1. Title of Case Study: Radiation damage in chemical crystallography
2. Grant Reference Number or Facility Name: RCUK/D/EPSRC/Facilities/XRC/10, National Crystallography Service, University of Southampton
3. One sentence summary: World-leading research aims to reveal cause of radiation damage in chemical crystallography
4. One paragraph Summary Scientists at Southampton's National Crystallography Service are global leaders in innovative research to minimise the X-ray radiation damage caused to small molecule crystals during analysis.
5. Key outputs in bullet points: • World leaders in pioneering research to reveal ways of minimising crystal radiation damage during analysis • Developing protocols to inform the chemical crystallography community • Enabling the better protection of crystals during analysis to allow the extraction of significant data • The publication of a poster detailing experiments and initial findings that has been presented at two international conferences

6. Main body text

Scientists at Southampton's National Crystallography Service (NCS) are global leaders in innovative research to minimise the X-ray radiation damage caused to small molecule crystals during analysis.

"Although radiation damage to crystals in macromolecular crystallography is a well-known and studied phenomena, there have been no such studies relating to our field of small molecule crystallography," said Dr Peter Horton, who is leading the pioneering research at NCS.

"We are leading the world in exploring this area in depth and trying to change collection protocols to ensure we can extract as much information as possible before the samples are damaged beyond use."

The NCS handles a wide variety of samples over the course of a year and takes a number of these up to Diamond Light Source (DLS), in Oxfordshire, where they study them using the facility's small molecule synchrotron beamline (I19).

During this analysis they have noticed about fifteen per cent of the samples have experienced what they believe to be radiation damage. It is very important to be able to combat the effects of this phenomenon as its only valuable samples that cannot be examined anywhere else that are taken to DLS.

Peter, a Research Scientist at NCS, is heading up the research to try and determine which samples are more likely to be affected, and to understand the causes and symptoms of this effect in greater detail.

He said: "Because we have a regular allocation of time at DLS, we can run some controlled and systematic experiments to try and see what is causing the damage".

"We need to understand how we can slow down, or prevent, this damage until we have managed to extract the required data, because if we cannot extract the data using the equipment at DLS, we are never going to get the information. By limiting the damage as much as possible we are enabling researchers to get data on crystals that would otherwise have been impossible".

"In order to understand what is causing the damage we are looking at various factors such as reducing the intensity of the beam, limiting the time in the beam, and changing the temperature (see Fig 1). Testing each of these in turn will provide valuable insight into which factor is causing the most effect.”

So far Peter has investigated two different samples – a gold complex and a nickel complex – and has had his results published in a poster (http://eprints.soton.ac.uk/382915/) that has been presented at two international conferences.

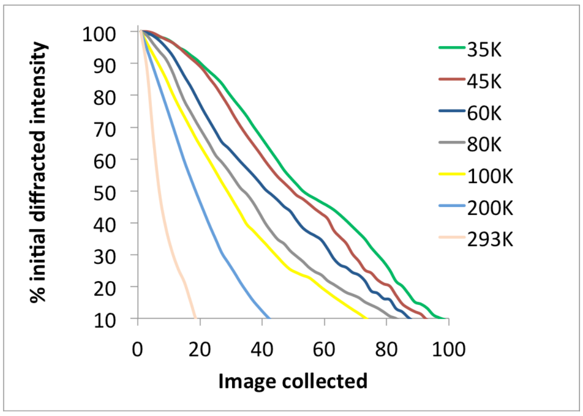

Figure 1. Decay as a Function of Temperature.

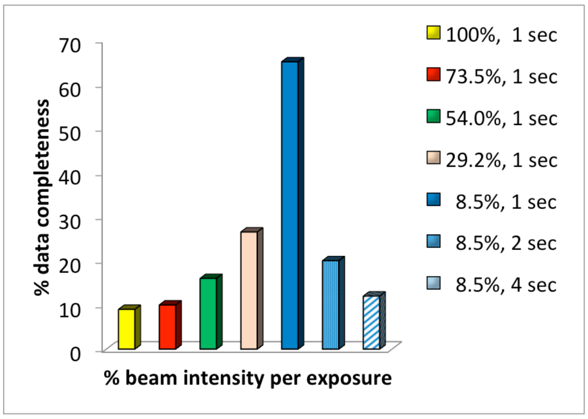

Figure 2. Percentage of viable data collected as a function of beam intensity.

The most significant finding of this approach is one that flies in the face of conventional wisdom. “The de-facto approach to addressing decay has been to reduce the strength of the beam, but then to compensate by increasing the exposure time. However our findings (see Fig 2) are that it is more effective to collect the data rapidly with the strongest beam the sample can withstand.”

The study has also now quantified the effect of decay – the first time this has been systematically addressed for small molecule crystallography. This provides a benchmark against which other facilities around the world can compare and an approach they can use to understand and combat it.

The impact and understanding generated by this work is becoming evident as other large central facilities around the world also increase their power. Dr Simon Teat, Principal Scientist for the chemical crystallography beamline at the Advanced Light Source (Lawrence Berkley National Lab, Berkley, CA) notes “The chemical crystallography program at the Advanced Light Source is due to move, in the middle of 2016, from a bending magnet to a superconducting bending magnet, with a gain in intensity of around two orders of magnitude. Even with our present intensity we see radiation damage in some types of compounds, with the new beamline this is only going to get worse. It is vital for us to understand the radiation damage process and how to minimize it to enable the best possible data to be collected from the $1.5 million investment in the new beamline. Further work of the NCS on radiation damage would be invaluable to us and to our user base.”

The next step is to use this new understanding to begin to predict the potential for a sample to be susceptible to this effect and develop approaches to alleviate it that can be incorporated into new approaches at beamlines.

“Our long-term aim is to develop protocols, based on our findings about how to better protect crystal samples from X-ray radiation damage, and share these protocols with the wider chemical crystallography community. By sharing these protocols we aim to enable researchers to extract more significant data from samples before they suffer radiation damage,” added Peter.

7. Names of key academics and any collaborators:

Professor Manfred Bochmann, University of East Anglia (provider of the Gold complex)

Dr. Sarah Barnett, Diamond Light Source (provider of the Nickel complex and several useful discussions on previous observations at the I19 beamline).

8. Sources of significant sponsorship (if applicable):

Diamond Light Source Ltd – for provision of facilities and subsistence.

9. Who should we contact for more information?

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