

# Tailor-Made "Smart" Polymers

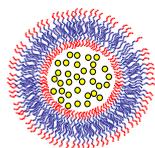
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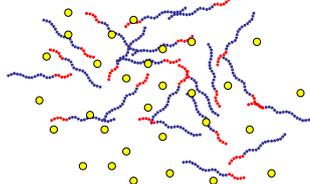
Polymers are exceptional materials; we can design them to behave in a predetermined manner by controlling their molecular structure. This is **MOLECULAR ENGINEERING**, as we write "code" within a polymer's molecular composition to control the way it behaves. My research involves the design of custom-made polymers to suit a wide range of applications. Shown here are a number of specific examples, but the materials can be custom-made to suit a plethora of needs.

## Drug Delivery



Loaded-Vesicle

Trigger  
E.g. pH or temperature

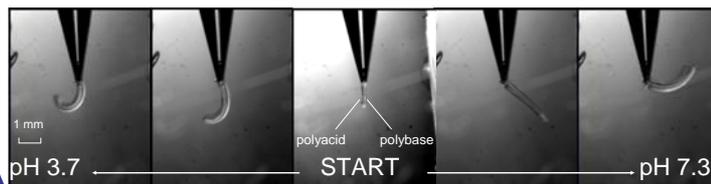


Triggered release of drug

Vesicles are hollow polymer "nano-balls" which can carry a payload. When made of "smart" polymers, we can control triggered release. These vesicles can be used as "stealth" vehicles, which deliver the payload to a specific site. There are many advantages that polymer nanotechnology provides over conventional drug delivery. Drugs can be loaded into foods at desired concentrations without affecting the taste because the active material is encapsulated in the polymer nano-vehicles. This also eliminates the need for intravenous introduction and allows a variety of different payloads to be delivered by the same method.

## Synthetic Muscles

The fabrication of synthetic muscles and biomimetic materials is an ongoing desire for many scientists. Smart polymers make this goal realisable. We can make molecular machines which are "soft and wet" and operate by converting chemical energy into mechanical energy, just like in nature. One example of a molecular machine is a bipolymeric strip. This is analogous to the bimetallic strip, but instead of the curvature being dependent on temperature, it is dependent on pH. Oscillations in pH can then be used to create a "wagging" motion to generate thrust.



**Polymer-Peptides**  
(for cosmetics/ foodstuffs)

**Foaming Agents**

**Biodegradable Wound-dressings**

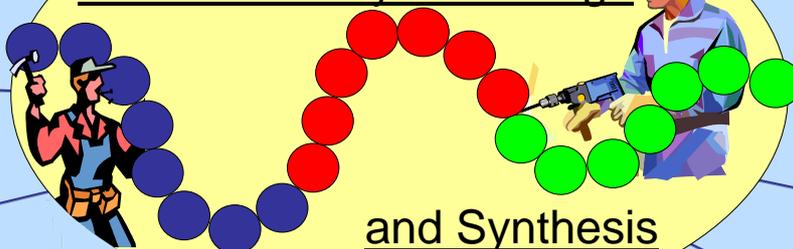
**Polymer Coatings**

We can design protective polymer coatings which "disintegrate" where desired (e.g. stomach, intestines or the mouth) for a variety of applications.

**Tissue/ Nerve Scaffolds**

**Nanovalves**

## Controlled Polymer Design



and Synthesis

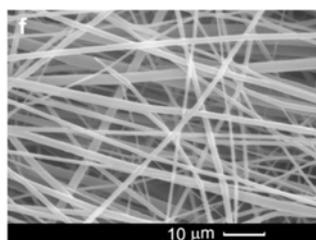
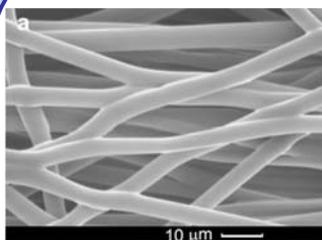
**Soft material**  
(e.g. cushions/ trainer soles)

**Robust material**  
(e.g. aircraft panelling)

**Contact Lenses**

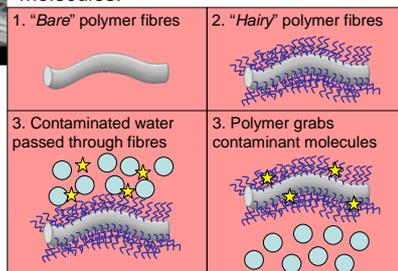
**Photonic Devices**

## Nanofibres



Using a technique known as electrospinning, we can create fibres with extremely small (and controllable) diameter of virtually any polymer. This increases the surface area of the polymer, which decreases its response time! Nanofibres are highly desirable for such applications as instant-response devices, tissue scaffolds, synthetic skin and responsive fabrics.

We can also grow polymer from the surface of the polymer fibres to make "hairy" nanofibres. These materials can be used as nanofilters, where the *hairs* are made from a *sticky* polymer which effectively grabs the contaminant molecules.



### Selected References

1. Tzokova, N.; Ferryhough, C.M.; Topham, P.D.; Sandon, N.; Adams, D.J.; Butler, M.F.; Armes, S.P. and Ryan, A.J. *Langmuir* (2009), 25(4), 2479-2485. 2. Topham, P.D.; Sandon, N.; Read, E.S.; Madsen, J.; Ryan, A.J. and Armes, S.P. *Macromolecules* (2008), 41 (24), 9542-9547. 3. Wang, L.; Topham, P.D.; Mykhaylyk, O.O.; Howse, J.R.; Bras, W.; Jones, R.A.L.; Ryan, A.J. *Advanced Materials* (2007), 19 (21), 3544-3548. 4. Topham, P.D.; Howse, J.R.; Crook, C.J.; Armes, S.P.; Jones, R.A.L.; Ryan, A.J. *Macromolecules* (2007), 40 (13), 4393-4395. 5. Howse, J.R.; Topham, P.; Crook, C.J.; Gleeson, A.J.; Bras, W.; Jones, R.A.L.; Ryan, A.J. *Nano Letters* (2006), 6(1), 73-77.