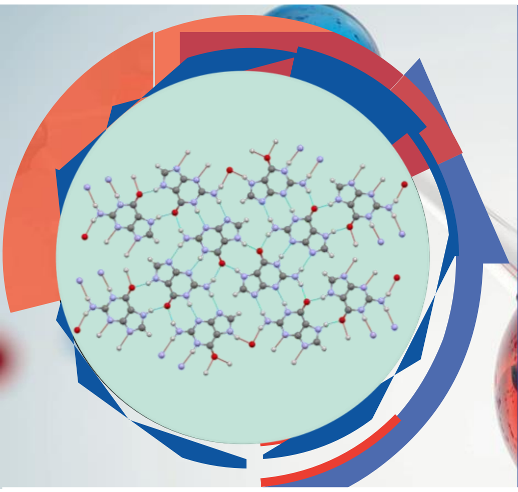


Biogenic Crystal Structure Determination with 3D Electron Diffraction

Biogenic crystals are naturally occurring crystalline materials produced by living organisms. Examples include calcium oxalate crystals in plant tissues, magnetite crystals in certain bacteria and animals, and various biominerals found in the human body. Their fundamental role in biological processes makes them a subject of great scientific interest, but their complexity and sensitivity present significant challenges for analysis and characterisation.

The susceptibility to undergo damage upon extraction from the parent organism presents major challenges to structure determination of biogenic molecular crystals. The size range spanning from nanometers to micrometers and the limited quantities make it very difficult to determine their structures using traditional methods like single-crystal X-ray diffraction (SC-XRD) or powder X-ray diffraction (PXRD).

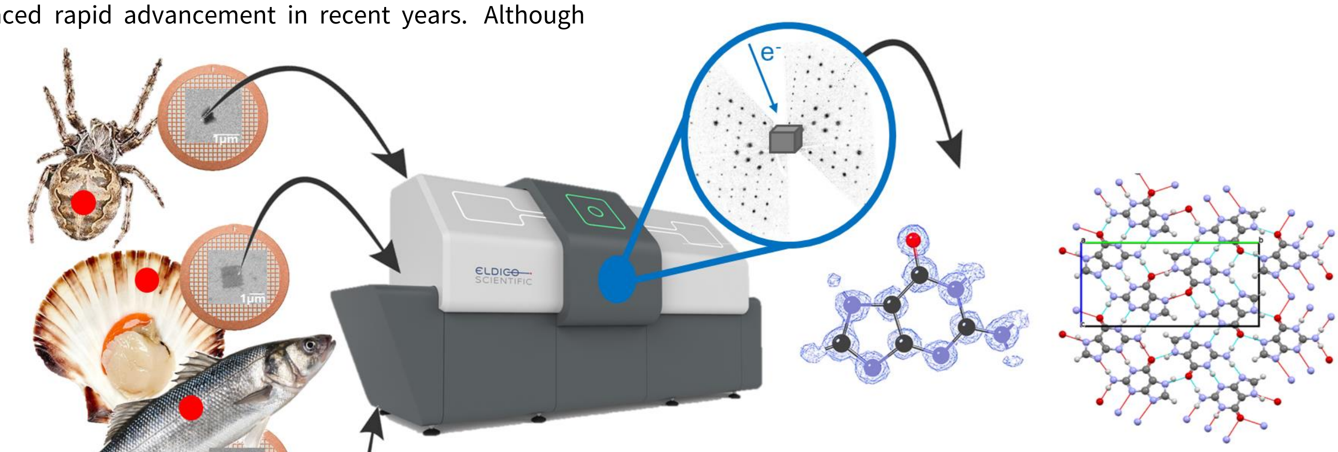
Electron diffraction

3D electron diffraction (3D ED) methods, also known as microcrystal electron diffraction (microED), have experienced rapid advancement in recent years. Although conceptually akin to SC-XRD, 3D ED offers a distinct advantage by utilizing electrons for diffraction experiments. Thanks to the strong interaction between electrons and matter, 3D ED data can be collected from crystals with volumes 10^6 times smaller than those required for X-ray diffraction, even when coexisting in a mixture. Thus, crystals from what traditionally would have been considered as powder samples by X-ray standards can now be handled as single crystals by electron diffraction.

ELDICO *ED-1*

The ELDICO *ED-1*, the world's first dedicated electron diffractometer, was built to measure crystallites in the nanometer range under ambient or cryogenic conditions.

It is designed to collect data with a minimal electron exposure of <0.01 $e^{-}Å^{-2}s^{-1}$ illuminating only the area of interest during data collection both in imaging and diffraction mode. This makes it optimal for data collection from beam sensitive materials like organic crystals.



read the paper:
Wagner, A.; Merkelbach, J.; Samperisi, L.; Pinsk, N.; Kariuki, B. M.; Hughes, C. E.; Harris, K. D. M.; Palmer, B. A. *Cryst. Growth Des.* **2024**, *24*, 899–905. https://doi.org/10.1021/acs.cgd.3c01290.

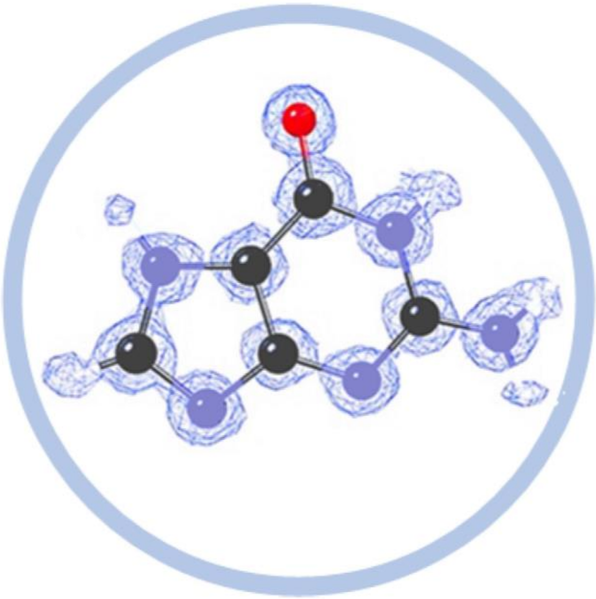
Case Study: Guanine crystals in spider integument, fish scales, and scallop eyes

In collaboration with scientists from Ben-Gurion University of the Negev, Cardiff University, and our application team from ELDICO Scientific AG we analysed biogenic guanine crystals extracted from fish scales, spider integument, and scallop eyes.

Results

Table 1: Refinement details for the β-polymorph of guanine [1].

Sample	Fish	Spider	Scallop
Resolution [Å]	0.67	0.67	0.80
Reflections	5155	6019	2289
Completeness [%]	87.4	97.7	80.2
R_1 (all refl.)	0.195	0.278	0.446
R_1 [$I > 2\sigma(I)$]	0.177	0.241	0.374
wR_2 (all refl.)	0.537	0.540	0.735
Goodness of fit	2.43	2.03	3.01

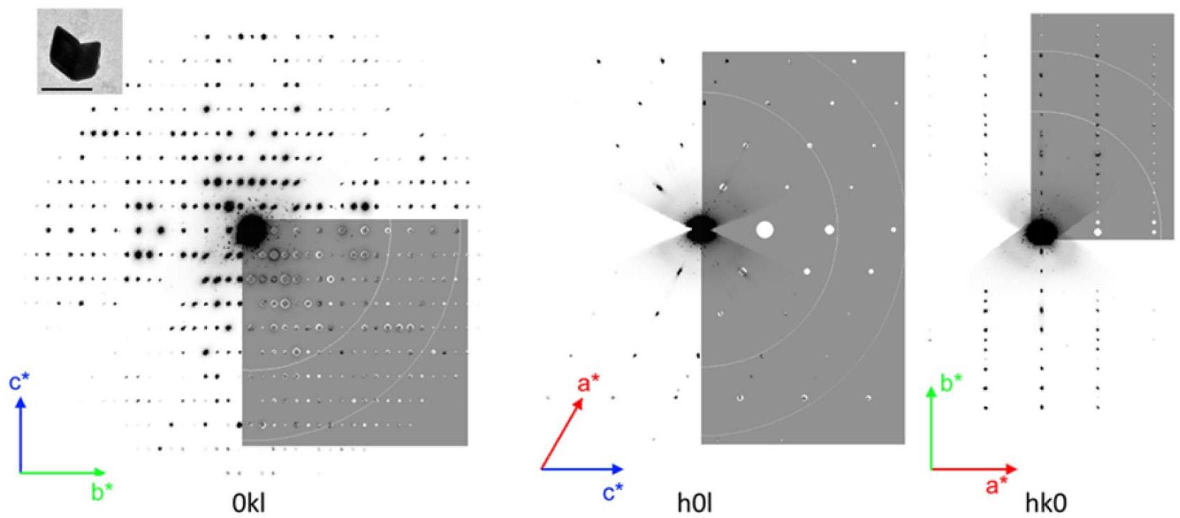


The hydrogen atoms were located directly in our structure determinations from 3D ED data, representing an improvement in the quality of the β-guanine crystal structure compared to the structure published previously

Conclusion

The findings represent a crucial step forward in understanding and harnessing the potential of biogenic crystals for sustainable and bio-compatible optical applications. Key benefits of the ELDICO *ED-1* were:

- effortless data collection
- *ab initio* structure solution
- refinement of the structures free from restraints
- no need of pure compound, data collection directly from crude material
- accurate electrostatic potential maps from which hydrogen atoms could be directly located



With the ELDICO ED-1 the experimental diffraction data show a perfect match with the simulated data

[1] Hirsch, A.; Gur, D.; Polishchuk, I.; Levy, D.; Pokroy, B.; Cruz-Cabeza, A. J.; Addadi, L.; Kronik, L.; Leiserowitz, L. "Guanigma": The Revised Structure of Biogenic Anhydrous Guanine. *Chem Mater.* **2015**, *27*, 8289–8297.