

Advancing Structure Solution of Organic Compounds: Strategies for Tackling XRPD Challenges

A. Altomare¹, C. Cuocci¹, M. De Feudis¹

¹*Institute of Crystallography-CNR, via Amendola 122/o, 70126 Bari Italy*

angela.altomare@cnr.it

Powder X-Ray Diffraction (PXRD) is a powerful technique for determining the crystal structures of micro- and nano-crystalline compounds, despite the inherent challenges that often complicate data interpretation. Common issues include peak overlap, background contribution, preferred orientation, limited experimental resolution, and reduced data quality. These last two problems, in particular, hinder the structure solution of organic compounds.

However, recent advancements in methodologies, computational techniques, and instrumentation have greatly expanded the range of complex structures that can now be solved using PXRD. Reciprocal-space methods [1], such as Direct Methods, and real-space techniques [2] like Simulated Annealing are widely applied—either independently or in combination—leading to frequent successes. These approaches are further enhanced by advanced computational and graphical tools designed to overcome specific challenges in structure determination. For instance, parallel computing has significantly improved the efficiency of Simulated Annealing, reducing execution times and enhancing performance, particularly in cases with a high number of degrees of freedom.

Among the various software tools developed for structure determination from PXRD data [3], EXPO [4] stands out for its comprehensive and versatile capabilities. It guides users through the entire structure solution process, from determining cell parameters and space groups to performing Rietveld refinement. EXPO seamlessly integrates both Direct Methods and Simulated Annealing and provides the flexibility of automated operations or customizable, non-standard strategies as needed.

This presentation will outline the core principles of structure determination from powder diffraction data, with a focus on its application to complex organic compounds [5]. Specific challenges and corresponding solution strategies will be discussed, demonstrating the effectiveness of modern computational approaches in overcoming the limitations of PXRD.

- [1] Altomare, A., Cuocci, C., Moliterni, A., & Rizzi, R. (2019). Solving crystal structures using reciprocal-space methods. In Gilmore, C.J., Kaduk, J.A., & Schenk, H. (Eds.), *International Tables for Crystallography, Volume H, Powder Diffraction* (pp. 395-413). Wiley: New York.
- [2] David, W.I.F. (2019). Real-space methods for structure solution from powder diffraction data: application to molecular structures. In Gilmore, C.J., Kaduk, J.A., & Schenk, H. (Eds.), *International Tables for Crystallography, Volume H, Powder Diffraction* (pp. 414-432). Wiley: New York.
- [3] Gilmore, C.J., Kaduk, J.A., & Schenk, H. (2019). Survey of computer programs for powder diffraction. In Gilmore, C.J., Kaduk, J.A., & Schenk, H. (Eds.), *International Tables for Crystallography, Volume H, Powder Diffraction* (pp. 698-715). Wiley: New York.
- [4] Altomare, A., Cuocci, C., Giacovazzo, C., Moliterni, A., Rizzi, R., Corriero, N., & Falcicchio, A. (2013). *J. Appl. Cryst.*, 46, 1231-1235.
- [5] Cuocci, C., Corriero, N., Dell'Aera, M., Falcicchio, A., Rizzi, R., & Altomare, A. (2022). *Computational Materials Science*, 210, 111465.

Financial support by MUR, PRIN 20223B4JWC project (Valorization of carbon oxides by sequential catalysis: Combining the reverse water gas shift reaction with catalytic carbonylation for the synthesis of high value added compounds - COXSECAT) is acknowledged.

We acknowledge financial support under the National Recovery and Resilience Plan (NRRP), Mission 4, Component 2, Investment 1.1, Call for tender No. 1409 published on 14.9.2022 by the Italian Ministry of University and Research (MUR), funded by the European Union – NextGenerationEU– Project Title A bottom/up approach for the study of the crystal structure of sustainable and eco-friendly polymers and the relationships with properties - ECOPOLYCRYS – CUP B53D23025580001 - Grant Assignment Decree No. 1064 adopted on 18/07/2023 by the Italian Ministry of Ministry of University and Research (MUR)..