

# Report on Internship at University of Toronto

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## 1. Research in Toronto

At the Toronto Smart Materials & Structures Laboratory, led by Professor Hani Naguib, I researched data-driven development of organic polymer aerogels. This laboratory is at the forefront of research on polymeric nanoporous materials and the application of machine learning. Organic polymer aerogels are nanomaterials with pore structures, offering ultra-low density, excellent thermal insulation, and rigidity, making them valuable across a range of fields such as aerospace. However, creating samples can take several weeks, and a trial-and-error approach is not practical for exploring and optimizing processing conditions to achieve high material properties. Therefore, my research aimed to develop a high-throughput method using machine learning to explore novel processing conditions on a computer.

Figure 1 illustrates the flow of this research. We collected datasets on processing conditions and material properties, from past papers. Analysis of these datasets confirmed a correlation between processing conditions and material properties. Additionally, we successfully developed a machine learning model that accurately predicts properties from creation conditions using techniques such as Gaussian process regression. We generated over 1,600,000 new creation conditions not explored in previous studies and successfully predicted the properties of materials created under these conditions. Among the predicted conditions with high material properties, we proposed new chemical structures not reported in past literature, which were confirmed to be reasonable from the perspective of polymer backbone chemistry. The results of

this research are being compiled into an academic paper, which will be submitted to an international journal soon.

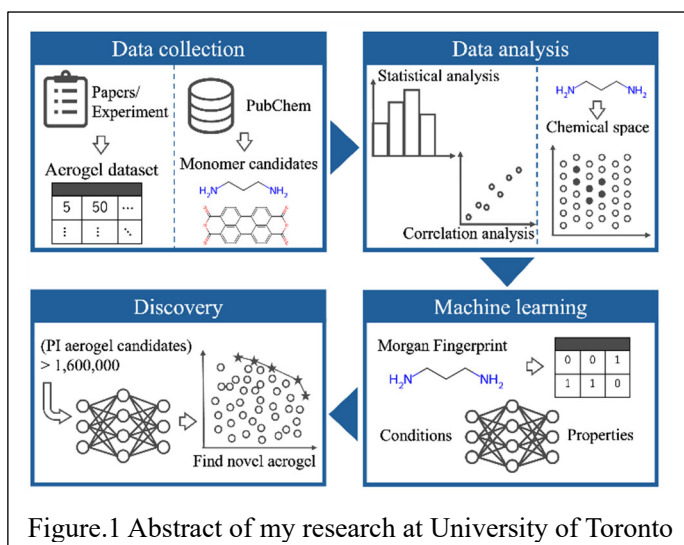
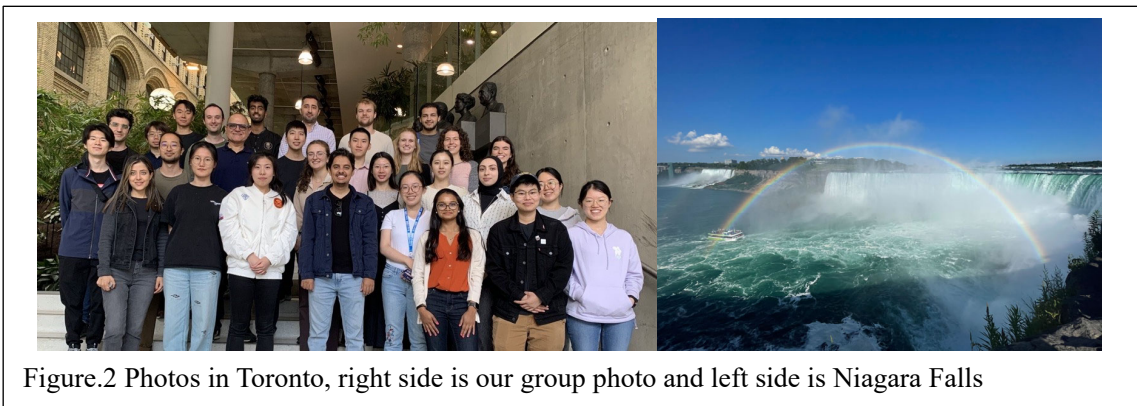


Figure.1 Abstract of my research at University of Toronto

## 2. Life at Toronto

Toronto is Canada's largest city with skyscrapers in the downtown area. However, the University of Toronto is located in a relatively tranquil area a bit away from the center of the city, with many historic buildings over 100 years old. Canada is a multicultural country, and the laboratory was composed of members from diverse regions. (Figure 2) I saw members at weekly meetings and weekends. I stayed at Chestnut Residence, located about a 10-minute walk from the university. This residence was originally used as a hotel, and the rooms were very comfortable hotel-style accommodations. The residence included breakfast and dinner, which made my first long-term stay abroad stress-free.

Toronto is a multicultural city with a diverse population and it has numerous restaurants offering specialized cuisine from various countries and supermarkets stocked with international ingredients. Japanese ingredients were readily available, so I rarely missed Japanese food. Conversely, I was able to enjoy authentic regional cuisines not easily found in Japan. On weekends, I explored Toronto and visited nearby cities. For example, Niagara Falls, one of the three major waterfalls in the world, is accessible within about two hours by train from Toronto. The area around the falls is a tourist hotspot, complete with restaurants, hotels, and cruise tour facilities. In the evening, a rainbow often appears over the falls, creating a very picturesque and enchanting scene.



## 3. Conclusion

Through this program, gaining experience in international collaborative research has been extremely valuable for advancing my career as a researcher. Besides acquiring new research findings and improving language skills, I developed a respect for diverse research team members and the ability to adapt to new environments. I would like to express my gratitude for the support provided by the Mazume Research Encouragement Prize at Kyoto University.