Young Career Focus: Prof. Agnieszka Nowak-Król (Universität Würzburg, Germany)

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. Agnieszka Nowak-Król (Universität Würzburg, Germany).

Biographical Sketch

Prof. A. Nowak-Król

Agnieszka Nowak-Król is a Junior Professor and an Emmy Noether group leader at the Institute of Inorganic Chemistry and the Institute for Sustainable Chemistry & Catalysis with Boron of the University of Würzburg (Germany). Agnieszka graduated with honors from the Rzeszów University of Technology in Poland. She earned her doctorate at the Polish Academy of Sciences in Warsaw (Poland) with Prof. Daniel Gryko in 2013 and continued her career as an Alexander von Humboldt postdoctoral fellow with Prof. Frank Würthner at the University of Würzburg in Germany. In 2016, she started her independent career as a group leader at the Center for Nanosystems Chemistry (Germany). In 2019, she received the Emmy Noether fellowship to establish an independent research group. In 2020, she was appointed a Junior Professor at the University of Würzburg. Agnieszka is a recipient of several awards and honors including the Thieme Chemistry Journals Award, Hector Research Career Development Award 2020, Wojciech Świętosławski Prize, and Zonta Prize. She is a member of the Societas Humboldtiana Polonorum, Soltech, and the Polish Chemical Society. Her research lies at the interface of organic, inorganic and materials chemistry. Her current activities focus on achiral and helically chiral π-conjugated organoboron compounds, boron-containing polycyclic aromatic hydrocarbons, photoswitches, helicenes containing other main group elements and their applications in organic electronics and bioimaging.

INTERVIEW

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

Prof. A. Nowak-Król Our current research focuses on functional π-conjugated organoboron compounds, particularly chiral derivatives such as azaborole helicenes. We introduce boron, an element with unique properties, into the core structure of single helicenes, helically elongated congeners, chiral photoswitches and boron-containing polycyclic aromatic hydrocarbons including single molecules with multiple helical subunits. Once introduced, these helically chiral azaboroles form an entirely new class of compound. So, we're intensively studying their optical, chiroptical and electronic properties alongside their stability and reactivity. We're interested in the applications of these compounds as luminescent emitters in circularly polarized organic light-emitting diodes (CP-OLEDs) and bioimaging or as charge- and spin-transport materials. Since our syntheses typically proceed via highly congested intermediates, the preparation of our target molecules can be quite challenging at times. Therefore, we devote a significant amount of our time to develop effective and efficient synthetic protocols, or strategies to access these novel helicenes in the first place. In general, we apply a modular approach where the product molecules are prepared in a stepwise fashion from small achiral building blocks (Figure 1a). This is a conceptually simple and powerful approach as it offers the possibility to prepare a large variety of molecules through a simple combination of different building blocks, limited only by the accessibility of key intermediates. This drives us to develop alternative synthetic routes to the currently accepted protocols and pushes our research forward.

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SYNFORM *When did you get interested in synthesis?*

Prof. A. Nowak-Król Shortly after I started my undergraduate studies, I joined the lab of Dr. Grażyna Groszek, a synthetic chemist working on bioactive compounds and natural products from the Technical University of Rzeszów in Poland. This was before having had any official training in practical organic chemistry. During that time I spent each weekend, winter and even summer holidays in the synthetic lab developing my own individual project. Dr. Groszek had close connections to the Institute of Organic Chemistry (IChO) of the Polish Academy of Sciences in Warsaw, one of the top organic chemistry institutes in Poland, where she herself had finished her doctoral studies. We had frequent official and unofficial visits in the lab from the IChO and other institutes, allowing for plenty of opportunities to discuss various facets of chemistry. Such a stimulating atmosphere definitely fostered my interest in synthesis. Very quickly, pursuing my PhD at IChO became a dream of mine. Initially, I planned to work on total synthesis of natural products or purely synthetic methodology, but after meeting Prof. Daniel Gryko, a member of the IChO, at the annual Meeting of the Polish Chemical Society in 2007, my perspective and plans changed. This is how I entered the field of functional dyes, while still being an undergraduate student.

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

Prof. A. Nowak-Król While organic chemistry, with all its diversity, will always play a pivotal role in the development of new drugs and materials, it shouldn't be decoupled from other disciplines. Perhaps now, more than ever before, are the various branches of science so heavily interdependent. Therefore, it is essential to be open and draw as much as possible from recent achievements in engineering, physics and biology to support the progress in organic chemistry. Also, we observe a steady increase in molecular complexity; a prominent example can be seen in the design of new drugs. In an ideal scenario, this should be accompanied by an increased simplicity with regards to accessing these compounds. After all, the beauty lies in simplicity. To achieve this, we need improved synthetic strategies and new chemical reactions to shorten reaction routes, improve selectivity and avoid protecting groups, etc. I suppose computational tools may play an important role in the discovery of new chemical transformations, unexpected compound reactivity and unusual reaction sequences. Some research groups have indeed demonstrated the potential of computer-aided synthesis planning, but as always, whatever is predicted has to be experimentally verified by a well-trained synthetic chemist.

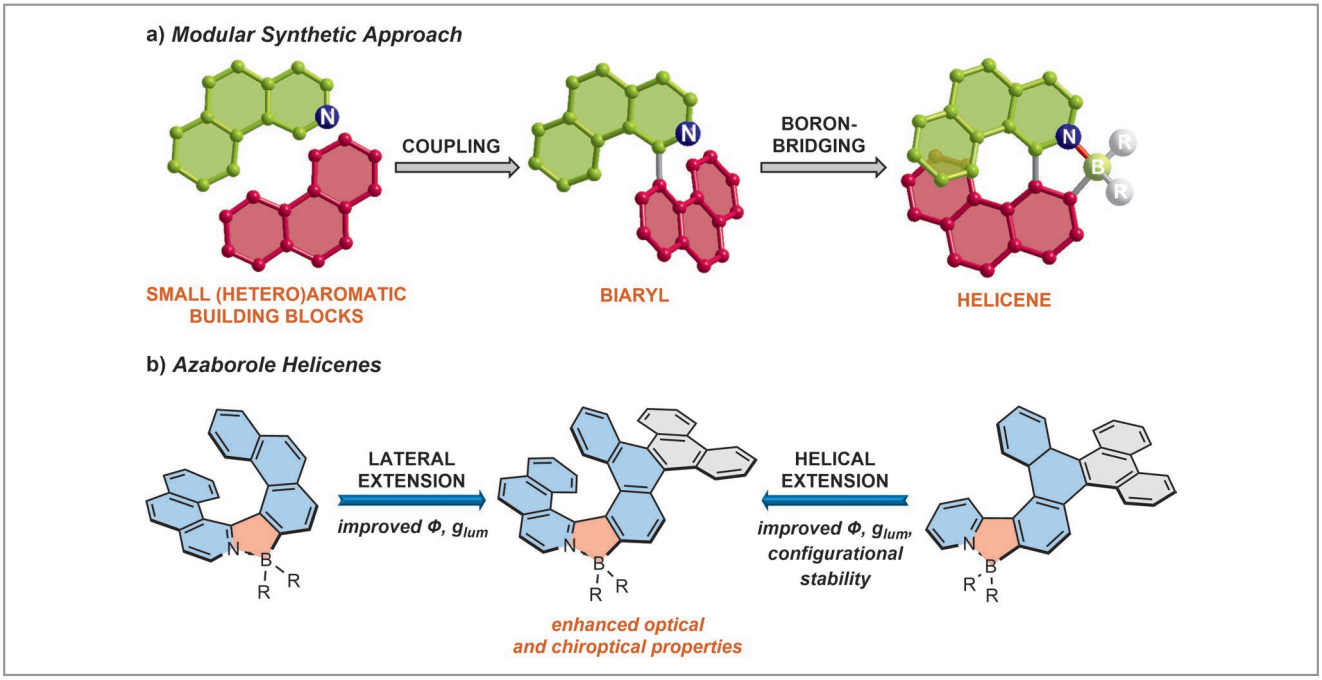

Figure 1 a) Modular synthetic approach for the synthesis of helically chiral compounds via boron-bridging. R = aryl, alkyl, halide. b) Molecular engineering of azaborole helicenes leading to improved physical and optical properties.

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

Prof. A. Nowak-Król Our research is interdisciplinary and incorporates elements of organic and inorganic chemistry, photophysical characterization with support from computational tools, and materials chemistry. Currently, our lab's major research focus is in the design, synthesis and characterization of chiral azaboroles. On one hand, we're developing new methods for the synthesis of azaboroles and the methods allowing for the stereoselective preparation of B,N-helicenes; while on the other hand, we endeavor to establish key design principles to improve their optical properties. For instance, the application of chiral compounds in CP-OLEDs requires materials that combine strong emission and large luminescence dissymmetry factors (g_{lum}), which quantify the differential emission of right- and left-handed CP light. Recently, through modification of the helicene structure, we were able to enhance both the luminescence quantum yield and the g_{lum} values (Figure 1b). The insights gained from this study will assist us in the further design of azaborole CPL emitters. Noncovalent interactions will also play a vital role in developing excellent candidates for OLEDs. In addition to finding efficient emitters, whether for applications in real-world devices or as luminescent probes, we'd also like to address important fundamental questions regarding charge and spin transport in organic semiconductors. Thus, we are actively engaged in a systematic investigation of this class of compound. Among the current efforts in our group, we are exploring helicenes containing heavier main group elements with the aim of providing a platform to develop catalytic systems for asymmetric synthesis.

Apart from *sensu stricto* scientific aims, my personal goal is to prepare highly qualified researchers in a healthy and supportive environment. I have the pleasure of working with a group of talented and motivated PhD students. It's extremely rewarding to observe their development in becoming independent researchers, responsible for their own respective projects. There is no doubt in my mind, they will be successful, whatever career path they choose.

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

Prof. A. Nowak-Król I don't look at my research in terms of scientific achievements. I think we're in a process of continuous learning. The longer we work, the greater understanding we have of the properties of our compounds, their stability and reactivity. This knowledge governs the molecular design of even better materials. At this point, I can already say, we have developed the chemistry of azaborahelicenes and established a new class of materials but there is still a lot more to be discovered. I believe that big achievements usually come in small steps and consist of little failures and victories. One needs to be patient and persistent in one's work and rely on one's critical thinking abilities. When I take a glance at my past achievements, this is exactly the approach I took to solve numerous problems.

In a more general sense, one of my most important accomplishments was pursuing my undergrad and PhD studies while being a mother. The scientific career requires high mobility and full involvement, which may be challenging when someone has established a family. Naturally, I wouldn't have achieved this without the support of my family and meeting important people on my way, like Prof. Daniel Gryko. Moving to Warsaw for my PhD studies was the first step towards the place where I am now. When I took up a postdoctoral position in the group of Prof. Frank Würthner, I already had clear plans and goals regarding my scientific career, although later, life made some adjustments.

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