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Supporting information for article:

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SUPPLEMENTARY MATERIALS

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Table Sup1: Comparison of covalent bond lengths in experimental and theoretical models.

Bonds	Exp length(Å)	Theo length(Å)
C1-H1A	1.076(18)	1.090
C1-H1B	1.077(18)	1.094
C1-H1C	1.076(18)	1.100
C2-H2A	1.077(18)	1.094
C2-H2B	1.077(18)	1.090
C2-H2C	1.075(18)	1.101
N2-H2D	1.013(18)	1.016
N2-H2E	1.016(18)	1.018
N4-H4A	1.013(18)	1.019
N4-H4B	1.014(18)	1.020
N5-H5A	1.014(18)	1.027
N5-H5B	1.014(18)	1.016

Table Sup2: Comparison of experimental and theoretical angles.

Angles	Exp(°)	Theo(°)
N1-C1-H1C	108.9(3)	110.07
N1-C1-H1A	108.9(3)	110.49
N1-C1-H1B	107.9(3)	108.66
H1C-C1-H1A	110.8(5)	109.74
H1C-C1-H1B	110.3(5)	109.93
H1A-C1-H1B	110.0(5)	107.94
N1-C2-H2C	110.8(3)	110.84
N1-C2-H2A	110.8(4)	110.55
N1-C2-H2B	108.9(3)	108.76
H2C-C2-H2A	109.1(5)	109.18
H2C-C2-H2B	109.3(5)	109.03
H2A-C2-H2B	108.0(5)	108.43
H2D-N2-H2E	119.0(6)	117.73
H4A-N4-H4B	119.6(5)	118.93
H5B-N5-H5A	119.8(5)	116.76
N1 - C3 - N3	122.40(3)	
N1 - C3 - N2	120.42(2)	
N3 - C3 - N2	116.85(2)	
N3 - C4 - N5	123.78(2)	
N3 - C4 - N4	118.10(2)	
N5 - C4 - N4	118.01(2)	
C3 - N1 - C2	122.06(3)	
C3 - N1 - C1	122.27(2)	
C2 - N1 - C1	115.11(3)	
C4 - N3 - C3	115.11(3)	

Table Sup3: Comparison of experimental and theoretical torsion angles.

Torsion angles	Exp(^o)	Theo(^o)
C1-N1-C2-H2C	-83.3(7)	-90.99
C1-N1-C2-H2A	155.5(8)	147.80
C1-N1-C2-H2B	36.9(7)	28.87
H1A-C1-N1-C3	-16.4(7)	-21.19
H1A-C1-N1-C2	155.3(8)	150.60
H1B-C1-N1-C3	-135.8(8)	-139.42
H1B-C1-N1-C2	36.0(7)	32.37
H1C-C1-N1-C3	104.4(7)	100.15
H1C-C1-N1-C2	-83.8(7)	-88.05
H2A-C2-N1-C3	-32.7(7)	-40.38
H2B-C2-N1-C3	-151.3(8)	-159.32
H2C-C2-N1-C3	88.5(7)	80.83
N1-C3-N2-H2D	-1.1(7)	-2.69
N1-C3-N2-H2E	164.9(7)	165.98
N3-C4-N5-H5B	179.9(2)	178.65
N3-C4-N5-H5A	-7.0(7)	-7.95
N3-C4-N4-H4A	-16.8(7)	-16.95
N3-C4-N4-H4B	172.3(4)	173.74
N3-C3-N2-H2D	172.7(4)	171.09
N3-C3-N2-H2E	-21.3(8)	-20.24
N4-C4-N5-H5B	-3.6(7)	-4.84
N4-C4-N5-H5A	169.5(5)	168.56
N5-C4-N4-H4A	166.5(6)	165.34
N5-C4-N4-H4B	-4.4(8)	-2.96

Table Sup4: Topological properties of the covalent bonds of MetCl. The first line indicates the experimental values; the second line indicates the values obtained from the periodic theoretical calculation. $\rho_{\text{BCP}}(\mathbf{r})$, $L(\mathbf{r}) = -\nabla^2\rho(r)$ are the electron density and its Laplacian at the BCPs; ε , bond ellipticity; $G(\mathbf{r})$, $V(\mathbf{r})$, $H(\mathbf{r})$, kinetic, potential and total energy density; BD, bond degree parameter; d_1 , d_2 , the distance between BCP and each bonded atom; R_{ij} , total bond path length; $\Delta d = |d_1 - d_2|/2R_{ij}$ is the % displacement of the BCP from the midpoint of the bond.

Bonds	ρ_{BCP} ($e/\text{\AA}^3$)	$L(\mathbf{r})$ ($e/\text{\AA}^5$)	ε	$G(\mathbf{r})$ (a.u.)	$V(\mathbf{r})$ (a.u.)	$H(\mathbf{r})$ (a.u.)	BD	R_{ij} (\AA)	d_1 (\AA)	d_2 (\AA)	Δd (%)
C1-H1A	1.792	15.01	0.05	0.211	-0.578	-0.367	-0.205	1.076	0.703	0.373	15
	1.803	15.64	0.05	0.210	-0.582	-0.372	-0.206	1.090	0.687	0.404	13
C1-H1B	1.841	15.92	0.04	0.440	-0.714	-0.274	-0.149	1.077	0.709	0.368	16
	1.787	15.12	0.04	0.209	-0.575	-0.366	-0.205	1.096	0.694	0.402	13
C1-H1C	1.800	15.58	0.05	0.427	-0.690	-0.262	-0.146	1.076	0.709	0.367	16
	1.748	14.55	0.05	0.202	-0.554	-0.353	-0.201	1.102	0.695	0.407	13
C2-H2A	1.782	14.69	0.05	0.422	-0.679	-0.257	-0.144	1.077	0.714	0.363	16
	1.781	15.37	0.05	0.205	-0.570	-0.365	-0.205	1.095	0.691	0.404	13
C2-H2B	1.777	14.56	0.07	0.421	-0.676	-0.256	-0.143	1.077	0.707	0.370	16
	1.800	15.65	0.04	0.209	-0.581	-0.371	-0.207	1.091	0.686	0.404	13
C2-H2C	1.773	14.74	0.08	0.420	-0.674	-0.254	-0.143	1.075	0.714	0.361	16
	1.740	14.65	0.05	0.253	-0.576	-0.324	-0.185	1.104	0.695	0.409	13
C1-N1	1.704	10.76	0.04	0.400	-0.634	-0.235	-0.137	1.4590(4)	0.604	0.855	9
	1.645	6.833	0.07	0.226	-0.523	-0.297	-0.181		0.628	0.832	7
C2-N1	1.742	11.10	0.09	0.411	-0.656	-0.245	-0.141	1.4566(5)	0.598	0.859	9
	1.671	7.183	0.08	0.091	-0.466	-0.375	-0.224		0.628	0.828	7
C3-N1	2.361	25.09	0.26	0.609	-1.053	-0.444	-0.188	1.3376(4)	0.547	0.791	9
	2.296	27.32	0.22	0.287	-0.858	-0.571	-0.248		0.519	0.818	11
C3-N2	2.375	25.43	0.25	0.614	-1.062	-0.449	-0.188	1.3372(4)	0.552	0.786	9
	2.275	24.81	0.23	0.579	-0.993	-0.414	-0.182		0.546	0.792	9
C3-N3	2.307	20.37	0.15	0.590	-1.015	-0.425	-0.184	1.3545(4)	0.595	0.761	6
	2.205	21.16	0.15	0.299	-0.817	-0.518	-0.235		0.577	0.778	8
C4-N3	2.495	24.64	0.21	0.657	-1.149	-0.492	-0.197	1.3332(4)	0.595	0.738	5
	2.324	26.59	0.18	0.302	-0.880	-0.578	-0.249		0.547	0.786	9
C4-N4	2.420	29.41	0.24	0.630	-1.094	-0.465	-0.192	1.3407(4)	0.542	0.798	10
	2.277	25.80	0.24	0.291	-0.850	-0.559	-0.245		0.547	0.794	9
C4-N5	2.451	27.37	0.24	0.641	-1.117	-0.476	-0.194	1.3398(3)	0.568	0.772	8
	2.297	25.56	0.24	0.300	-0.864	-0.565	-0.245		0.554	0.785	9
N2-H2D	2.158	23.21	0.06	0.539	-0.914	-0.374	-0.174	1.013	0.748	0.265	24
	2.153	24.09	0.07	0.261	-0.772	-0.511	-0.237	1.018	0.729	0.289	22
N2-H2E	2.133	21.74	0.06	0.531	-0.897	-0.366	-0.172	1.016	0.746	0.269	24
	2.141	24.45	0.07	0.255	-0.763	-0.508	-0.237	1.019	0.733	0.287	22
N4-H4A	2.198	24.36	0.06	0.553	-0.940	-0.388	-0.176	1.013	0.749	0.264	24
	2.118	23.44	0.07	0.254	-0.751	-0.497	-0.235	1.021	0.731	0.289	22
N4-H4B	2.142	23.97	0.05	0.534	-0.903	-0.369	-0.172	1.014	0.753	0.261	24
	2.117	23.48	0.07	0.253	-0.751	-0.497	-0.235	1.024	0.735	0.289	22
N5-H5A	2.117	22.04	0.06	0.526	-0.887	-0.361	-0.171	1.014	0.749	0.265	24
	2.092	23.43	0.07	0.246	-0.734	-0.489	-0.233	1.027	0.738	0.289	22
N5-H5B	2.166	23.65	0.04	0.542	-0.919	-0.377	-0.174	1.014	0.749	0.264	24
	2.147	23.26	0.07	0.318	-0.771	-0.506	-0.211	1.018	0.726	0.292	21

Conspicuously, the charge concentrations are stronger on the N-H bonds CPs compared to the C-H bonds and the average Laplacian $L(\mathbf{r}) = -\nabla^2\rho(\mathbf{r})$ EXP/THEO values for the N-H and C-H bonds are 23.2/23.7e/Å⁵ and 15.1/15.2e/Å⁵ respectively (Fig. 8a,b). Table 5 gives the values of $\Delta d\%$ ($\Delta d\%$ is the displacement/bond length percentage of the b.c.p from the midpoint of the bond). $\Delta d\%$ is found largest in the N4-H4B bond (24% / 22% in EXP/THEO) and the BCP shift is towards H4B atom. The electron accumulations can be seen in the Laplacian maps (Fig. 8c,d). The electron pair of atom N3 atom is clearly visible (Fig. 8d) while two LPs are also distinguished around the chloride anion in the plane shown (Fig. 8c).

The Laplacian distribution shows that the most prominent VSCC is directed towards the H atoms for N2, N4 and N5 atoms. The N1 atom forms three N-C bonds, N1-C3 is the shortest bond among the three (Table 5), $L(\mathbf{r})$ value has the largest magnitude while the electron density is highest on the Laplacian CP of this bond. The atomic charge on NH₂ type nitrogen atoms is the highest in the cases of N4 and N5 atoms (Table 8); they exhibit globally higher VSCCs towards their bonding regions than N2, the third NH₂ type atom.

Table Sup5: Topological properties at the critical points of a selection of intermolecular interactions in the crystal lattice (EXP model): electron density, Laplacian, G : kinetic energy density, V : potential energy density, $H=G+V$: energy density. ORTEP symmetry code applies to chloride atom. To give an estimation of uncertainties, the ssd of values was computed for the Cl1...H2A hydrogen bond from 20 models at standard deviation from the final refined one.

Bond paths	symmetry code	$\rho(\mathbf{r})$ ($e/\text{\AA}^3$)	$L(\mathbf{r})$ ($e/\text{\AA}^5$)	$G(\mathbf{r})$ (kJ/mol)	$V(\mathbf{r})$ (kJ/mol)	$H(\mathbf{r})$ (kJ/mol)	$ V/G $
Cl1...H1B	-X ; Y- $\frac{1}{2}$; -Z+ $\frac{1}{2}$	0.048	-0.71	14.9	-10.4	4.5	0.70
Cl1...H5B	-X+1; Y- $\frac{1}{2}$; -Z+ $\frac{1}{2}$	0.070	-0.94	20.9	-16.0	4.8	0.77
Cl1...H4A	-X+1; Y- $\frac{1}{2}$;-Z+ $\frac{3}{2}$	0.084	-1.31	28.8	-21.9	6.6	0.76
Cl1...H2E	-X+1 ; -Y+1 ; -Z+1	0.114	-2.01	45.0	-35.2	9.9	0.78
Cl1...H4B	X-1; -Y+ $\frac{3}{2}$; Z- $\frac{1}{2}$	0.115	-2.11	46.8	-36.1	10.8	0.77
Cl1...H2A	X ; Y ; Z	0.042	-0.52	11.1	-7.9	3.2	0.71
ssd		0.0011	0.007	0.13	0.15	0.093	0.0085
Cl1...H2D	X ; Y ; Z	0.093	-1.74	37.6	-27.8	9.8	0.74
Cl1...C1	X ; -Y+ $\frac{3}{2}$; Z+ $\frac{1}{2}$	0.029	-0.36	7.3	-4.9	2.4	0.68

The topological properties and electronic energy densities give insight into the nature and strength of the bonds. The conditions $L(\mathbf{r}) < 0$, $H > 0$ and $|V/G| < 1$ are true and the bonds are characterized by pure closed-shell interactions. All non bonded interactions display, as expected $|V/G| < 1$. Moreover some interactions, such as Cl1...C1, are not hydrogen bonds and form a bond path with a CP.

Table Sup6

Contributing 17 MetCl molecules to the surrounding electrostatic potential ESP (Corresponding to Figure 9 and 10)

List of ORTEP codes and symmetry cards

45401	X-1 ; Y ; Z-1
45501	X-1 ; Y ; Z
65501	X+1 ; Y ; Z
65601	X+1 ; Y ; Z+1
54502	-X ; Y-½ ; -Z+½
55502	-X ; Y+½ ; -Z+½
64502	-X+1 ; Y-½ ; -Z+½
64602	-X+1 ; Y-½ ; -Z+3/2
65502	-X+1 ; Y+½ ; -Z+½
65602	-X+1 ; Y+½ ; -Z+3/2
66603	-X+1 ; -Y+1 ; -Z+1
67603	-X+1 ; -Y+2 ; -Z+1
77703	-X+2 ; -Y+2 ; -Z+2
47504	X-1 ; -Y+3/2 ; Z-½
57504	X ; -Y+3/2 ; Z-½
57604	X ; -Y+3/2 ; Z+½
67604	X+1 ; -Y+3/2 ; Z+½

Figure Sup1: Residual electron density in the N2-C3-N1 plane of molecule Metformin Hydrochloride, cutoff $I > 2\sigma(I)$, contour $0.05 \text{ e}/\text{\AA}^3$, blue represents positive; red represents negative. a) computed at $0.71 < d < 7.14 \text{ \AA}$ resolution b) computed at $0.45 < d < 7.14 \text{ \AA}$ resolution.

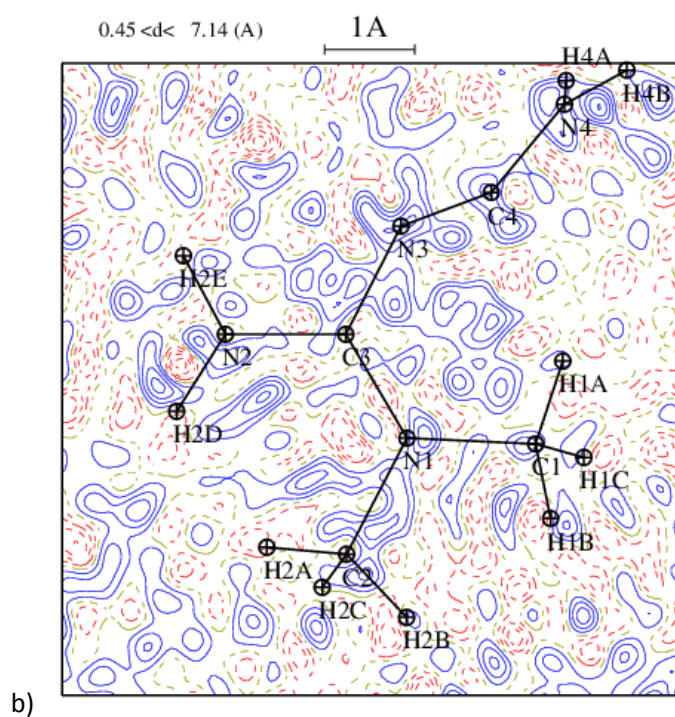
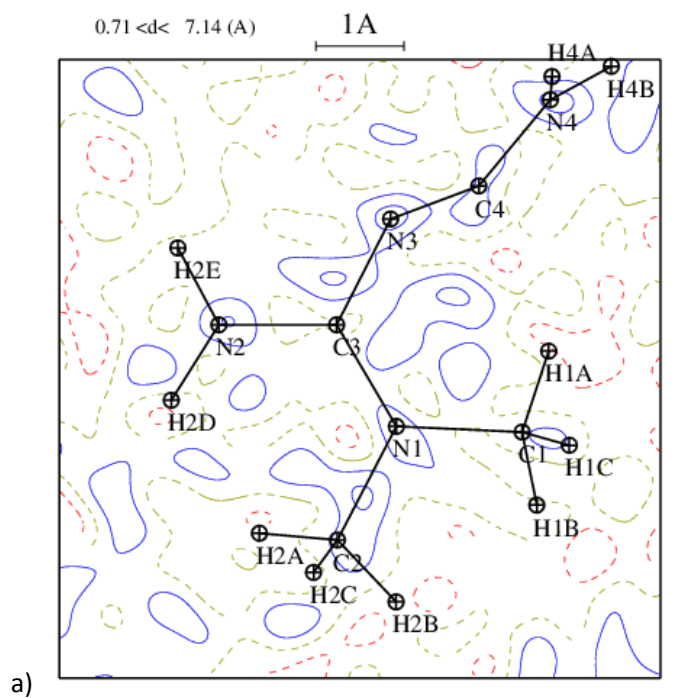


Figure Sup2:

Variation of scale factor, $\Sigma(F_o^2)/\Sigma(F_c^2)$, with respect to resolution for the MetCl molecule.

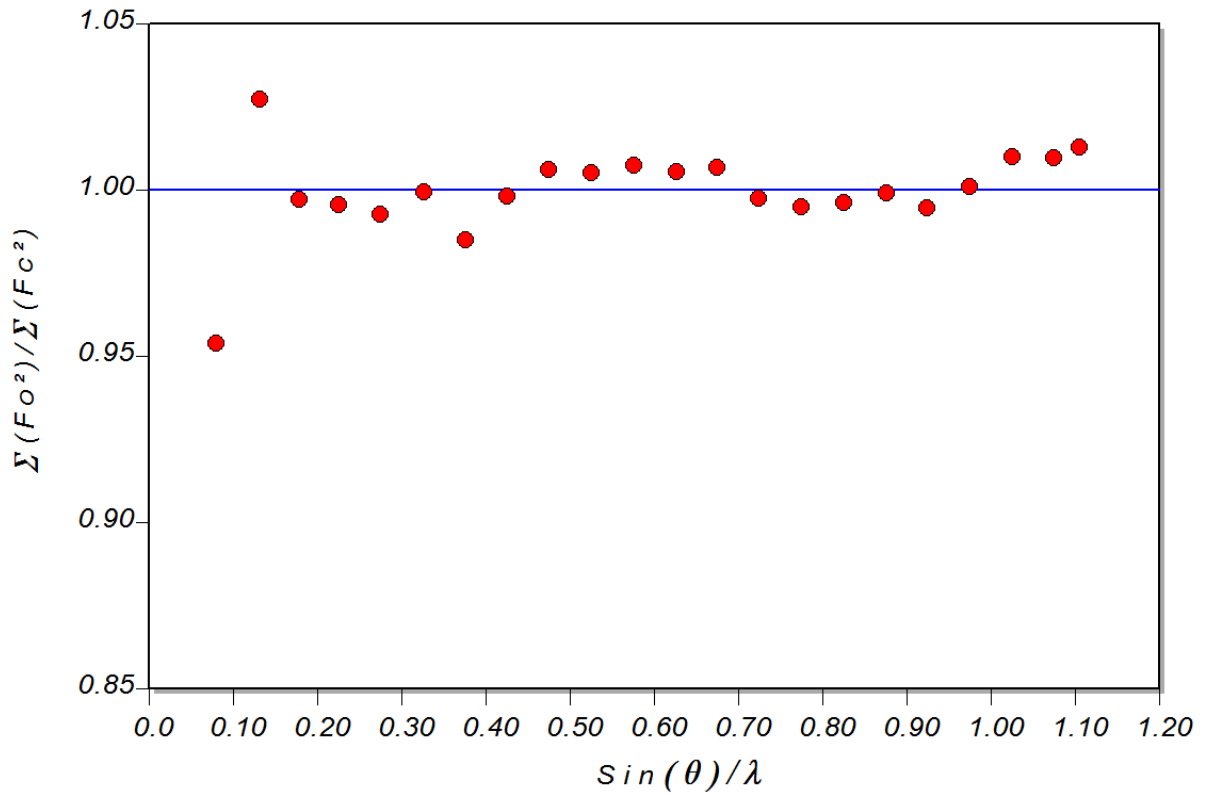


Figure Sup3: Normal probability plots of $(F^2_o - F^2_c)$ for METCl using program DRKplot (Zhurov, Zhurova & Pinkerton, J. Appl. Cryst. (2008). 41, 340–349). The weighting scheme used is $\sigma^2 = [\sigma(F^2)]^2$.

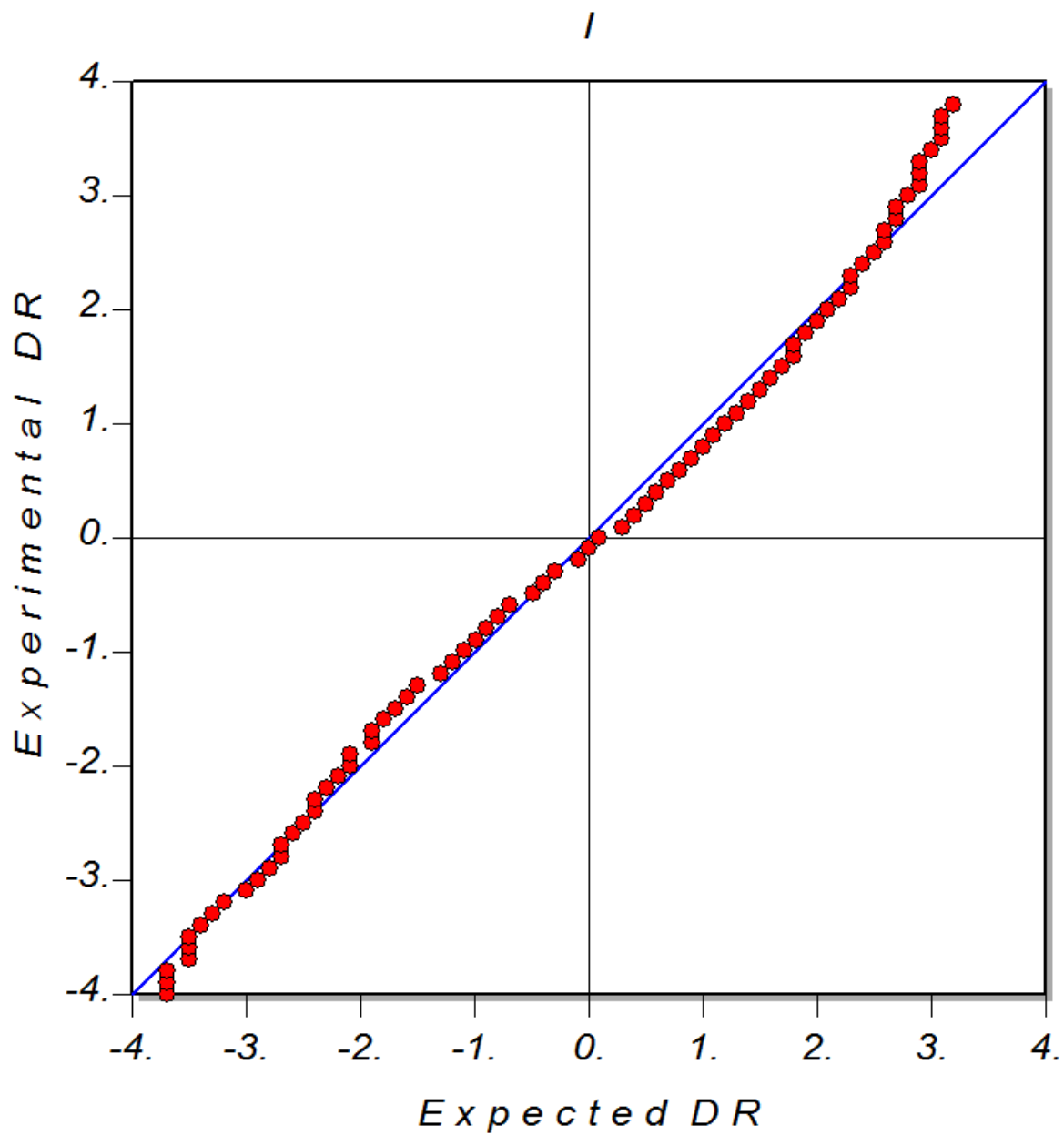


Figure Sup4.

Fractal dimension vs. residual electron density F_o-F_c using all reflections.

(Meindl, K & Henn, J., *Acta Cryst.* (2008). A64, 404-418)

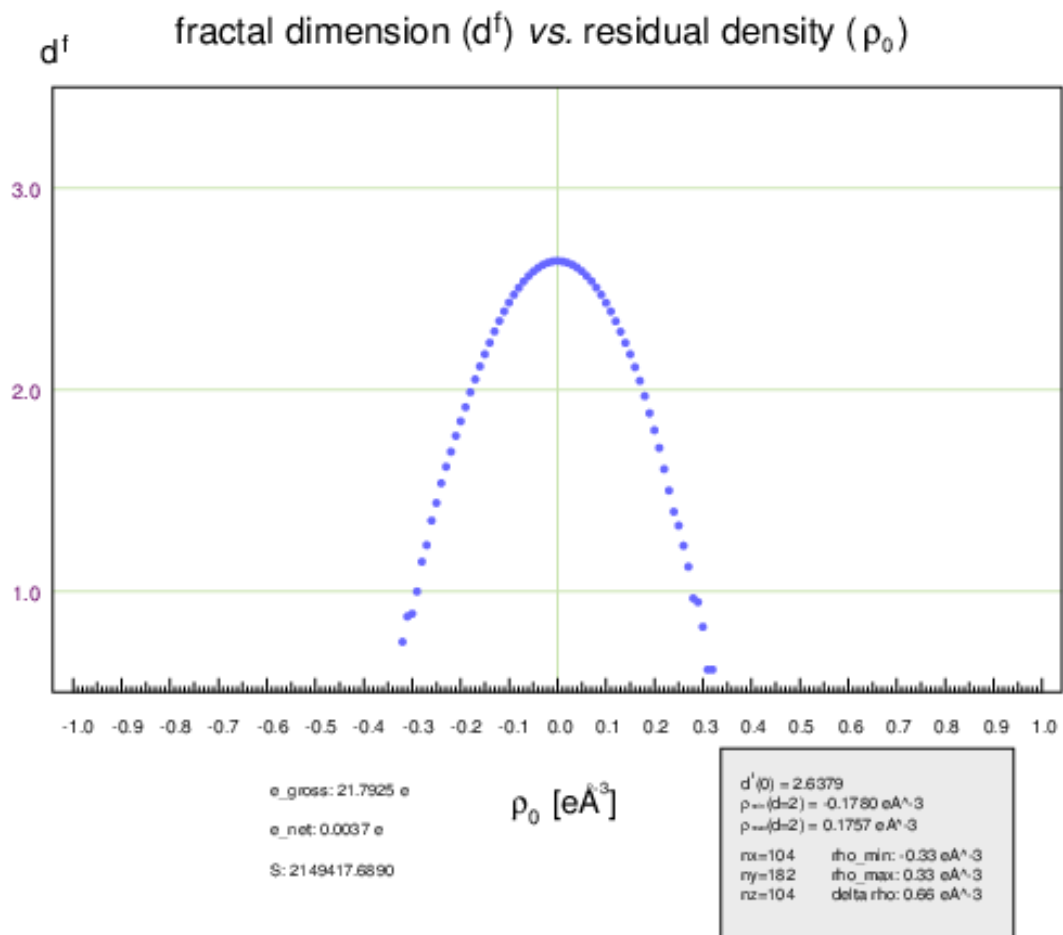


Figure Sup5: Resonance structures of the isolated MET cation within the NBO framework.

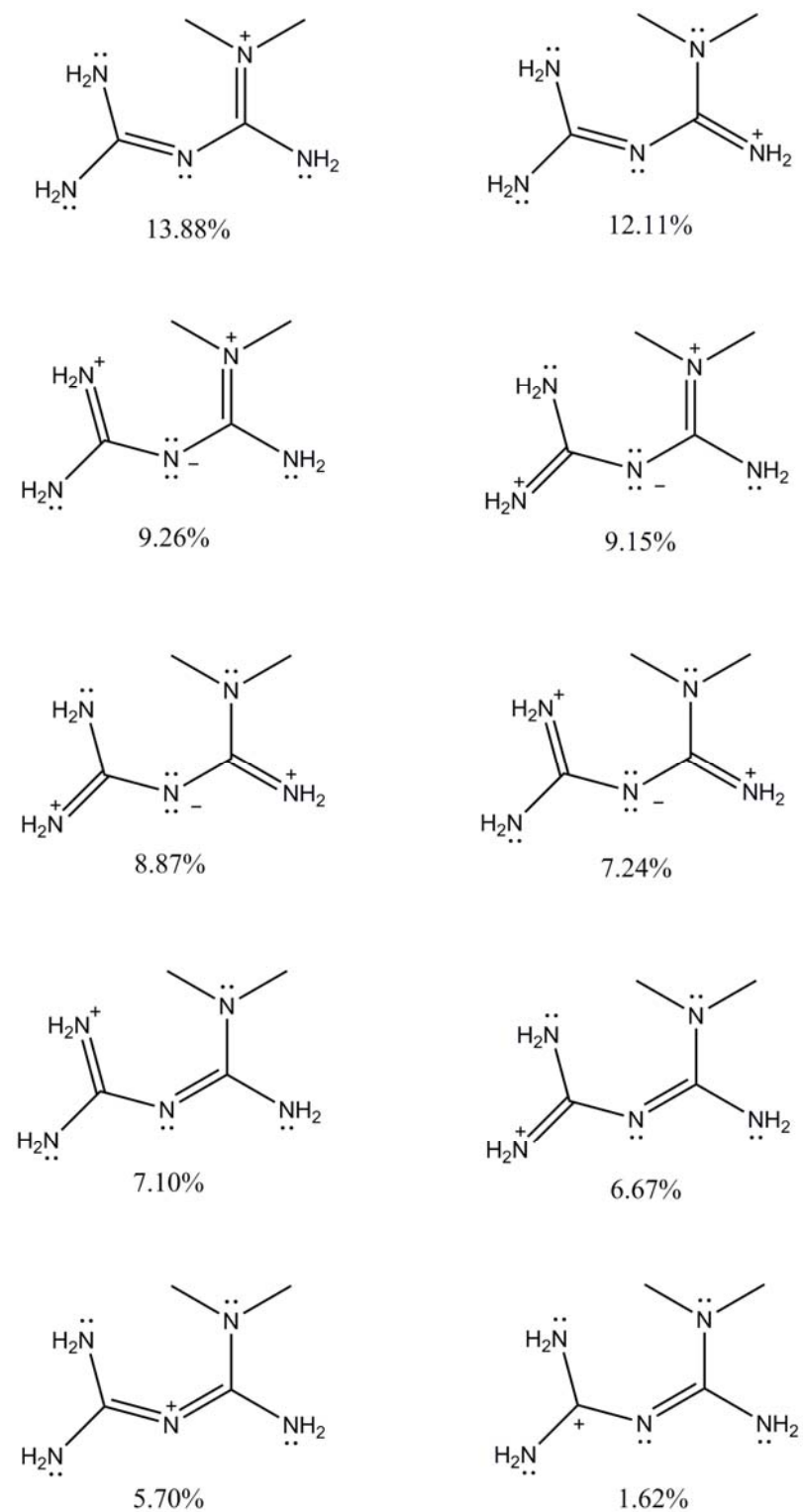


Figure Sup6: Plot of theoretical and experimental Dipole moments D_{theo} & D_{exp} with origin at barycenter of protons. The scale is 1 \AA equivalent to 1 Debye.

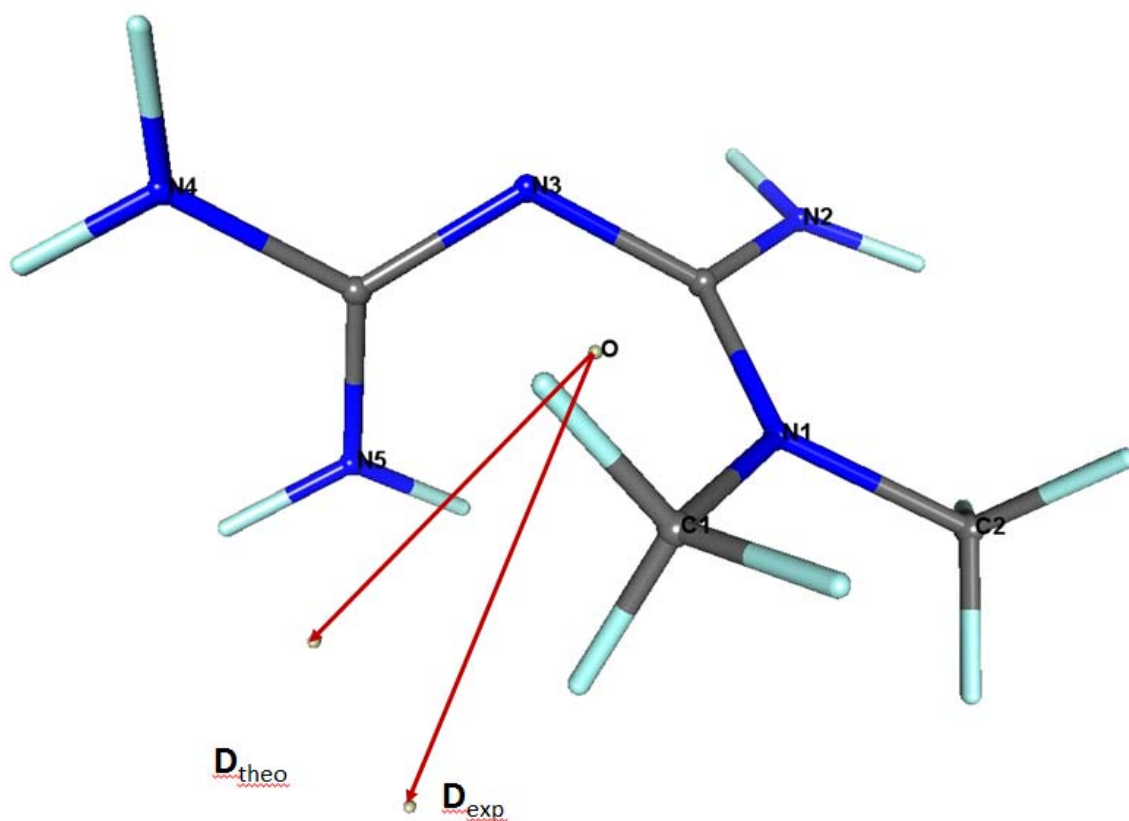
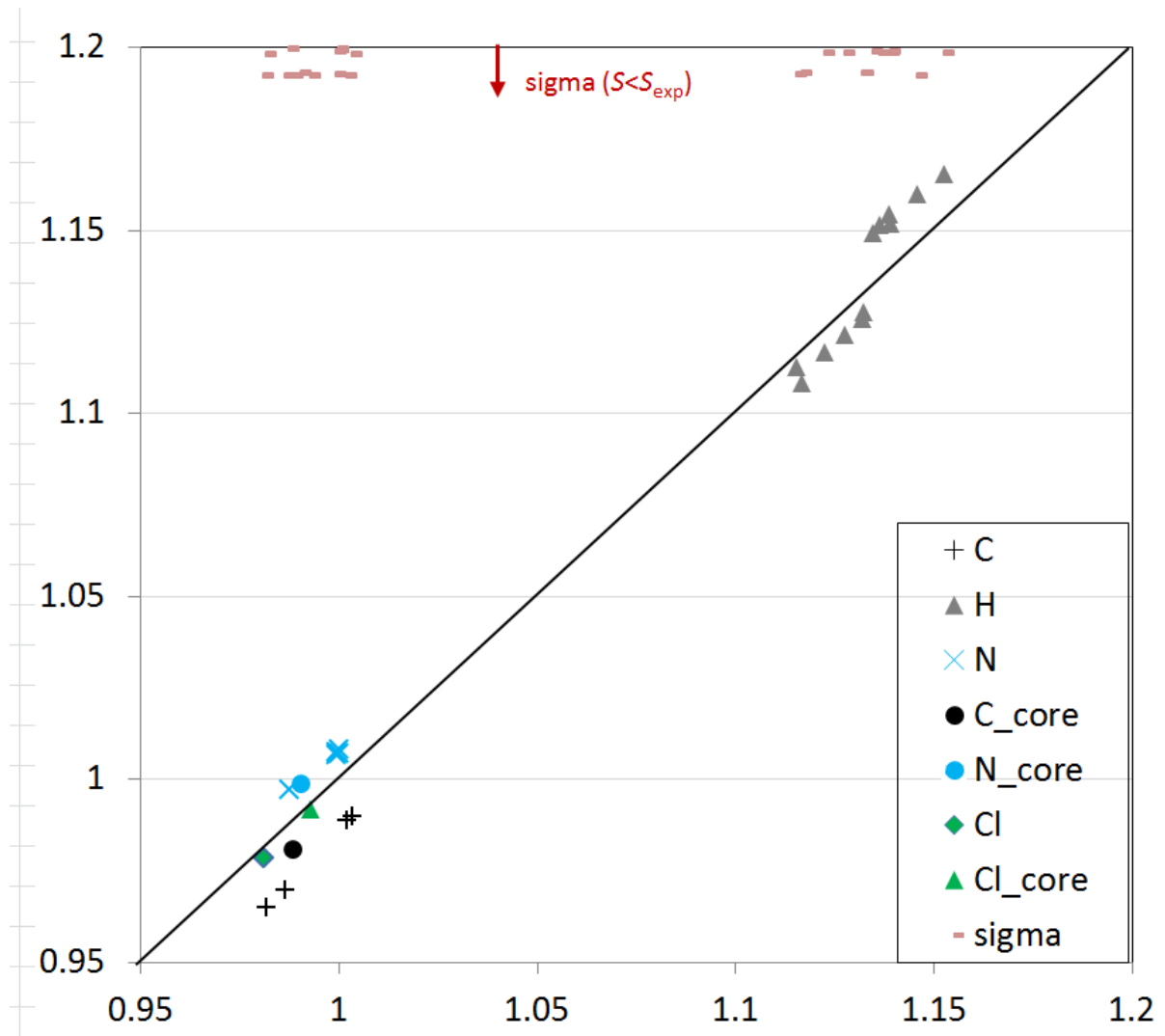


Figure Sup7.



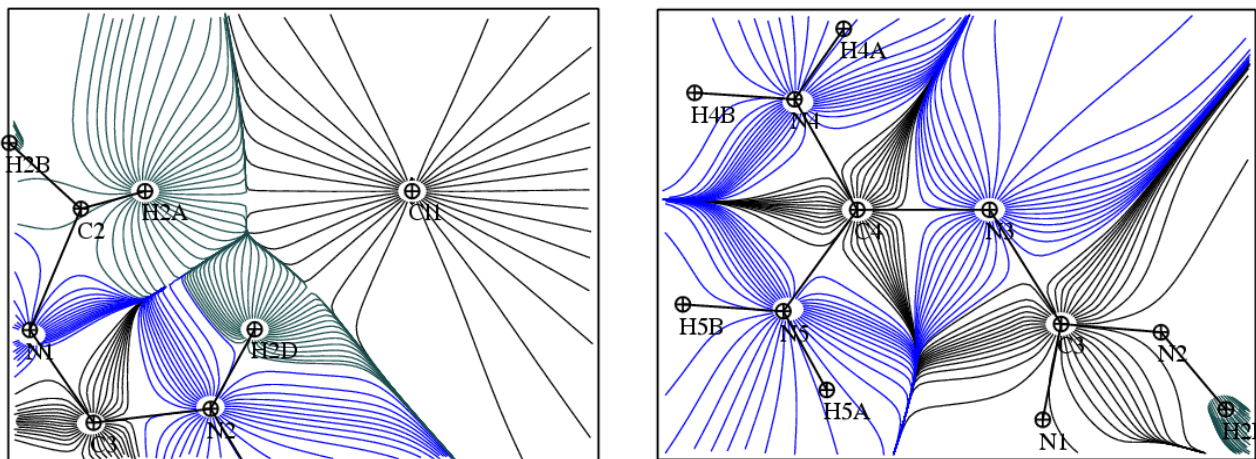
Text Sup 1

1. Gradient vector field

The gradient vector field of electron density $\nabla\rho(\mathbf{r})$ which originates at atomic centers and terminates at the BCP is plotted in Sup Fig. 1. The Cl⁻ anion exhibits largest Bader atomic basin compared with the other atoms in the molecule (Sup Fig. 1a). The highly positively charged C atoms, especially C3 and C4 exhibit smaller Bader atomic basins than the negative N atoms. The basins of the N and C atoms have a prismatic shape in the molecule (Sup Fig. 1b).

Figure : Gradient trajectory plots of the experimental electron-density distribution of the metformin/HCl molecule for the planes (a) H2A-C11-H2D and (b) C4-N3-C3 in the crystal.

a) b)



Text Sup 2. Bond order analysis

The topological bond order defines the number of electron pairs shared between two bonded atoms and is mainly related to orbital representations of chemistry and is highly used to characterize the bonding (Borisova & Semenov, 1973; Mayer, 1983, 1986; Angyan *et al.*, 1994; Reed & Schleyer, 1990; Bridgeman *et al.*, 2001; Angyan, 2000; Mayer *et al.*, 2004). An expression of the bond order has been proposed by Howard & Lamarche (2003) for some covalent bonds:

$$n_{topo}=a_0+a_1(\lambda_1+\lambda_2)+a_2\lambda_3+a_3\rho_{BCP}$$

where a_0 , a_1 , a_2 , a_3 are empirical coefficients and λ_1 , λ_2 , λ_3 are the electron density curvatures(in atomic units).

Table : Bond orders for the C-N bonds obtained from the topology of the electron density (equation no.3) and from molecular orbital analysis in the isolated cation.

Bonds	n_{topo} EXP	n_{topo} THEO	n_{Mayer} THEO <i>in vacuo</i>
C1-N1	1.02	1.01	0.92
C2-N1	1.04	1.02	0.93
C3-N1	1.33	1.26	1.28
C3-N2	1.33	1.28	1.26
C3-N3	1.36	1.28	1.35
C4-N3	1.44	1.30	1.47
C4-N4	1.36	1.26	1.24
C4-N5	1.36	1.28	1.21

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Text Sup 3 HOMED Index Calculation

The HOMED index (Raczynska *et al.*, 2010) based on the modification of the geometry, is used to describe π -electron delocalization in cyclic and acyclic heteroatomic systems. It is calculated by the expression:

$$\text{HOMED} = 1 - \alpha/n \cdot \Sigma(R_o - R_i)^2 \quad (2)$$

Where α , n , R_o and R_i represents the normalization constant, number of bonds taken into account, optimal and real bond lengths, respectively. The calculated HOMED value is high and found to be 0.92 for the group of six C-N bonds and hence this strongly supports the occurrence of π -electron delocalization among these C-N bonds. This is also confirmed by the calculation of the resonance structures of the isolated Metformin cation within the Natural Resonance Theory framework (Glendening *et al.*, 1998) (Fig. S4), which shows partial double bond character of all C-N bonds excepted N1-C1 and N1-C2, involving the methyl groups.

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