Young Career Focus: Prof. Chris Slootweg (Van ’t Hoff Institute for Molecular Sciences, University of Amsterdam, The Netherlands)

Background and Purpose. SYNFORM regularly meets young up-and-coming researchers who are performing exceptionally well in the arena of organic chemistry and related fields of research, in order to introduce them to the readership. This Young Career Focus presents Prof. Chris Slootweg (Van ’t Hoff Institute for Molecular Sciences, University of Amsterdam, The Netherlands).

Biographical Sketch

Prof. J. C. Slootweg

Chris Slootweg studied physical organic chemistry at Vrije Universiteit Amsterdam (The Netherlands), main-group chemistry at the University of Sussex (UK) and homogeneous catalysis at the University of Amsterdam (The Netherlands) for his undergraduate and MSc degrees. He completed his PhD on highly strained organophosphorus compounds with Koop Lammertsma at Vrije Universiteit Amsterdam in 2005 before taking up a postdoctoral position with Peter Chen at ETH Zürich (Switzerland) until 2006. Now he is an associate professor at the Van ’t Hoff Institute for Molecular Sciences, University of Amsterdam (The Netherlands).

INTERVIEW

SYNFORM *What is the focus of your current research activity?*

Prof. J. C. Slootweg The mission of my laboratory at the Van ’t Hoff Institute for Molecular Sciences of the University of Amsterdam is to educate students at the intersection of fundamental physical organic chemistry, main group chemistry and circular chemistry. I find it most exciting to combine state-of-the-art computational chemistry with synthetic chemistry to facilitate the discovery of new concepts, processes and unique species.

SYNFORM *When did you get interested in synthesis?*

Prof. J. C. Slootweg My interest in chemistry was sparked by determining the identity of the minerals that I found in nature. Crystals of pyromorphite (Figure 1), the first phosphorus-containing mineral to be discovered, were displayed on the cover of my PhD thesis (2005) to reflect my quest for novel, structurally unique organophosphorus compounds. Growing crystals is still a key facet of my research. I love to create novel synthetic methodologies, to unravel mechanistic insights aiming for transferable understanding, as well as to develop scalable recycling methods.

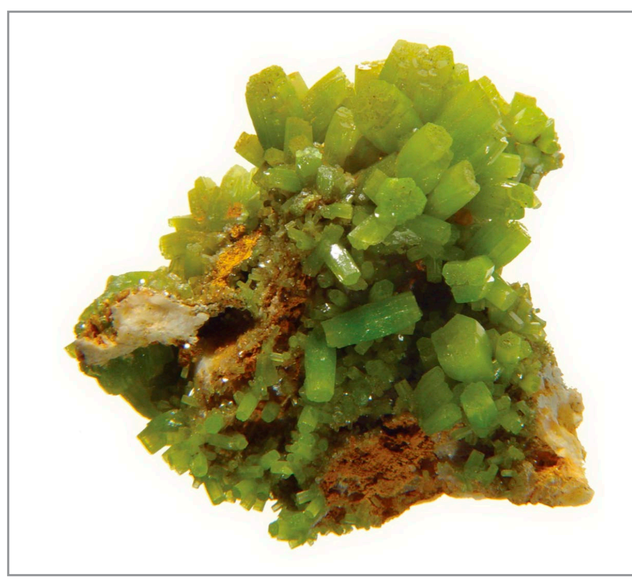

Figure 1 Pyromorphite [$Pb_5(PO_4)_3Cl$] (Gongcheng, Guangxi, China) was the first phosphorus-containing mineral, and was discovered in 1779. In 1813, it was named after the Greek words for “fire” and “form”, since after being melted, a sample will begin to take on a crystalline shape during cooling. *(Photograph by Willem Dijkstra)*

SYNFORM *What do you think about the modern role and prospects of organic synthesis?*

Prof. J. C. Slootweg Organic synthesis has always used fossil feedstocks as a resource and in recent years has also exploited the use of renewable resources, such as biomass. The next synthetic challenge will be to use waste as a resource for the development of novel (and existing) chemical products and processes, which will contribute to realizing a circular economy and securing our sustainable future. Only by reusing, recovering and recycling our valuable resources can we overcome material scarcity and solve environmental problems.

SYNFORM *Could you tell us more about your group's areas of research and your aims?*

Prof. J. C. Slootweg While my previous research endeavours targeted solely closed-shell (two-electron) processes in main-group chemistry, currently my laboratory also generates radicals on purpose and studies their redox chemistry and one-electron reactivity. This presents a unique possibility to advance, for example, the single-electron reduction of CO_2 as a productive strategy for carbon–carbon bond formation under mild conditions and propel the use of the CO_2 radical anion as a reactive intermediate in organic synthesis. Furthermore, driven by "how can I as a chemist contribute to sustainability", I explore circular chemistry (see below), which offers a holistic systems approach for the *bottom-up* development of molecular and materials chemistry to combat global sustainability issues.

SYNFORM *What is your most important scientific achievement to date and why?*

Prof. J. C. Slootweg To promote life-cycle thinking and circularity in chemistry, I developed the concept of circular chemistry and formulated the corresponding 12 principles (*Nature Chem.* **2019**, *11*, 190–195; Figure 2). Circular chemistry aims to replace today's linear 'take–make–dispose' approach with circular processes, which optimize resource efficiency across chemical value chains and enable a closed-loop, waste-free environment. By making chemical processes truly circular, molecules and materials can be repurposed near-indefinitely, resulting in energy as the only input. Chemistry is all about making molecules and materials and the principles of green chemistry provide an enabling framework for optimizing their synthesis and production. After their use, these molecules and materials ultimately need to be reused, recovered and/or recycled. To promote the development of molecules and materials from waste, circular chemistry highlights that chemistry is all about remaking molecules and materials too.

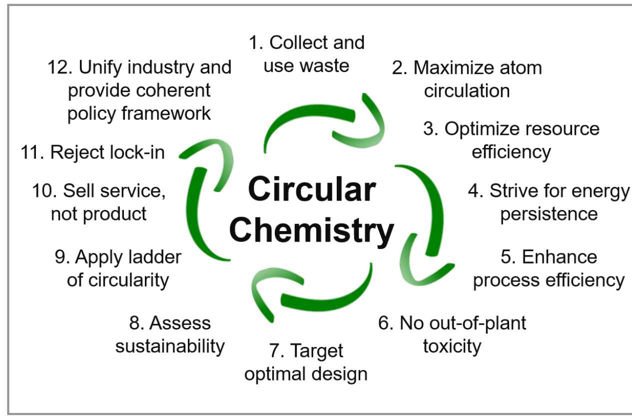

Figure 2 The twelve principles of circular chemistry (reproduced with permission from *Nature Chem.* **2019**, *11*, 190)

In Amsterdam, we develop sustainable phosphorus chemistry using waste phosphates as resource to produce high-grade phosphate products, such as specialty fertilizers and flame-retardants (Figure 3). SusPhos, now also a UvA spin-off, presents an ideal showcase for circular chemistry, since we contribute to solving environmental crises caused by a surplus of phosphates in the environment and make valuable products at the same time.

Figure 3 Steven Beijer, SusPhos researcher, showing phosphate waste (right) that are used as resource to make value-added phosphate products (left). *(Photograph by Rogier Chang)*

It is my desire to develop in the short term a Circular Technologies Center that uses chemistry as enabling tool to target the conservation of critical raw materials (element scarcity) as well as contributes to solving pressing waste problems. Such a Circular Technologies Center will, for the first time, combine design, synthesis and catalysis with the environmental fate and impact of current products targeting safe by design (no persistent, bio-accumulative, and toxic compounds; green chemistry) and design for re-use, recovery and recycling (circular chemistry).