From Catalysis to Oscillations

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Oscillatory systems are fundamental to many biological processes, from cellular metabolism and division at the microscopic level to circadian rhythms and heartbeats at the macroscopic level. While chemical oscillations in abiotic systems were first discovered over 70 years ago, designing such systems remains a significant challenge. A promising approach to overcoming this challenge is the modular design of chemical oscillators, allowing for the introduction of novel functionalities alongside the core reactions driving the oscillation.
Inspired by the interplay of catalysis and oscillations in nature, our research group has developed a novel chemical oscillator based on catalytic organic molecules. Central to this oscillator is Fmoc-protected piperidine (Fmoc-pip), which serves as a source of free piperidine within the system. A key feature of our oscillator is its ability to achieve periodic catalysis, enabling temporal control over a secondary catalytic reaction. In our study, we harnessed the organocatalytic properties of piperidine to catalyze a Knoevenagel condensation in parallel with the oscillator's core reactions. This system demonstrated sustained oscillations under various conditions and significantly enhanced the selectivity of the catalyzed reaction, favoring the kinetic product. The oscillatory production of a species that catalyses an additional reaction represents a large amplification of oscillatory activity, enabling the temporal variations to be transferred across complex reaction network.
The first part of my talk will focus on recent catalytic methodologies developed in the group using Mn-complex. In the second and the main part I will cover the development process of catalytic organic oscillator, its successful application in achieving selective catalysis, and potential extensions of this system.

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Syuzanna R. Harutyunyan *after her Masters studies in Armenia, a PhD in Moscow with Prof. Belokon, a postdoctoral fellowship with Prof. Feringa and a Senior Scientist position at Janssen Pharmaceutica, was appointed as an Assistant Professor at the University of Groningen, the Netherlands in 2010, where she is Full Professor since 2018 and Chair of Homogeneous Catalysis unit. Syuzanna's research is in the field of homogeneous and dynamic catalysis, out of equilibrium systems and reaction mechanisms.*
Her scientific prowess has been recognized by high-profile awards and grants, including the Solvias Ligand Contest Award (2011), the KNCV Gold Medal from the Royal Dutch Chemical Society (2016) and the Royal Society of Chemistry's Homogeneous Catalysis Award (2017), as well as by an ERC Consolidator grant (2017) and an NWO Vici (2018), the most prestigious Dutch personal grant. Recognition of her work is also evident from many invited lectures to international conferences including the recent (2022) plenary talk at the prestigious 'Stereochemistry, Bürgenstock' conference, the invitation to become an ERC panel member (from 2023) and from an invitation by the American Chemical Society (ACS) to serve as associate editor for one of the most prominent catalysis journals, ACS Catalysis (2020-2023). She is an author of more than 80 papers published in the most prestigious journals, e.g., Science, Angew. Chem. Int. Ed., J. Amer. Chem. Soc., Chem. Soc. Rev., ACS Catal. Her research was cited more than 5000 (h index = 32).