Supplementary Material

What Are the Preferred Horizontal Displacements of Aromatic-Aromatic Interactions in Proteins? Comparison with Calculated Benzene-Benzene Potential Energy Surface

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Data from Protein Data Bank

Fig. S1 The correlation of the normal distance (R) with the offset values (r) ; R < 10 Å and r < 10 Å.

The PDB search yielded 24 002 contacts in which centre of the phenyl ring from phenylalanine residue was found to be within the area that corresponds to R < 10 Å and r < 10 Å around another phenylalanine ring. The data suggest that two interacting rings form ellipsoid on diagram. The final number of 6 919 structures were extracted from initial set of structures using equation of an ellipsoid \((x/a)^2 + (y/b)^2 = 1\) where \(a=(r)=7\text{Å}\) and \(b=(R)=6\text{Å}\).

Fig. S2 The correlation of the normal distance (R) with the offset values (r) for ellipsoid with R= 6 Å and r=7 Å.
Fig. S3 Distributions of normal distance R for various tilt angles a) for the tilt $P_1/P_2$ angle in the range 0-50° b) for the tilt $P_1/P_2$ angle in the range 50-90°

For the tilt angle $P_1/P_2$ in the range 0-30° (Figure S3a) the distribution shows large number of interactions with R value in the range of 3.5-4.0 Å. These R values are typical for stacking interaction. The values of R increase with the tilt angles increase and reach its maximum in the range of 4.5-5.0 Å, for the torsion angles larger than 50° (Figure S3b).

Fig. S4 The mean force (according to Boltzmann law)$[S1]$ for different r values  a) for the tilt $P_1/P_2$ angle in the range 0-50° b) for the tilt $P_1/P_2$ angle in the range 50-90°
Results of Calculations

The geometry of isolated benzene molecule was optimized using B2PLYP-D2/def2-TZVP method. The optimized benzene geometry is a planar regular hexagonal ring, with a C-C bond of 1.392 Å and a C-H bond of 1.082 Å.

Fig. S5 The side view of the A orientation at different values of tilt angles (0°, 20°, 40°, 60° and 90°) for the offset \( r \) of 1.5Å.

Fig. S6 a) Calculated interaction energies (\( \Delta E \)) presented on 2-D (up) and 3-D (down) diagrams; b) the optimal normal distances (\( R \)) of orientation A (Figure S4) for values of tilt P\(_1\)/P\(_2\) angle of 0°, 20°, 40°, 60° and 90°. The values for angle 0° are obtained in previous work\(^{15}\).
Fig. S7 The side view of the B orientation at different values of tilt angles (0º, 20º, 40º, 60º and 90º) for the offset \( r \) of 1.5Å.

Fig. S8 a) Calculated interaction energies (\( \Delta E \)) presented on 2-D (up) and 3-D (down) diagrams; b) the optimal normal distances (\( R \)) of orientation B (Figure S6) for values of tilt \( P_1/P_2 \) angle of 0º, 20º, 40º, 60º and 90º. The values for angle 0º are obtained in previous work.15
Fig. S9 The side view of the C orientation at different values of tilt angles (0°, 20°, 40°, 60° and 90°) for the offset $r$ of 1.5Å.

Fig. S10 a) Calculated interaction energies ($\Delta E$) presented on 2-D (up) and 3-D (down) diagrams; b) the optimal normal distances ($R$) of orientation C (Figure S8) for values of tilt $P_1/P_2$ angle of 0°, 20°, 40°, 60° and 90°. The values for angle 0° are obtained in previous work.1

Fig. S11 The side view of the D orientation at different values of tilt angles (0°, 20°, 40°, 60° and 90°) for the offset $r$ of 1.5Å.
Fig. S12 a) Calculated interaction energies (\(\Delta E\)) presented on 2-D (up) and 3-D (down) diagrams; b) the optimal normal distances (R) of orientation D (Figure S10) for values of tilt \(P_1/P_2\) angle of 0º, 20º, 40º, 60º and 90º. The values for angle 0º are obtained in previous work.  

Fig. S13 The view of electrostatic potential map of benzene, \(C_6H_6\); electrostatic potential increases from blue (\(V(r) < -8.9\) kcal/mol) and green (\(V(r) = -8.9\) to 0.0 kcal/mol) to yellow (\(V(r) = 0.0\) to +6.7 kcal/mol) and red (\(V(r) > +6.7\) kcal/mol); grey dots and lines represent atoms and bonds.  