Prayogik Rasayan

Chemical Safety Concern Led to Small-scale Chemistry and Green Chemistry

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Abstract

My interest in chemical safety has led me to focus on small-scale chemistry and green chemistry, which enables me to introduce the low-cost and practical hands-on chemistry experiments to schools and universities in Thailand and ASEAN countries. These experiments include the organic chemistry using the Small-Lab Kit, the portable organic lab kit invented by me. It has the benefit of saving chemicals and energy, as well as reducing experimental time and waste, but most importantly increasing chemical safety to the students and laboratory staff. In addition, I have voluntarily serviced for several scientific and science-related non-profit organizations which I can contribute more to the scientific community and also learn some new things at the same time.

Keywords: chemical safety, green chemistry, small-scale chemistry

Discussion

After obtaining my M.Sc. in chemistry, I went on to join the Department of Chemistry, Faculty of Science, at Chulalongkorn University as an instructor in 1975. About a year later, I obtained a Fulbright scholarship to further my Ph.D. study in Worcester Polytechnic Institute (WPI), USA, and graduated in 1982. I returned to Chulalongkorn University in the year that the government began developing the first petrochemical complex in Thailand, so I was assigned to be one of the four faculty members to design and teach a multidisciplinary master's program on petrochemistry and polymer science and later was appointed to be the Founding Director of the Petroleum and Petrochemical College, the first of its kind in Thailand, established in 1989. It provided me with a great opportunity to get to know and interact with many executives from different industries and businesses. Furthermore, I was a consultant for a group of petrochemical companies for 11 years since 1989. This gave me the opportunity to better understand the industry and the importance and the influence of chemical accidents on human beings, as well as the relationship between chemistry, education, industry and business.

Based on my exposure to industry and business, I could initiate an international undergraduate program in applied chemistry, accepting students in 2005. It offers a unique integration of chemistry and its applications to industry, business and society. Another program initiated by me is a multidisciplinary Master and PhD program called 'Technopreneurship and Innovation Management', accepting students in 2007. This program aims to bring lab-bench work and patents to the market, Both programs become popular in the country till now. Recently I have helped my Department to launch the graduate program on Green Chemistry and Sustainability", which will accept the students in August, 2021.

Professor Supawan Tantayanon

At the beginning of my career, I was just a lecturer in organic chemistry of Chulalongkorn University in Thailand. Along with my teaching and research work, I had the opportunity to do several other tasks, including the volunteering services to science and science-related foundations and societies. These experiences gradually influenced my teaching and research interest so much that my focus shifted to "greener" and application-driven chemistry.

In another angle of my teaching career, I pay much attention on the chemical safety in the chemistry laboratory till now. In fact, academic laboratories have been considered as more hazardous than industry due to the use of diverse chemicals, especially for doing research, and the relaxed approach of academic management for chemical safety. That means the risk of chemical exposure to the teachers, students and laboratory staff of all academic and research institutes is higher than industry.

I believe everyone in my department understands the danger of chemicals, but we seem to ignore the importance of chemical safety - probably because of

budgetary constraints and lack of enforcement. A few colleagues and I attempted to promote and set up a chemical safety program in 1990, beginning with the formation of the Chemical Safety Steering Committee of Department of Chemistry. Through this committee, we established rules and regulations regarding chemical safety. Each research lab must be audited and the graduate chemistry students must pass a chemical safety test before gaining permission to conduct research in the lab. Now, universities require all science and science-related undergraduates to learn chemical safety and pass a test before they will be allowed to take lab courses. For the graduate students, they must attend a safety training with staff and pass a chemical safety test before beginning their research. I am responsible for the development of the university chemical safety training program and conducting training courses until 2018.

In 2000, I initiated a project, supported by the Thailand Research Fund, entitled "Chemistry laboratory based on chemical safety and pollution minimization", collaborating with 14 different faculties from seven Thai universities. This arose from my concern for the safety of students and laboratory staff, while performing chemistry lab experiments. We selected and tested experiments from both general chemistry and organic chemistry labs. During our investigation, we all agreed to go for small-scale chemistry or microscale chemistry, which is defined by IUPAC as the reduction of chemical use to the minimum level at which the experiments can be effectively performed. Several advantages of using small quantities of chemicals in academic laboratories, besides lowering the risk of the chemical exposure, include reducing costs, time, energy, waste, and allowing many experiments to be done outside of the laboratory.

For general chemistry, it can be done using apparatus and techniques developed in microbiology and molecular biology research. For example, using plastic pipettes and well plates that scale down the chemicals' volume and mass to one-thousandth the size of those used in traditional chemistry labs. However, we were faced with a lack of small-scale glassware in our country. To solve this, I designed a few pieces of special glassware. For example, a recovery distilling head and suction filter with ground glass joint. I thought about what we would need to carry out safe and convenient organic experiments, and so other equipment, like hot plates, lab stands, clamps, water hoses as well as water suppliers and suction pumps were put together. I made a prototype of a portable, complete set of small-scale organic equipment, called Small-Lab Kit (Figure 1 upper left and right). I patented several pieces of the kit as an inventor and the university has licensed the kit to the company. Today, the Small-Lab Kit is commercially available. I have promoted the Small-Lab Kit through workshops, lectures, exhibition displays and presentations at several conferences nationally and internationally.

In 2001, I was selected to join the green chemistry workshop prior to the CHEMRAWN XIV in Boulder, Colorado, U.S. I learned the concepts, principles, and methodologies of green chemistry. Green chemistry is particularly helpful for introducing new pedagogies because it introduces new ways of thinking about chemical concepts within the context of "real life" issues. In addition, given its intrinsic safety, green chemistry allows the introduction or reintroduction of experiments and demonstrations in settings for which safety and cost issues prohibit traditional chemical experimentation,

Figure 1: A box of Small-lab kit (upper left) and its components (upper right), Small-lab kit on UNESCO website (lower left) and Green Chemistry book in Thai (lower right).

allowing science to "come to life" in the lab. The experimental procedures, designed to highlight green chemical concepts, were for the most part risk free. Rather than dogmatically insisting on protective gear even when it was not necessary, the instructors honestly appraised each situation and recommended appropriate safety precautions. In so doing, I and my team avoided contributing to the "chemophobia" that is instilled by insisting that all chemical experimentation is dangerous and simultaneously highlighted a central lesson of green chemistry regarding the assessment rather than assumption of risk. Through this thoughtfulness, we were able to engage participants in the proper use of protective gear in those few cases where it was indeed called for.

I have also translated a book, "Green Chemistry: Theory and Practices", by Paul Anastas and John Warner, into Thai. The translated book was printed and disseminated to schools, universities, research institutes and the Chemical Society of Thailand members during the International Year of Chemistry in 2011(Figure 1 lower right). I used the Small-Lab Kit to illustrate several principles of green chemistry, including the prevention of waste, energy efficiency, and minimization of the potential for accidents. Fortunately UNESCO requested me to share online the experiments the Small-Lab Kit can perform, which can now be accessed and downloaded from the UNESCO website since 2009 (Figure 1 lower left). This has made me very proud of the invention.

The laboratory work is considered very important to promote students' learning of science. Teaching hands-on chemistry experiments in schools can then help increase students' interest in chemistry.

The small-scale chemistry laboratory techniques together with green chemistry concept can enable teachers and students overcome obstacles to availability of laboratories, equipment and materials which together influence learning opportunities and outcomes, while the risk of the chemical exposure is much lower than the traditional experimentation. Accordingly, I have been able to organize the teachers' training about small-scale chemistry whenever possible. Fortunately, DOW Chemical Thailand Co., Ltd. has financially supported such trainings consecutively in Thailand for eight years since 2013, while Bangkok Bank Public Co., Ltd. has funded the similar trainings for 3 years in each country; Myanmar (2017-2019), Cambodia and Indonesia (began in 2018), Vietnam (began in 2019) and the Philippines (due to COVID-19 pandemic, it may begin in 2022). These activities gradually gained recognition from schools, teachers and chemists in Thailand and ASEAN countries.

Furthermore, I voluntarily serviced for several scientific and science-related non-profit organizations and I held numerous national and international positions including;

- The first President of Polymer Society of Thailand (PST), (1997-2003).
- The eighth President of Pacific Polymer Federation (PPF), (2002-2003).
- The tenth President of Chemical Society of Thailand under the Patronage of HRH Princess Chulabhorn (CST), (2007-2013).
- The seventeenth President of Federation of Asian Chemical Societies (FACS), (2011-2013).
- The second President of the Council of Science and Technology Professionals (CSTP), (2017-2021).
- The seventeenth President of Science Society of Thailand under the Patronage of His Majesty the King (SST), (2020-2021).

My accomplishments have been recognized and awarded. Some selected honorary awards are as follows:

- The Science to Excellence Award from the Thailand Senate in 2012.
- The Honorary Fellow from the Singapore National Institute of Chemistry in 2013 (Figure 2).
- The International Microscale Chemistry Award from the Microscale Chemistry Network in 2015.
- The CST Award for Distinguished Contribution to Chemical Education 2016.
- FACS Distinguished Contribution to Advancement in Chemical Education 2017.
- 2018 IUPAC CCE Distinguished Contribution to Chemistry Education.
- 2021 IUPAC Distinguished Women in Chemistry or Chemical Engineering.
- 2021 CRS® India Gold medal for her contribution for advancement and popularization of science.

Figure 2: Receiving the first international award: The Honorary Fellow of Singapore National Institute of Chemistry award together with 2010 Nobel Laureates, Professor Akira Suzuki (third from the left) and Professor Ei-ichi Negishi (second from the right).

My mother has taught me to plan and do several housework efficiently and responsibly. She always worked hard and made many sacrifices for her 10 sons and daughters. Of course, my mother is my role model. As I had been working, since I was a child, I do not feel that I have to work, but rather always do something I enjoy. My experiences have taught me to simply open up, look for opportunities, and never say no. I always did most of it with dedication and a well-thought out plan. Sometimes when obstacles arose, I altered my path to reach my goal, but I never changed my decision to achieve my goal – however, always making my family's happiness my top priority. I believe that my success is not just about what I have accomplished, but what I can inspire others to do.

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