

It's a polymer, Jim, but not as you know it

Wherever you are, it is safe to assume that you are not far from a human-made polymer. Usually known simply as 'plastic', this versatile class of materials includes nylon, polyester, PVC, polystyrene and Teflon, to name a few. Polymers can be found in everything from clothing, building materials and furniture to adhesives and lubricants.

Virtually all current polymers are organic, containing a backbone of linked carbon atoms. But this is not the only option. Polyphosphazenes, for example, are materials that look and feel similar to carbon-based polymers, but are made from a backbone of alternating phosphorus and nitrogen atoms. Until recently, their metal-binding chemistry has been relatively unexplored but, funded by a Marsden grant, a team led by Professor Andrew Brodie and Associate Professor Eric Ainscough from the Institute of Fundamental Sciences at Massey University has been carrying out research into this interesting new area of polymer chemistry. "We decided to move away from carbon-based polymers because their chemistry is well established, and look at inorganic polymers based on phosphorus and nitrogen," explained Associate Professor Ainscough.

Much of the work carried out by the team has involved establishing the fun-

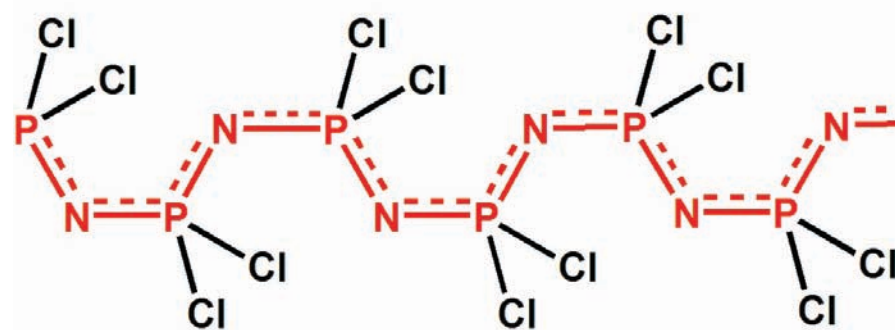


Dr Steve Kirk's stretchy pyridine-substituted polymer.

damentals of metal-polyphosphazene chemistry, including their structure and ways to make and attach different side groups to bind metals. This has led to some interesting new insights – such as the fact that some polyphosphazenes are not as stable as first thought. For example, PhD student Steve Kirk developed a pyridine-substituted polymer that is a powder when dry, initially stretchy when wet, and then degrades over several days. Although initially a frustration, this discovery could have potentially positive implications for materials made from these polymers. Such a substance could be used, for instance, as a scaffold for tissue growth, as it would be stable for a short period of time, and then eventually dissolve.

The instability of polyphosphazenes, and what is released when they break down, could also give them environmental benefits above traditional plastics. "Water would hydrolyse the bonds, and produce phosphoric acid and probably ammonia, which could then act as fertilisers," said Associate Professor Ainscough.

Another area that the team has explored is whether polyphosphazenes that conduct electricity could be developed, like certain types of carbon-based polymers. Masters student Ross Davidson carried out computational work to analyse whether metal ions in polyphosphazenes



Segment of a typical polyphosphazene, showing the backbone of alternating nitrogen (N) and phosphorus (P) atoms.



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Polyphosphazenes in a variety of colours due to different metal-binding properties.

communicate with each other, a necessary part of electricity conduction. The results showed that they do, but not very well. "It's like an old fashioned party line telephone, where you have to yell to hear anything," said Professor Brodie. "Whether or not something more akin to a copper wire can be developed from a polyphosphazene is an open question," he continued.

In talking about their research, the team emphasised how crucial their Marsden grant has been in allowing them to make progress. The funding has certainly been used to the full, allowing Ross Davidson,

Steve Kirk, and postdoctoral fellow Dr Carl Otter to join the team, and helping to produce two theses, one BSc(Hons) research report, 11 conference presentations, four overseas lectures, and 11 journal articles, with more to come. "It's been a great four years," said Professor Brodie.

Dr Kirk, who graduated in November 2008, is especially grateful to have been involved in the project. "I'm slightly more mature than most students, and I'm very thankful to the Marsden Fund for providing the funding and to Eric and Andrew for giving me the opportunity. Every day

was like a voyage of discovery. My background is in engineering, so I was always thinking about potential functional uses of these materials, as well as trying to understand the fundamental chemistry. The whole experience has been fantastic."

FOR MORE INFORMATION

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The inorganic polymer team. Left to right: Ross Davidson, Steve Kirk, Andrew Brodie, Eric Ainscough, and Carl Otter (with his wife Jo).