

# SUPRAMOLECULAR WORLD

Edited by Elham Radvar and Dominic Collis

## A Brief Introduction to Supramolecular Chemistry

In 1987, Donald J. Cram, Jean-Marie Lehn and Fritz Vogtle received the Noble Prize in Chemistry for the work in the field of Supramolecular Chemistry. The work of Pedersen, Lehn and Cram build the foundations of today's expanding field in chemical research, which Lehn describes as the chemistry beyond the molecule that is based on the non-covalent bonds. By looking at molecules as a system, rather than a single molecule and thinking about how they interact with one another, we can design and fine tune desired interactions within molecules to create functional assemblies.

A good example of supramolecular assembly is deoxyribonucleic acid (DNA) molecule, which is the foundation of every living organisms, being made of 4 simple base pairs (Fig 1).

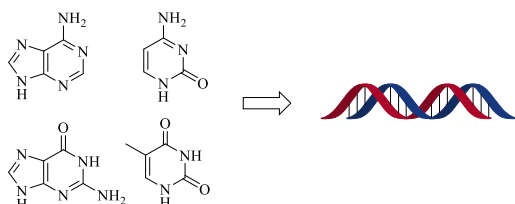


Figure 1 – Base pairs used to form DNA. Top Left to Bottom Right. Adenine (A), Cytosine (C), Guanine (G) and Thymine (T).

The DNA bases are able to pair together A-T, G-C through intermolecular hydrogen bonds and  $\pi$ - $\pi$  stacking, to form the double helix.

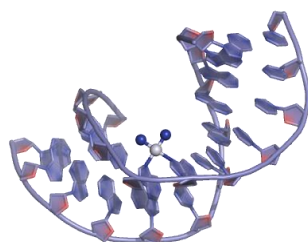


Figure 2 – Cisplatin bending DNA to stop replication of DNA in cancer cells.

Supramolecular chemistry can aid in the fight for cancer, molecules such as Cisplatin are able to disturb DNA replication in cancer cells by binding and bending the DNA double helix and stopping the translation (Fig 2). Other diseases can also be targeted by using supramolecular chemistry. Scientists are creating systems which are light, pH and temperature sensitive to allow localised drug delivery in the body, such as using micelles as drug carriers which can be effected by environmental changes (Fig 3). Potent drugs can be targeted thus allowing a decrease in the dosage.

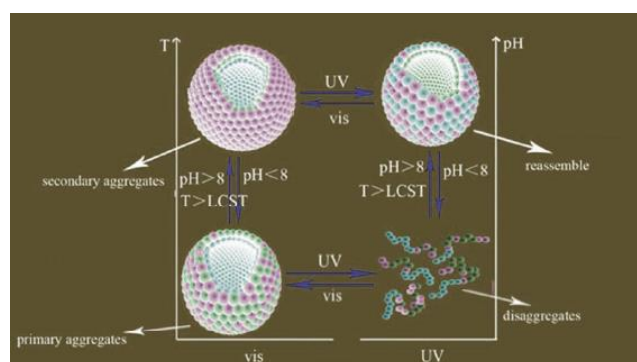


Figure 3 – Micelles which can be controlled by all 3 stimuli to change the nature of the capsule.<sup>2</sup>

Supramolecular chemistry has a wider scope than just medical applications, such as making novel materials to create more efficient solar cells. Today scientists have adopted a supramolecular ideology to think about the molecules as a system, rather than a single molecule to provide novel solutions to problems.

1. NUCLEIC ACID-DRUG INTERACTIONS. <http://www.atdbio.com/content/16/Nucleic-acid-drug-interactions> (accessed 24/08/2015).
2. Guo, W.; Wang, T.; Tang, X.; Zhang, Q.; Yu, F.; Pei, M., Triple Stimuli-Responsive Amphiphilic Glycopolymers. *J. Polym. Sci., Part A: Polym. Chem.* **2014**, *52* (15), 2131-2138.

## MHAtricell Group

### Principal Investigator:

*Dr Helena Azevedo*, Senior Lecturer in Biomedical Engineering & Biomaterials



Our group works at the interface of chemistry, materials science, nanotechnology, self-assembly, biomaterials and medicine. In particular, we are interested in using self-assembling peptides and their combination with macromolecules (natural and synthetic polymers) to develop nanostructured biomaterials (microcapsules, membranes, hydrogels) with potential applications in regeneration medicine. Within these studies, we are interested in using supramolecular chemistry to program molecules for self-assembly into structures with bioactivity and to understand the energy pathways for their self-assembly into functional macroscopic biomaterials. Over the last

few months, the MHAtricell Group has moved from one student to a multinational collaboration of people, taking on 3 new PhD students as well as Postdoctoral Researchers, collaborating with many different people to make the research more diverse.

### Postdoctoral Researchers:

Joao Conde	May 2014	Hydrogel-Nanoparticle Patches As Prophylactic Scaffold Agents For In Vivo Local Gene / Drug Delivery In Colorectal Cancer Tumours. <i>Collaborator(s): Dr Natalie Artzi (Institute for Medical Engineering and Science, MIT, USA. Funding: Marie Curie Fellow</i>
Daniela Ferreira	Oct 2014	Hyaluronan Based Multifunctional Hydrogels for Wound Healing. <i>WHRI Academy Marie Curie COFUND: Fellow</i>
Jayati Banerjee	June 2015	Hyaluronan-Rich Matrices Crosslinked With Collagen-Like Peptides For The 3D Culture Of Ovarian Cancer Cells. <i>Marie Skłodowska-Curie Fellow</i>

### PhD Researchers:

Yejiao Shi	Apr 2014	Self-Assembled Nanostructures for Intracellular Drug Delivery and Targeted Therapies. <i>Collaborator(s): Dr. Alvaro Mata</i>
Clare O'Malley	Oct 2014	Peptide-Polymer Conjugates for Detection of Specific Markers in Cancer Stem Cells and for Targeted Therapies. <i>Collaborator(s): Prof. Ian Mackenzie</i>
Dominic Collis	Oct 2014	Development of Innovative Supramolecular Biomaterials Combining Hyaluronan Glycopolymers with Self-Assembly Peptides. <i>Collaborator(s): Dr Remzi Becer</i>
Kseniya Shuturminska	Oct 2014	Design and Synthesis of Bioactive Peptide Based Self-Assembling System for Enamel and Bone Therapeutics. <i>Collaborator(s): Dr. Alvaro Mata, Dr. Maisoon Al-Jawad (Department of Density), Dr. Paul Anderson (Department of Density) &amp; Dr. Andy Bushby.</i>

Elham Radvar	Dec 2014	Design and Synthesis of Peptide-polymer Conjugates Containing Secondary Structural elements of proteins. <b>Collaborator(s): Dr Remzi Becer</b>
--------------	----------	---

**Past Research Students:**

Sofia Ribeiro (Visiting student)	Feb-Jun 2015	Fabrication of Bioactive Periosteum Membranes for Bone Regeneration Using Innovative Self-Assembling and Nanofabrication Approaches. <b>from 3B's Research Group, University of Minho, Portugal</b>
Carla Cunha (Visiting student)	Feb-Jul 2015	Exploring the Size of Hyaluronan to Modulate the Properties of Hyaluronan-Peptide Self-Assembled Membranes for Wound Healing Applications. <b>Erasmus Student from University of Porto (FEUP), Portugal</b>
Filipa Duarte (Visiting student)	Feb-Jul 2015	Drug Delivery into The Brain: Challenges and Current Developments. <b>Erasmus Student from University of Porto (FEUP), Portugal</b>
Lucia Lombardi (Visiting student)	Jul-Sep 2015	Self-Assembling Peptide Nanosystems Against Bacterial Infections. <b>Erasmus Student from University of Naples , Italy</b>



**From Left to Right:** Dr Daniela Ferreira, Clare O'Malley, Elham Radvar, Dr Helena Azevedo, Yejiao Shi, Carla Cunha, Sofia Ribeiro, Filipa Duarte and Dominic Collis.

**Doctor Ferreira**

In March 2015, Daniela successfully completed her PhD in Tissue Engineering, Regenerative Medicine and Stem Cells at University of Minho, Portugal after 6 hard years. She was welcomed back to Queen Mary by welcome party keen to celebrate her achievement. Daniela has since taken on a Post-Doctoral role in the MHAtricell Group and continues her work on peptides.



## Recent Publications

- D. S. Ferreira, Y.-A. Lin, H. Cui, J. A. Hubbell, R. L. Reis, H. S. Azevedo, "Molecularly Engineered Self-assembling Membranes for Cell-mediated Degradation", *Advanced Healthcare Materials* 2015, 4(4): 602–612.
- H. S. Azevedo, I. Pashkuleva, "Biomimetic Supramolecular Designs for the Controlled Release of Growth Factors in Bone Regeneration", *Advanced Drug Delivery Reviews*, DOI: 10.1016/j.addr.2015.08.003.
- K. E. Inostroza, E. Collin, O. Siton, K. H. Smith, A. Monge-Marcet, M. Alonso, J. C. Rodríguez-Cabello, D. S. Ferreira, R. Pérez Rodríguez, R. L. Reis, F. Sagués, L. Botto, R. Biton, H. S. Azevedo, A. Mata, "Co-assembly, Spatio-temporal Control, and Morphogenesis of a Hybrid Peptide/Protein System", *Nature Chemistry* 2015, 7: 897–904.

## Conferences

### International Events

- Pacifichem 2015 – 15-20 December 2015, Honolulu, Hawaii, USA. [Link](#)
- Biomed 2016 – 15-17 February 2016, Innsbruck, Austria. [Link](#)
- BHI-2016 International Conference on Biomedical and Health Informatics – 24-27 February 2016, Las Vegas, USA. [Link](#)
- 10<sup>th</sup> World Biomaterials Congress – 17-22 May 2016, Montreal, Canada. [Link](#)
- ISMSC-2016 – 10-14 July 2016, Seoul, Korea. [Link](#)
- 6th EuCheMS Chemistry Congress – 11-15 September 2016, Seville, Spain. [Link](#)
- International Conference on Applied Chemistry – 17-18 October 2016, Istanbul, Turkey. [Link](#)

### UK Events

- Advanced Vibrational Spectroscopy for Biomedical Applications: Faraday Discussion – 21-23 March 2016, Cambridge. [Link](#)
- Designing new heterogeneous catalysis: Faraday Discussion – 4-6 April 2016, London, [Link](#)

For more conference visit: <http://www.chemistry-conferences.com/topics/>

## Acknowledgements

We'd like to thank European Union for the Marie Curie Career Integration Grant SuprHApolymers (PCIG14-GA-2013-631871) for funding.