Meet the Flow Chemist – Dr. Anna G. Slater

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Education	PhD in Chemistry, University of Nottingham (2011)
Past positions	Royal Society-EPSCRC Dorothy Hodgkin Fellow (2016–2021), University of Liverpool Postdoctoral researcher, University of Liverpool Postdoctoral researcher, University of Nottingham
Awards	2 x Royal Society Fellowships (DHF 2016, URF 2021) Fellow of the Young Academy of Europe (2020) Associate Fellow of the Royal Commonwealth Society (2016)

- 1) When did you start with flow chemistry? Describe the first paper or the first experiments.

My first introduction to flow was at the EPSRC Directed Assembly Network (Rose et al., *Chem. Cent. J.*, **2017**, 11, 1, 77), at a meeting for early career researchers designed to promote interdisciplinary collaboration. There, I met Prof. Harris Makatsoris, who spoke about his fascinating work with oscillatory baffled reactors (OBR). Supported by the Network's travel grant scheme, Harris kindly hosted me in his lab to try out porphyrin synthesis in an OBR. Everything that followed came from that chance encounter – I am very grateful! I moved to Liverpool and continued learning about flow via funds from the Dial-a-Molecule Network (<http://generic.wordpress.soton.ac.uk/dial-a-molecule/>) which supported a collaboration with Prof Steven Ley on the dynamic

flow synthesis of organic cages (*Chem Commun.*, **2015**, 51, 17390–17393). This paper was key for my fellowship application.

- 2) What are the main benefits of flow that convinced you to use and implement this technology in your research?

As a supramolecular chemist, it is key to be able to control the reaction environment in which the processes I use take place. Flow chemistry offers a different way to think about this, and I think has great potential to increase the control we have over complex processes like self-assembly, host–guest complex formation, or the formation of 3D molecular architectures such as molecular cages and macrocycles. Better control should lead to new structures, new understanding, and easier access to multi-gram quantities of these systems. Coupled with the wider process windows accessible in flow, the enhanced safety, and the options for adding a trigger mid-process (whether photochemical, rapid temperature change, or the addition or removal of species), I think there is a lot of exciting ground to explore! I also love

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working at the interfaces of chemistry, chemical engineering, and beyond: it is such a vibrant community.

3) What do you think the future holds for flow chemistry?

I hope flow will become more of a mainstream tool, complementing existing techniques and used when it has a clear benefit: to accomplish this teaching of the underlying principles will need to be more common in undergraduate chemistry courses. There have been some exciting developments in combining flow with high-throughput screening of reaction conditions, for example by using droplet chemistry, and I think automation and automated optimization in flow offers some powerful strategies for accelerating discovery. I also hope that flow will have a role to play in improving the sustainability and reducing the energy use and waste production in chemical synthesis, in research laboratories and in industry; to achieve this will require collaboration across several fields. Just because a process is in flow does not mean it is green; there is a lot of work to do here to ensure we are making sustainable choices in research.

4) Do you have any relevant tips for newcomers in the field?

Seek collaborations to pick up the technique; like anything, it takes time and experimental experience to get used to what can be done (and what can't – or what is best done in batch). There is a wealth of literature, knowledge, and experience from process chemistry, industrial chemistry, chemical engineering, and the flow chemistry and custom-build communities; seek it out and (if you are like me) don't be afraid to ask lots of questions. Blockages are inevitable, method development done properly takes time, but once you have a robust process there is a beautiful phase where you can gather a lot of interesting data in a short time. You have to enjoy troubleshooting to at least some extent, but the rewards are worth it!

My three top papers in the field of Flow Chemistry:

- 1) High-Yielding Flow Synthesis of a Macrocyclic Molecular Hinge, C. D. Jones, L. J. K. Cook, D. Marquez-Gamez, K. V. Luzyanin, J. W. Steed, A. G. Slater, *J. Am. Chem. Soc.* **2021**, *143*, 7553–7565.

The use of flow, rapid temperature changes and at-line analysis allowed us to form a new macrocyclic structure with higher yield and selectivity than in batch. These macrocycles display unusual hinging behavior that affords us a platform for functionalization; we will build from this to make switchable molecular systems. The flow process makes this much easier!

- 2) Production of monodisperse polyurea microcapsules using microfluidics, M. F. Thorne, F. Simokovic, A. G. Slater, *Sci. Rep.* **2019**, *9*, 17983.

This work was led by a Masters student in the lab who was completely new to microfluidics and had an interest in formulation of industrially relevant products. Here, we use microfluidics to form monodisperse microcapsules filled with limonene. Better control over the size distribution of these capsules would allow companies to assess whether capsule size has an impact on product properties, which is not possible with the standard batch methods used in this setting.

- 3) Dynamic flow synthesis of porous organic cages, M. E. Briggs, A. G. Slater, N. Lunt, S. Jiang, M. A. Little, R. L. Greenaway, T. Hasell, C. Battilocchio, S. V. Ley, A. I. Cooper, *Chem. Commun.*, **2015**, *51*, 17390–17393

My first flow paper, demonstrating one of the few examples of reversible covalent chemistry carried out in flow; used here to form organic cages via imine condensation. Here, cages can be formed in 10 min (cf several days in batch), avoiding high-dilution conditions, and synthesis telescoped with precipitation can form multi-gram quantities of crystalline material in a convenient flow process.

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