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Report :

We aimed at determining, for the first time, the electron density distribution of the ribonucleotide thymidine and of anhydrous cytosine. The single crystal samples have been synthesized by slow evaporation. We therefore aimed also at characterizing the electrostatic properties (electrostatic potential, interaction energy) and topological analysis. The high-resolution diffraction measurement was performed at low temperature for the electron density (ED) analysis on BM1A.

Electron density distribution of the ribonucleotide thymidine and anhydrous cytosine

We have measured high resolution diffraction data at $\lambda = 0.71$ Å using the KUMA 6 circles diffractometer of BM1A in the 4 circles mode and the Onyx CCD. Cryogenic temperatures (T ~ 110 K) have been used. Data have been collected up to 1.09 $Å^{-1}$ resolution for the two molecules in several detector positions and reduced with the inhouse softwares for rejecting shadowed reflections (~48600 measured reflections, merged in ~6300 unique reflections, R_{int} = 0.04 for the ribonucleotide thymidine and ~12500 measured reflections, merged in ~2700 unique reflections, R_{int} = 0.03 for the anhydrous cytosine). The ED distributions have been refined based on a multipolar model (MoPro program). The high resolution of the data enabled us to clearly deconvolute thermal smearing effects from the deformation ED, the Hirshfeld rigid bond test being fullfilled for all interatomic bonds. The modelled static deformation density is of high quality (figure 1). This shows that despite the small size of the samples, which did not permit us to get a reliable data collection using laboratory equipment, the high flux available at the SNBL was absolutely necessary for our project. The high quality of data allows us to apply anisotropic displacement parameters on hydrogen atoms bonded to the plane rings, using Shade software (Figure2).

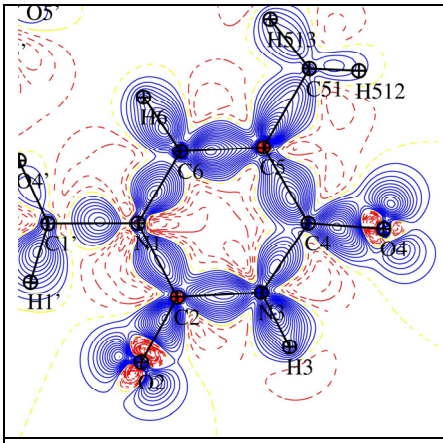

Figure 1. Static deformation electron density of the ribonucleotide thymidine in the thymine ring plane.

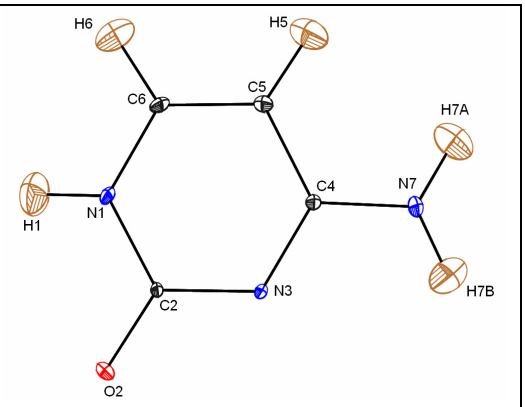

Figure 2. Ortep View of anhydrous cytosine showing 50% probability ellipsoids.

Electrostatic properties of the two DNA pyrimidine

The electrostatic properties study can induce a quantification of the intermolecular interactions in the crystal. We have first calculated the electrostatic potential (Figures 4-5) with VMoPro (which is part of the MoPro-package) after the multipolar refinement. The calculation of the potential allows us to analyze the intermolecular interaction such as hydrogen bonds. The intermolecular interaction energies are calculated from the model of Spackman where a precise experimental multipolar model is required. The electrostatic energy is evaluated by an elaborated numerical integration of the product: charge density by electrostatic potential. The calculation is performed with VMoPro. The ribonucleotide thymidine is bounded by four intermolecular H-bonds in the crystal. For example, the total electrostatic binding energy of the dimer formed by the O3'-H31'…O4 hydrogen bond is of E = -90,7 (1) kJ/mol. This is the most stable H-bond in the crystal and it participates at the stabilization of the crystal packing.

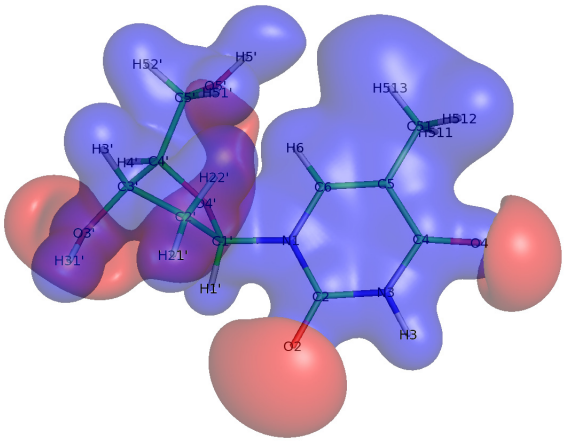

Figure 4. Total electrostatic potential of ribonucleotide thymidine.

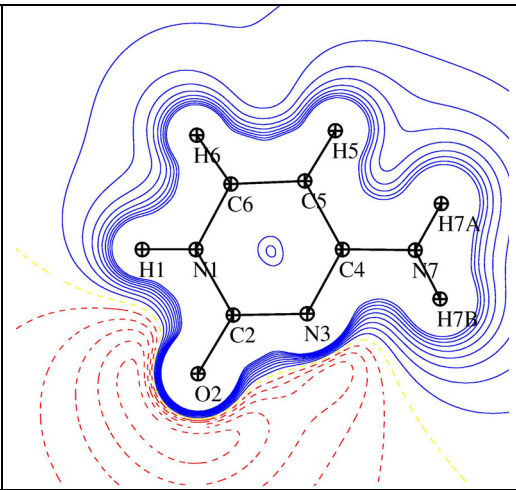

Figure 5. Total electrostatic potential of anhydrous cytosine in the cytosine plane.