

hydrogen bonds of the type C-H...O/N and weaker interactions of the type C-H...F and C-H... $\pi$  are also considered to have important role in the building of a crystal lattice in the presence of strong hydrogen bonds [3]. Different altered modes of hydrogen bonds and weak interactions are known to generate a number of polymorphs of many compounds [4]. Polymorphism is a phenomenon of immense importance in pharmaceutical industry [5] and generation of new polymorphs, [5] cocrystals [6] and salts [7] of known APIs are possible using different modes of hydrogen bonds and weaker interactions. Study of polymorphism and cocrystal formation have gained momentum in recent years in the view of intellectual property rights (IPR) as well as in the enhancement of physicochemical properties of the drug molecules for their better formulations [8]. We are interested to investigate the possibility of the formation of new polymorphs and cocrystals of a number of well-known Active Pharmaceutical Ingredients (APIs). Our recent experiments using Fluconazole, Ciprofloxacin, Lamivudine, Lamotrigine and Voriconazole reveal that these APIs form new polymorphs or cocrystals or salts when crystallized in the presence of stoichiometric amount of a cocrystal former. The cocrystallization screening experiments have been performed by using both single crystal and powder X-ray diffraction techniques and solid state Raman spectroscopy. We shall highlight our recent results of these experiments and elucidate the crystal structures of new polymorphs of Fluconazole and Lamivudine, new salts of Fluconazole, Ciprofloxacin, Lamivudine and Lamotrigine and a new cocrystal of Voriconazole. Our studies indicate that the presence of a number of weak hydrogen bonds or weaker intermolecular interactions collectively can alter the mode of strong hydrogen bonds and generate new polymorphs, cocrystals and salts of the known APIs.

[1] L. Pauling, *The Nature of Chemical Bond*, Cornell Univ. Press, Ithaca, **1939**. [2] G.R. Desiraju, *Angew. Chem. Int. Ed.* **2010**, *49*, 2-10. [3] G.R. Desiraju, T. Steiner, *The Weak Hydrogen Bond in Chemistry and Biology*, Oxford University Press, Oxford, **1999**. [4] J. Bernstein, *Polymorphism in Molecular Crystals*, Oxford University Press, Oxford, **2002**. [5] S.M. Reutzel-Edens, J.K. Bush, P.A. Magee, G.A. Stephenson, S.R. Byrn, *Crystal Growth & Design*, **2003**, *3*, 897-907. [6] J. Kastelic, I. Hodnik, P. ket, J.Plavec, N. Lah, I. Leban, M. Pajk, O. Planinek, D. Kikelj, *Cryst. Growth Des.* **2010**, *10*, 4943-4953. [7] J. McMahon, M. Peterson, M.J. Zaworotko, T. Shattock, M.B. Hickey, WO patent, WO 2006/007448 A2, **2006**. [8] P. Vishweshwar, J.A. McMahon, J.A. Bis, M. J. Zaworotko, *J. Pharm. Sci.* **2006**, *95*, 499-516.

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**Geometry of C-H...O interactions: case of aromatic CH donors.**  
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C-H...O interactions play important role in biological systems, especially in biomolecules, in stabilizing structures of proteins, in interactions with the ligands, and in recognition of host-guest systems [1,2]. Based on directionality it was shown that C-H...O interactions, although can be weak, are hydrogen bonds and not the van der Waals interaction. Directionality is one of the most important properties of hydrogen bonds [3]. Hydrogen bonds with linear or close to linear geometries are energetically more stable than bent ones.

In this paper, angular distribution of C-H...O interactions of aromatic C-H donor was studied by *ab initio* calculations and by analyzing data in the Cambridge Structural Database (CSD). Crystal structures involving C<sub>6</sub>-H aromatic groups and oxygen atoms were

screened for intermolecular contacts. Following systems with oxygen atom were taken: HOH (non-coordinated), HOZ, Z<sub>1</sub>OZ<sub>2</sub>, O=CZ and O=YZ (Z, Z<sub>1</sub>, and Z<sub>2</sub> are not hydrogen atoms, Y is not carbon atom). High level *ab initio* calculations were performed on three model systems: benzene-water, benzene-methanol, and benzene-acetone.

The analysis of the C-H...O interactions in crystal structures indicate that aromatic C-H donors do not show strong preference for linear contacts and that the preference depend on the type of the atom or group in o-position to the interacting C-H group. The acceptor oxygen atom has possibility for simultaneous C-H...O interactions with the hydrogen atom in o-position to the interacting C-H group. The C-H...O interactions of aromatic molecules with two hydrogen atoms in o-positions do not show preference for linear contacts. Bifurcated interactions are observed in substantial number of structures. Moreover, in the structures with a substituent in o-position there is possibility for simultaneous hydrogen bonds, depending on the nature of the substituent. The calculated energies for linear C-H...O interactions of benzene with water, methanol, and acetone are 1.28, 1.47, 1.45 kcal/mol; while for bifurcated interactions are 1.38, 1.63, and 1.70 kcal/mol, respectively. The calculations are in agreement with the results obtained by analysing crystal structure data from the CSD and show that stabilization energy is larger for bifurcated than for linear interactions. Analysis of the data in the CSD and the *ab initio* calculations indicate that the vicinity of the other possible hydrogen donors in the aromatic molecules cause small tendency for the linear contact the in C-H...O interactions. The result shows that nonlinear interactions are not energetically disfavoured because of the possibility for simultaneous interactions. This can be very important for recognizing C-H...O interaction in biomolecules containing aromatic groups, like proteins. It can also help in recognizing important C-H...O interactions, showing that nonlinear interactions are not energetically disfavoured, because of the possibility for simultaneous interactions.

[1] R.K. Castellano, *Current Organic Chemistry*, **2004**, *8*, 845-865. [2] S. Scheiner, T. Kar, *J. Phys. Chem. B*, **2005**, *109*, 3681-3689. [3] G.R. Desiraju, *Angew. Chem. Int. Ed.*, **2010**, *49*, 2-10.

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**Synthesis, structural characterization and hydrogen bond of new hybrid compound based on indium.**

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The Tris(piperazine-1,4-dium) bis[hexachloridoindate(III)] tetrahydrate, 2[InCl<sub>6</sub>]<sup>3-</sup>·3[C<sub>4</sub>H<sub>12</sub>N<sub>2</sub>]<sup>2+</sup>·4H<sub>2</sub>O was prepared as part of our ongoing studies of hydrogen-bonding interaction in the crystal structures of protonated amines and imines (Bouacida, 2008; Bouacida et al., 2005; 2007). we report here the synthesis and crystal structure of new hybrid compound based on indium with piperazine-1,4-dium that promises both the superior carrier mobility of inorganic semiconductors and the processability of organic materials.

It has been prepared by slow evaporation of an aqueous solution of piperazine, indium(III) chloride and hydrochloric acid in a molar ratio of 10:5:1.

The asymmetric unit consists of one and half independent piperazinium cations, an hexachloridoindiumate anion and two