SUPRAMOLECULAR WORLD

Edited by Elham Radvar and Dominic Collis

Host-guest interactions are rapidly becoming a popular supramolecular approach to produce self-healing properties in materials, due to the dynamic system formed which can be broken and reversibly fixed. Host-guest interactions are based on the principle that a guest will bind into a cavity within the host to produce a stable complex. These two components have been modified and used to form dynamic bridges between compounds. Two of the most famous examples of these interactions are streptavidin-biotin and cyclodextrin-adamantine.

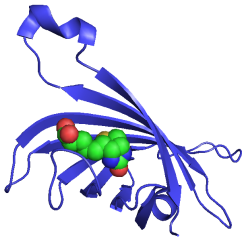


Figure 1 – Crystal structure of biotin binding to streptavidin

Streptavidin is a large protein found in bacteria, whilst biotin (or vitamin B7) is a water-soluble molecule which is used in the synthesis of fatty acids, valine and isoleucine. Streptavidin and Biotin (Fig 1) have a binding constant within 10^{-14} mol/L, inferring an extremely strong binding with only a small amount of biotin needed to bind to streptavidin. The binding within this system is highly potent and this interaction has been used for surface modifications. For example, plates coated with streptavidin are commercially available to bind biotin-marked compounds on the plate.

Cyclodextrin (CD) has been known since 1891 with a cyclic cellulose structure which comes in three forms alpha, beta (Fig 2) and gamma, with 6, 7 and 8 sugar units within the rings, respectively. Whilst the exterior of sugar ring is very hydrophilic, the interior of the cavity is very hydrophobic, which allows organic molecules to enter to form a stable complex in water. Adamantine (Ada) is the favoured guest for CD due to the bulky hydrocarbon, matching the cavity size perfectly to support many Van der Waals interactions within the cavity, therefore stabilising the system.

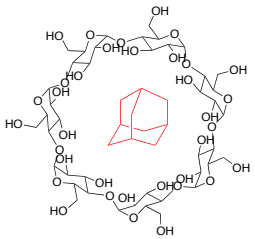


Figure 2 – The structure of the beta (7) CD ring based on the cyclic linkage of glucose and Ada, the favoured ß-CD binder within the ring (red).

These host-guest systems have been used as potential foundation for self-healing materials. By mixing the two components of a host-guest system, they will spontaneously coordinate; however, by using mechanical stress or applying heat to the system these bonds can be broken, but given time and energy the systems can reassemble (Fig 3).

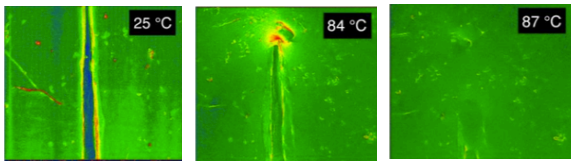


Figure 3 – Material developed in the Hayes Lab[1], University of Reading, which has been cut and heated to show the self-healing properties of the material. Taken from Burattini et al. 2009[1].

Hyaluronic acid (HA) has shown great potential as a biomaterial and for this reason has been used in various systems to form hydrogels obtained by physical or chemical crosslinking.

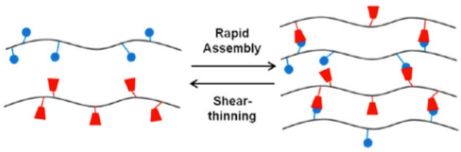


Figure 4 – Modified HA (black) with CD (red) and Ada (blue) to produce hydrogels based on host-guest interactions. Taken from Rodell et al. 2013[2].

Alternatively, the Burdick group[2] has made a dynamic system modifying HA with CD and Ada (Fig 4) From these, they could make a robust hydrogel, which on sheering could self-heal through the CD and Ada groups on the HA, with the aim to tune the mechanical properties of the hydrogel and control the release of drugs.

References

1. Burattini, S., et al., *A novel self-healing supramolecular polymer system.* Faraday Discussions, 2009. **143**(0): p. 251-264.
2. Rodell, C.B., Kaminski, A.L., Burdick, J.A., *Rational design of network properties in guest–host assembled and shear-thinning hyaluronic acid hydrogels.* Biomacromolecules, 2013. **14**(11): p. 4125-4134.

MHAtriCell Group

Visiting PhD student

Aliya Bekmurzayeva Sep 2016	Design of aptamer-functionalized medical wire for breast cancer stem cell isolation and detection. **School of Engineering, Nazarbayev University, Kazakhstan**	Funded by the Newton Fund Researcher Links programme (Researcher Travel Grant)

Group photo (November 2016): Left to right; Dominic, Elham, Clare, Helena, Kseniya, Yeijao, Jayati and Joao.

Recent and upcoming publications

- I. M. Martins, R. L. Reis, H. S. Azevedo, Phage Display Technology in Biomaterials Engineering: Progress and Opportunities for Applications in Regenerative Medicine, ACS Chemical Biology 2016, 11 (11): 2962–2980.
- J. Banerjee, Y. Shi, H. S. Azevedo, In Vitro Blood-brain Barrier Models for Drug Research: State-of-the-art and New Perspectives on Reconstituting these Models on Artificial Basement Membrane Platforms, Drug Discovery Today 2016, 21: 1367-1386.
- J. Banerjee, H. S. Azevedo, Crafting of Functional Biomaterials by Directed Molecular Self-Assembly of Triple Helical Peptide Building Blocks, Interface Focus, submitted.
- K. Shuturminska, C. O'Malley, D. W. P. Collis, J. Conde, H. S. Azevedo, Displaying biofunctionality on materials through templated self-assembly, in Self-Assembling Biomaterials: Molecular Design, Characterization and Application in Biology and Medicine, Eds. H. S. Azevedo, R. M. P. da Silva, Elsevier

Invited lectures:

- *16th September 2016* "Customized Biomaterials through Precise Molecular Engineering", Bioengineering Seminar Series, University of Southampton, UK.
- *24th – 25th October 2016* "Engineering Peptide Display for Self-assembly and Interactions with Cells", Royal Society Theo Murphy International Scientific Meeting on Self-Assembled Peptides: From Nanostructure to Bioactivity, Royal Society's Chicheley Hall Conference Centre, Buckinghamshire, UK.
- *8th November 2016* "Engineering Biomaterials at the Molecular Scale: Efforts Towards Precise & Customized Medicine", Life Sciences Society, Metropolitan University, London, UK.
- *14th November 2016* "An Academic Career in Bioengineering", City of London School for Girls London, UK.
- *22nd November 2016* "Simple Chemistry to Assemble Biomaterials with Complexity and Desired Functionality", Chemistry Centre Seminars, University of Minho, Portugal.
- *24th November 2016* "Exploring New Avenues in Synthetic Chemistry to Open New Roads in the Natural-based World", Chem2Nature (European Horizon 2020 Twinning project CHEM2NATURE: Enabling precision chemical methodologies

applied to natural-based systems for the development of multifunctional biomedical devices) First School, University of Minho, Portugal.

Past and future presentations at national and international conferences/meetings

Dominic Collis	Polymer conference, Warwick, UK 11th – 14th July	Design and synthesis of hyaluronan based glycopolymers for self-assembly with hyaluronan binding peptides
	RSC Material Division, London, UK 25th November 2016	Neoglycopolymers of hyaluronan: mimicking the simplest glycosaminoglycan
Elham Radvar	TERMIS-EU 2017, Davos, Switzerland 26th – 30th June 2017	Multi-functional self-assembling hydrogels as biomimetic scaffolds for protein delivery and stem cell culture

International courses

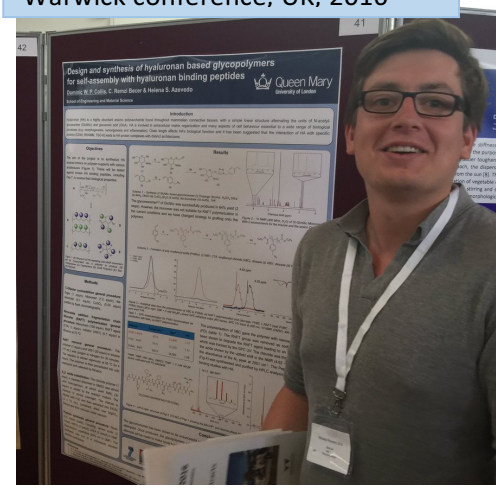
Clare O'Malley	Cold Spring Harbour Laboratories, New York, US. 27th October- 10th November 2016	Course title: 'Antibody Engineering, Phage Display & Immune Repertoire Analysis' Funding Awards: QMUL Postgraduate Research Fund and Helmsley Fellowship

MHAtriCell activity overview 2016

IoB group at WBC, Canada, 2016

WBC, Canada, 2016

Warwick conference, UK, 2016



Phage Display Course, New York, 2016

Conferences

International events

- 5th International Conference on Multifunctional, Hybrid and Nanomaterials, 6th – 10th March 2017, Lisbon, Portugal Link.
- 33rd Southern Biomedical Engineering Conference 2017, 17th - 19th March 2017, Mississippi, US Link.
- 2nd Annual Conference and Expo on Biomaterials, 27th – 28th March 2017, Madrid, Spain Link.
- Gordon Research Conference Self-Assembly & Supramolecular Chemistry, 21st - 26th May 2017, Les Diablerets, Switzerland Link.
- 11th International Conference of Hyaluronan, 11th – 15th June 2017, Cleveland, US Link.
- 9th International Conference on Materials for Advanced Technologies, 18th – 23rd June 2017, Suntec, Singapore Link.
- TERMIS-EU 2017, 26th – 30th June 2017, Davos, Switzerland Link.

UK events

- Controlled Release Delivery, 3rd – 4th April 2017, London, UK Link.
- 4th Annual Peptides Congress, 24th – 25th April 2017, London, UK Link.
- Chemical Biology Symposium, 4th May 2017, London, UK Link.
- 10th International Conference on Cancer Stem Cells and Regenerative Medicine, 29th – 30th June 2017, London, UK Link.

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