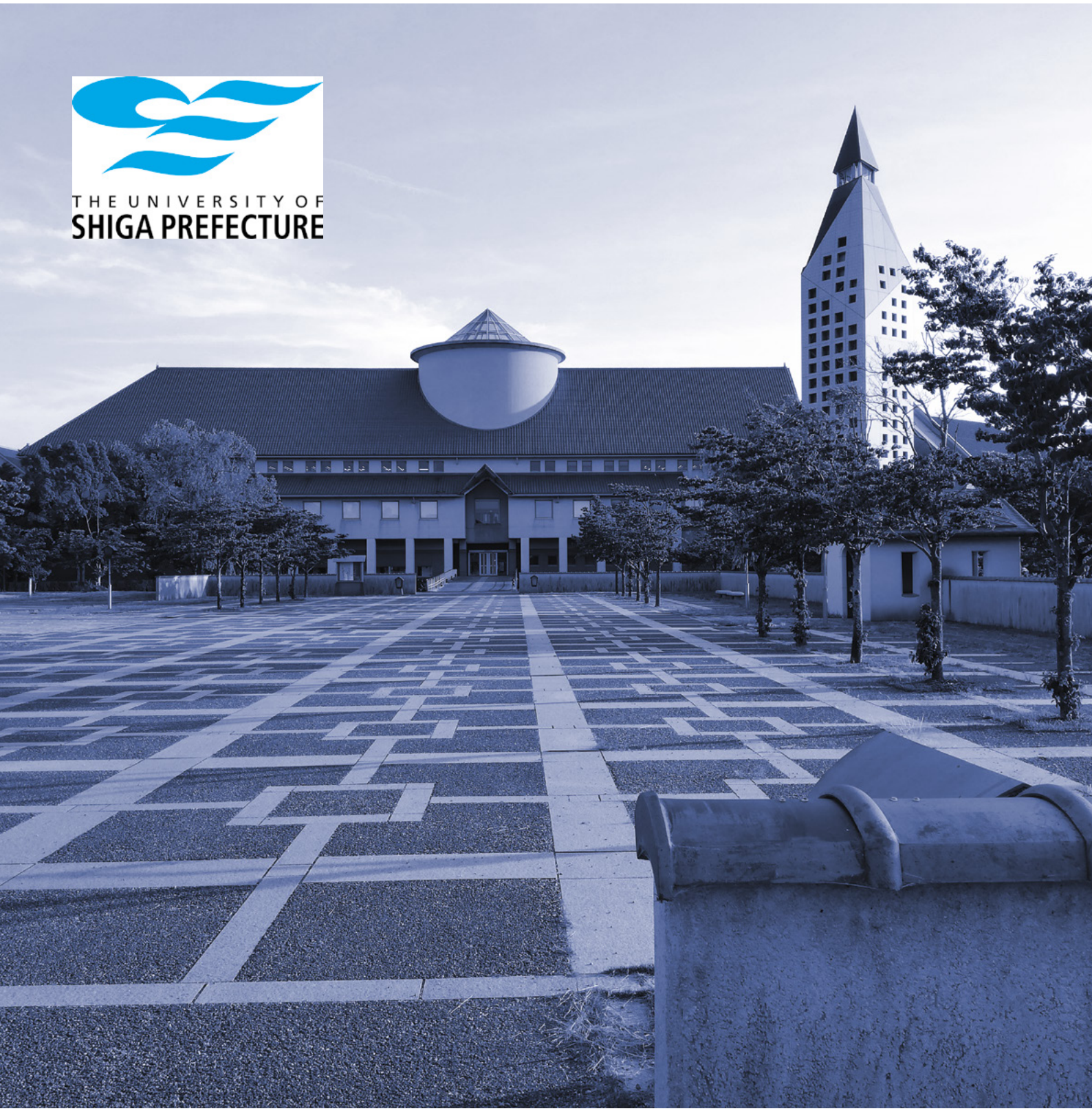
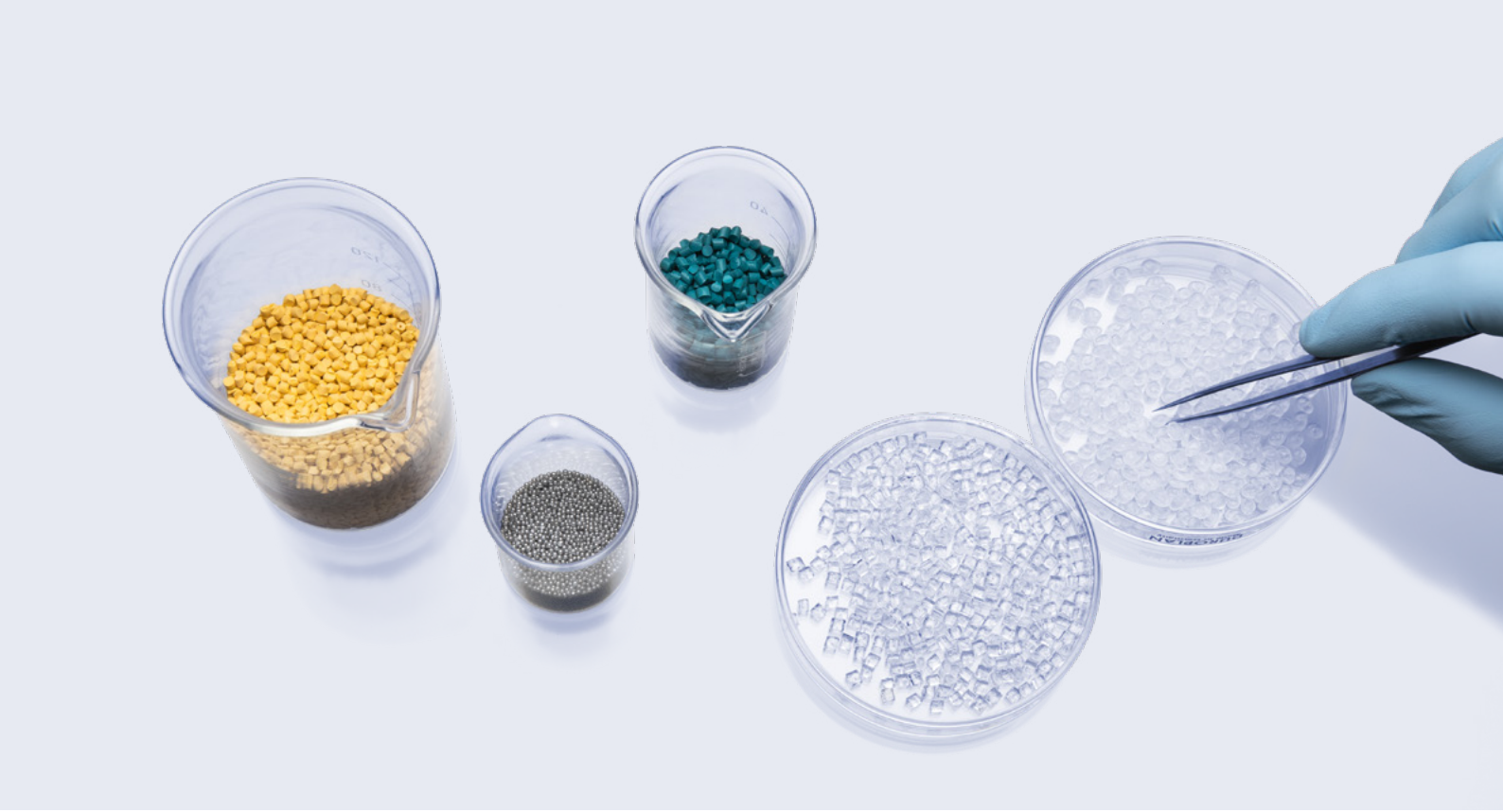
Anton Paar



Using Anton Paar Instruments to Research Polymer Crystallization

Relevant for Chemical Industry



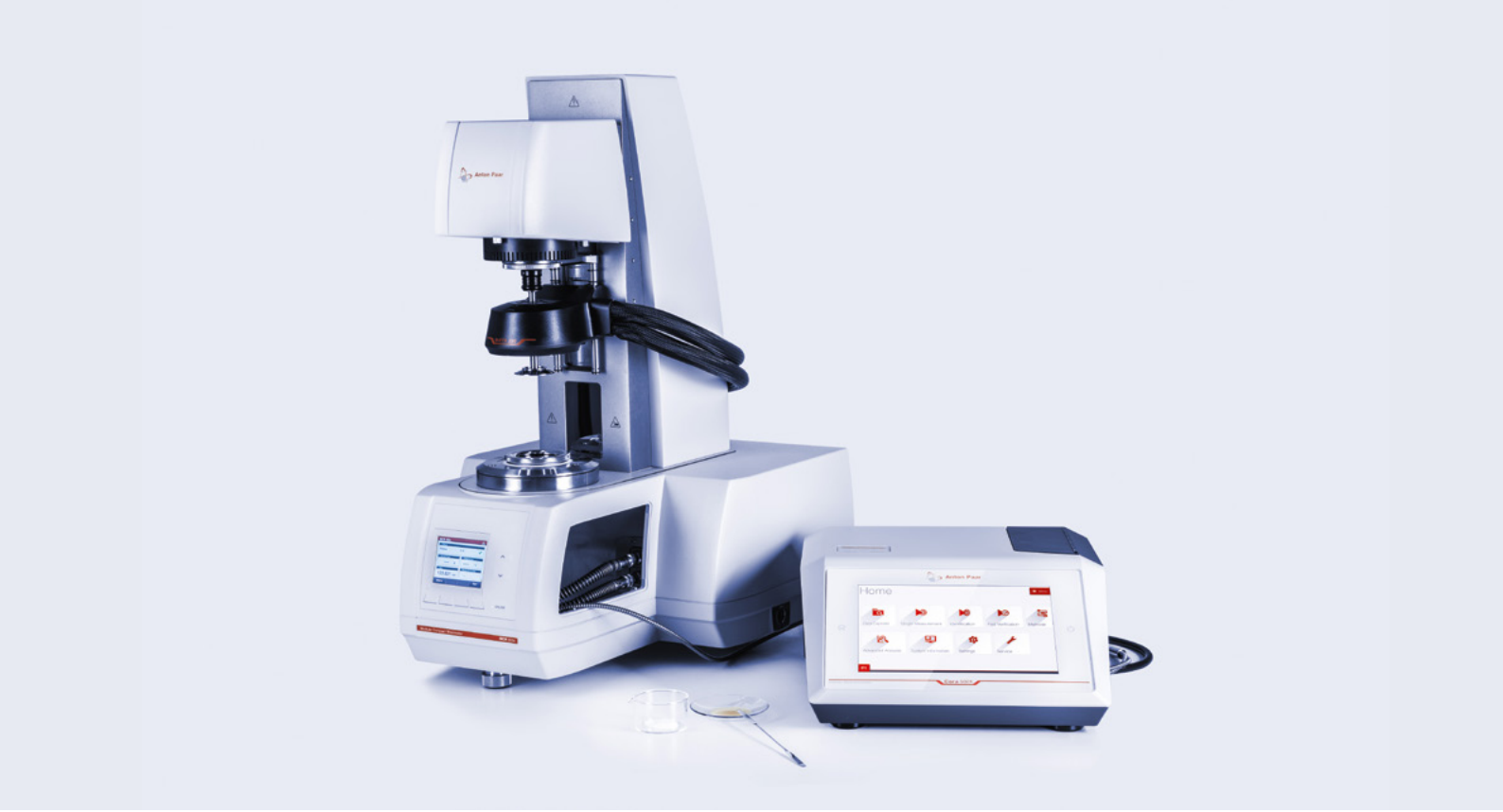
→ Polymer materials

Dr. Takumitsu Kida, PhD, is Lecturer at the University of Shiga, Japan. He talked with us about how his team is using Anton Paar instruments to research polymer crystallization, in particular to analyze semi-crystalline polymers.

Could you please introduce yourself briefly?
I am Takumitsu Kida and am affiliated with the University of Shiga at the Faculty of Advanced Engineering. I moved to this position last April. Before that, I worked at the Japan Advanced Institute of Science and Technology. I mainly study polymer physics and the rheology of polymer materials, and my main research topic is the mechanical properties of polymers.

What kind of work does the Faculty of Advanced Engineering do now?
We study the very basic rheological and tensile properties and behavior of polymers and polymeric materials to develop excellent new materials. So, we use various kinds of polymers, such as polyethylene, polypropylene and also new polymers. And we try to develop new theories between chemical structure and mechanical properties.

And why is that important? What's the link to real-world applications and benefits?
In our daily life, we actually use various kinds of polymers; polyethylene and polypropylene are widely used for things we use every day. Sometimes we even use polyethylene as fibers, but the controlling of the rheological and mechanical properties of such polymers is very difficult because such polymers have a very complicated structure. For example, polyethylene has a crystalline structure, and the degree of the crystallization and orientation of such crystals strongly affect the mechanical properties of polymers. So, the controlling of the mechanical properties of those is very tricky, even though such polymers are very simple on a basic level. In particular, the recycling of plastic is a very important issue for polymeric materials. To ensure high quality recycling, it's vital to control the



→ MCR Evolution and Cora 5001

polymers' structure.

Which Anton Paar instruments do you use?
The MCR modular compact rheometer and the Cora Raman spectrometer.

What exactly do you use these instruments for?
We use the rheometer to obtain basic rheological properties of polymers under various conditions. When it comes to investigating the crystallization behavior of polymers, sometimes the rheometers are subjected to loads that are too heavy. Since Anton Paar's rheometers efficiently control the stress, there is no need to be afraid of instrument failure. This is a very important point. Also, the software of the Anton Paar rheometer is excellent for controlling the measurement conditions.

Raman spectroscopy can be easily combined with Anton Paar's rheometers, and this combination is really important for me. Of course, we can measure the rheological properties and Raman spectra by using each instrument separately, but the simultaneous measurement adds another dimension. In the case of a separate measurement, for example, the controlling of the temperatures and deformation of the sample is very difficult. So, if we can measure the rheological properties and Raman spectroscopy at the same time, we can get excellent results.

What are the main challenges that the instruments allow you to address?
I think the most promising aspect is the combination of the Raman and the rheometers that opens the door to rheo-optical measurement. Rheo-optical means the combination of vibrational spectroscopy and mechanical testing. We have developed various kinds of rheo-optical measurements such as the combination of IR and tensile machine, and also Raman and tensile machine. But usually, the combination of the rheometer and Raman spectroscopy is very difficult. In the case of laboratories, we cannot develop it by ourselves, but fortunately Anton Paar developed the combination of the Raman spectroscopy and rheometers. Thanks to this combination, we can accurately control the temperature and get great results in record time.

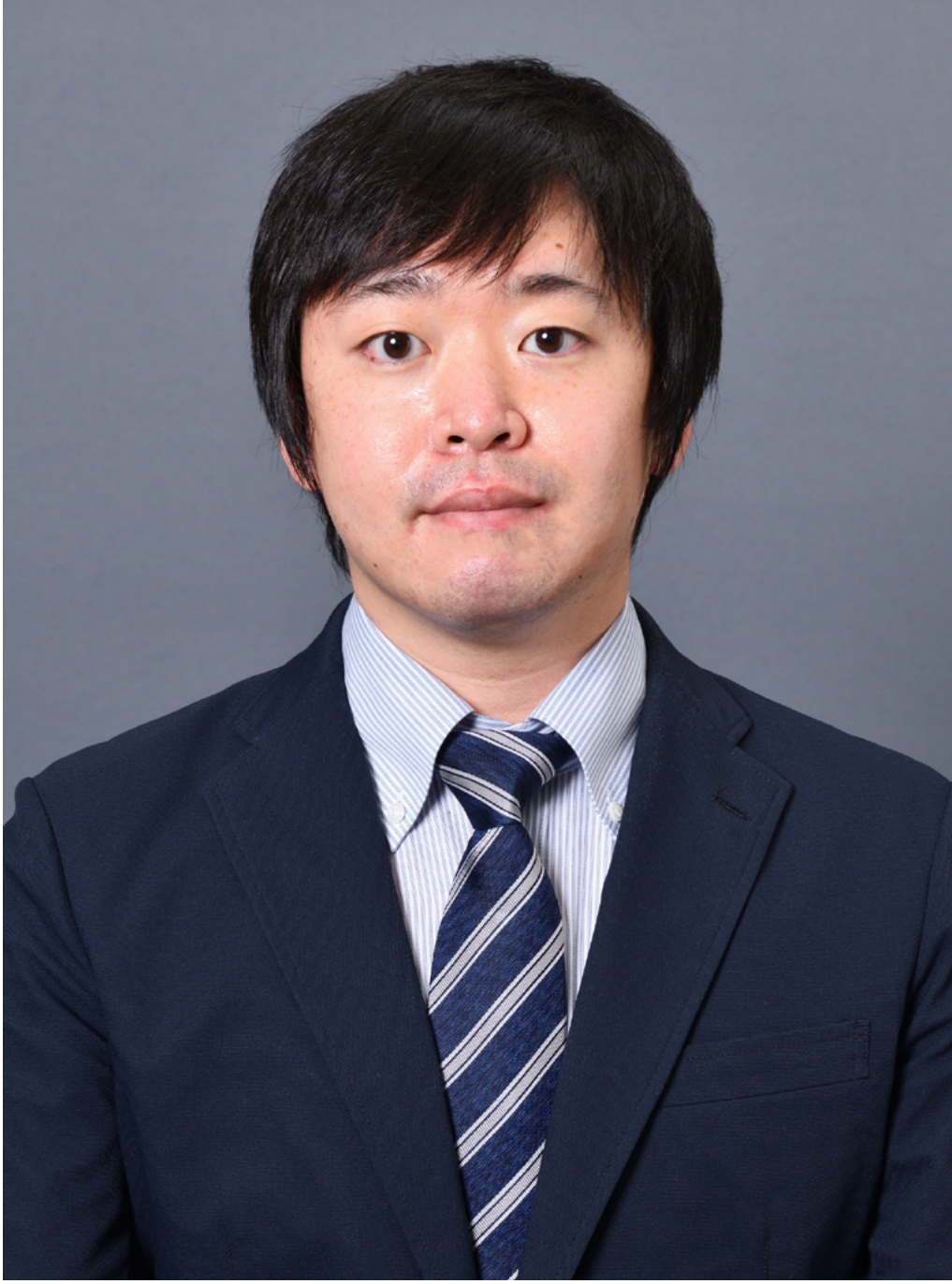
What are some of the follow-on benefits of that ability to your work?

"The Rheo-Raman combination itself is very unique. We cannot get such results by using other instruments, so I think this is the most important point."

Dr. Takumitsu Kida, PhD, Lecturer at the University of Shiga, Japan

“The software of the Anton Paar rheometer is excellent. We can easily use it and control the measurement conditions”

Dr. Takumitsu Kida, PhD, Lecturer at the University of Shiga, Japan



→ Dr. Takumitsu Kida, PhD, Lecturer at the University of Shiga, Japan

By using the Rheo-Raman spectroscopy, the combination of Raman and rheometers, we can get two kinds of data from the instrument: the macroscopic behavior of polymers and also the microscopic information of polymers.
We applied this system to the crystallization of polymers. In this case, the polymer has a super-molecular structure. The structure has a huge size range, from nanometers to micrometers, so, if we want to get such results over a wide length scale, we need to measure with the rheometer and the Raman spectrometer at the same time. This way, we can get complete results during the crystallization. By using this instrument, we can deeply understand the mechanism of the crystallization of the polymers. And this crystallization knowledge is very important for polymer processing since the polymer is solidified at various conditions at various temperatures and various shear flows. So, the understanding of the crystallization behavior at various conditions is very important for obtaining excellent material properties. The Rheo-Raman spectroscopy simultaneously provides us with very good results in record time.

What are some other advantages that you can think of?

We can also combine the Raman spectrometer with other instruments, because Anton Paar's Raman spectrometer can be adjusted to serve different applications. Thanks to its flexibility, we can combine it with another tensile testing or mechanical machine.

You already mentioned the importance of this unique setup of combining a rheometer with a Raman spectrometer. What is the main benefit?
I think the reliability is the most important point, because if we measure separately with the rheometer and the Raman spectrometer, the temperature history and the deformation history is completely different. Since Anton Paar's Rheo-Raman setup is measuring simultaneously, we can fully rely on the data we get. This is a huge advantage when it comes to publishing papers. We received great comments from reviewers when we published the results.

A follow up question to the point you also made about the robustness and safety. So, if I understand correctly, this means that these instruments are also very good for young scientists who are developing their knowledge and their skills and training?
Yes. Because in the case of the polymer materials, sometimes polymers show very high stress values during the measurement, and sometimes when we use the strength control rheometers, the rheometer is completely broken and that costs a lot of money. But Anton Paar's rheometers control stress very effectively. When we apply too much deformation or the sample shows too much stress, the rheometer automatically stops. I think this is a very good point for young researchers and students.

Anton Paar has a reputation for very good service. How would you describe that aspect of your relationship with Anton Paar and the instruments?
The Anton Paar staff are always so helpful, providing us with a lot of information on new instruments and new software updates for the Raman spectrometer and the rheometers.

How happy are you with your relationship with Anton Paar?
Usually after we buy a new instrument from other companies, many relationships are then finished. But in the case of Anton Paar, after we bought the new instrument, they provided us with new developments, other complementary instruments and advice on how to use them. When we attend international and domestic conferences, we usually attend some of the presentations from the Anton Paar staff as these are always very informative.

FIND OUT MORE

www.anton-paar.com/css-raman-setup

Instruments: Cora 5001, MCR 102e

Measured parameters Raman spectra change during rheological investigations, changes in chemical functionality and microstructure

Samples Polymer materials

Temperature range -20 °C to +300 °C