PREFACE

Crystal structure analysis has gained its importance during the last few decades due to its intense application in the field of material science and medicine particularly in the drug industry. The characterization of materials which are biologically interesting is important and hence the technique of single crystal X-ray diffractometry has gained prominence. The three dimensional structure of the materials will help in formulating structure property/function correlation which in turn will enable to modify materials to suit any requirement. The knowledge of stereochemistry of the molecules is also derived from single crystal X-ray diffraction studies. The double-helical structure of DNA, the planarity of peptide bond, the triple helical structure of collagen, the globular conformation of enzymes and antibodies—all owe their discoveries to X-ray diffraction studies. Practically all the drugs known today are the result of either accidental discoveries or from trial and error process. The X-ray studies thus play an important role in the design of appropriate drugs.

Single crystal X-ray diffraction is the most common experimental method of obtaining a detailed picture of a large molecule that allows resolution of individual atoms. It is performed by analyzing the diffraction of X-rays from an ordered array of many identical molecules. Many molecular substances, including proteins, polymers, and others solidify into crystals under the proper conditions. When solidifying into the crystalline state, these individual molecules typically adapt one of only a few possible orientations. A crystal is a three dimensional array of these molecules that are held together by Vander Waals, non-covalent bonding. The smallest representative unit of crystals is referred to as the unit cell. Understanding the unit cell of these arrays simplifies the understanding of a crystal as a whole. This is the basis of crystallography.

Crystallographic studies on the structure, symmetry and conformation of some organic molecules of wide interest form the basis of this thesis.

Pharmaceutical chemistry is the chemistry of drugs, medicinal and pharmaceutical products. It is defined as any substance or product that is used or intended to be used to modify or explore physiological systems or pathological states
for the benefit of the recipient. The achievement of modern medicine is demonstrated in the successful eradication and control of many deadly diseases. In the past few decades, pharmaceutical chemistry is widely explored in finding and developing organic compounds that are now available in pharmaceutical formulation for the treatment of diseases and often for the maintenance of better quality of human health. In recent decades, more and more synthetic organic and inorganic compounds are used as drugs.

Many organic compounds having pharmaceutical importance exhibit polymorphism. Polymorphism, the ability of a substance to exist in several different crystal forms or modifications, is a frequently observed phenomenon in molecular compounds. If a solid substance includes a solvent during crystallization, this structure is known as a pseudopolymorph, and in case of, e.g., water such crystal forms are generally called hydrates. The polymorphic modifications of a compound are chemically identical but usually differ in their physical and chemical properties, such as density, vibrational spectra, and diffraction patterns.

Co-crystals are crystalline materials composed of different species held together by non-covalent forces and are typically differentiated from a salt by the lack of proton transfer. Co-crystals offer the framework to modify the physical properties of the compounds involved without changing the molecular structure. Pharmaceutical co-crystals have become increasingly important materials because of their potential to improve physical and chemical stability of the compounds involved, decrease hygroscopicity of the crystalline material, increase kinetic or thermodynamic solubility of the compounds or modify dissolution rates for a compound.

Piperidine is an organic compound with the molecular formula (CH₂)₅NH. This heterocyclic amine consists of a six-membered ring containing five methylene units and one nitrogen atom. It is a colourless fuming liquid with an odor described as ammoniacal and the name comes from the genus name *Piper*, which is the Latin word for pepper. A significant industrial application of piperidine is for the production of dipiperidinyl dithiuram tetrasulfide, which is used as a rubber vulcanization accelerator. Piperidine is a widely used building block and chemical reagent in the synthesis of organic compounds, including pharmaceuticals. Piperidine is also commonly used in chemical degradation
reactions, such as the sequencing of DNA in the cleavage of particular modified nucleotides and a base for the deprotection of Fmoc-amino acids used in solid-phase peptide synthesis. Piperidine is also commonly used as a base for the deprotection of Fmoc-amino acids used in solid-phase peptide synthesis. The piperidine structural motif is present in numerous natural alkaloids. This gave the compound its name. Other examples are the fire ant toxin solenopsin, the nicotine analog anabasine of the Tree Tobacco (**Nicotiana glauca**), lobeline of the Indian tobacco, and the toxic alkaloid conine from poison hemlock, which was used to put Socrates to death. Piperidine prefers a chair conformation, similar to cyclohexane. Unlike cyclohexane, piperidine has two distinguishable chair conformations: one with the N–H bond in an axial position, and the other in an equatorial position. In this connection, the present work reports the crystal structure studies of 4-(4-chlorophenyl)piperidin-4-ol, 4-(4-chlorophenyl)-4-hydroxy-piperidinium benzoate, 4-(4-chlorophenyl)-4-hydroxy-piperidinium 2-(2-phenylethyl)benzoate, 4-(4-chlorophenyl)-4-hydroxy-piperidinium maleate maleic acid solvate and bis[4-(4-chlorophenyl)-4-hydroxy-piperidinium] dipicrate dimethyl sulfoxide solvate.

Picric acid forms crystalline picrates with various organic molecules, and such picrates are convenient for identification and qualitative analysis of the organic compounds. The crystal structures of several aromatic hydrocarbon picrates and aromatic heterocyclic compounds have been investigated. Since it is useful to understand the nature of structures of picrates of basic compounds, it is advantageous to study the interaction of drug molecules with picric acid. Now, it has become clear that the picrates of basic aromatic hydrocarbons are formed through π-bonding (π-π interaction), while picrates of aromatic heterocycles are formed through ionic and hydrogen bonding or π-π interaction. Many organic picrates are of most interest to study because of the presence of hydrogen bonding interactions present. It is really worthwhile to study the picrates of organic compounds and also some intermediates which have pharmaceutical importance. Based on the investigations, the present chapter reports the crystal structure studies of opipramol dipicrate, orphenadrinium picrate, orphenadrinium picrate picric acid, fluphenazium dipicrate dimethyl sulphoxide solvate and tramadol picrate.

Chalcones and their analogues are used as potential therapeutic agents in diseases of the cardiovascular system. Photo-cross-linkable polymers having the chalcone moiety act as negative photo-resist materials used in a wide variety of applications. Chalcones are
also used in designing effective second-order non-linear optical materials. Chalcones and their heterocyclic analogues exhibit anti-inflammatory, anti-tumor, antibacterial, antifungal, anti-tubercular, antiviral, antiprotozoal and gastroprotective activities. Chalcones, one of the major classes of natural products with widespread distribution in fruits, vegetables, spices, tea and soy based foodstuff have been recently subjects of interest for their interesting pharmacological activities. Chalcone (1,3-diphenyl-2-propen-1-one) derivatives and their heterocyclic analogues are valuable intermediates in organic synthesis and exhibit a wide range of biological activities, as well as non-linear optical properties with excellent blue light transmittance and good crystallizability. As a part of our ongoing studies in the chalcone structural chemistry, we have synthesized and studied the crystal and molecular structure studies of new chalcones, viz., (2E)-3-(3-bromo-4-methoxyphenyl)-1-(4-methylphenyl)prop-2-en-1-one, (2E)-3-(3-bromo-4-methoxyphenyl)-1-(4-methylphenyl)prop-2-en-1-one, (2E)-3-(3-bromo-4-methoxyphenyl)-1-(4-fluorophenyl)prop-2-en-1-one & 1,3-bis(biphenyl-4-yl)-2,2-dibromo-3-oxopropyl acetate.

Anthrone is a tricyclic aromatic ketone. It is used for a popular cellulose assay and in the colorometric determination of carbohydrates (Trevelyan, 1952). Anthrone method is widely used for the determination of starch and soluble sugars in plant material. Its chief use is in the artificial production of alizarin. Anthracene is a solid hydrocarbon, which accompanies naphthalene in the last stages of the distillation of coal tar. Anthracene and its derivatives are long known polycyclic aromatic compounds showing a high potential for use in materials science (e.g. fluorescence probing, photochromic systems, electroluminescence) and several reviews have been published. It is used for a popular cellulose assay and in the colorometric determination of carbohydrates (Trevelyan, 1952) and anthracene itself is used in the production of red dye alizarin. Benzhydryl compounds contain two benzene rings which substitute hydrogen atoms in the methane molecule. This structure does not allow the fusion of benzene ring. This nomenclature system is particularly useful to describe the groups attached to the benzene rings and the additional substituents on the methane. The benzhydryl structure features as the motif for modified fibers, polymers and curing agents. The benzhydryl motif is a fundamental component also in drugs such antihistamines, antihypertensive agents and antiallergenic agents. Diphenylmethane structure is a moiety of pesticides such as hexachlorophene and dichlorophen. Benzhydrol is used as an intermediate of pharmaceuticals (including
antihistamines), agrochemicals and other organic compounds. It is used as a fixative in perfumery and as a terminating group in polymerizations. Benzhydyl is a skeleton for Histamine H1 antagonist which an ethylamine group is attached to a diphenylmethane structure. Common examples are diphenhydramine, diphenidol and phenyltoloxamine. Based on the present research work, this chapter reports the crystal structure studies of 10,10-dimethylantrone, 9,9-dimethyl-9,10-dihydroanthracene and (2-methylphenyl) (phenyl)methanol.

Benzophenone, an aromatic ketone (diphenyl ketone), is an important compound in organic photochemistry and perfumery as well as in organic synthesis. Benzophenone is used as a constituent of synthetic perfumes and as a starting material for the manufacture of dyes, pesticides and drugs (especially anxiolytic and hypnotic drugs). Benzophenone is used as a photoinitiator of UV-curing applications in inks, adhesive and coatings, optical fiber as well as in printed circuit boards. Photoinitiators are compounds that break down into free radicals upon exposure to ultraviolet radiation. Benzophenones can act as optical filters or deactivate substrate molecules that have been excited by light for the protection polymers and organic substances. Benzophenone derivatives are widely used in sunscreen lotions for UVA protection. Benzophenone and related analogues have been reported to act as antiallergic, anti-inflammatory, antiasthamatic, antimalarial, anti-microbial and antianaphylactic agents. The thesis reports the crystal structure studies of 2-chloro-N-[4-chloro-2-(2-chlorobenzoyl)phenyl]acetamide and 2-chloro-N-[2-(2-fluorobenzoyl)-4-nitrophenyl]-N-methylacetamide.

Tramadol is a very weak μ-opioid receptor agonist, induces serotonin release, and inhibits the reuptake of norepinephrine. Tramadol is converted to O-desmethyltramadol, a significantly more potent μ-opioid agonist. The opioid agonistic effect of tramadol and its major metabolite(s) is almost exclusively mediated by such μ-opioid receptors. This further distinguishes tramadol from opioids in general (including morphine), which do not possess tramadol's degree of receptor subtype selectivity and which are much stronger opiate-receptor agonists. Similarly, the habituating properties of tramadol (such as they are) are arguably mainly due to μ-opioid agonism with contributions from serotonergic and noradrenergic effects. Tramadol may be used to treat post-operative, injury-related, and chronic (e.g.,
cancer-related) pain in dogs and cats as well as rabbits, coatis, many small mammals including rats and flying squirrels, guinea pigs, ferrets, and raccoons. Tramadol comes in ampules in addition to the tablets, capsules, powder for reconstitution, and oral syrups and liquids; the fact that its characteristic taste is distasteful to dogs, but can be masked in food, makes for a means of administration. Tramadol hydrochloride (trademarked as Conzip, Ryzolt, Ultracet, Ultram in the USA, Ralivia and Zytram XL in Canada) is a centrally-acting synthetic analgesic used to treat moderate to moderately-severe pain. The drug has a wide range of applications, including treatment of rheumatoid arthritis, restless legs syndrome and fibromyalgia.

Opipramol is an antidepressant and anxiolytic typically used in the treatment of generalized anxiety disorder (Moller et al., 2001). Opipramol is a tricyclic compound with no reuptake-inhibiting properties. However, it has pronounced D2-, 5-HT2-, and H1-blocking potential and high affinity to sigma receptors (sigma-1 and sigma-2). Opipramol acts as a high affinity sigma receptor agonist. Opipramol has no reuptake-inhibiting properties. Its anxiolysis becomes prominent after only 1-2 weeks of chronic administration. Upon first commencing treatment, opipramol is rather sedating in nature due to its antihistamine properties, but this effect becomes less prominent with time. 2-(2-Benzylphenyl)propan-2-ol is used in synthetic organic chemistry for the preparation of many organic compounds including anthrone. Benzhydrols are widely used as intermediates for the synthesis of pharmaceuticals. Crystal structure studies of tramodol hydrochloride-benzoic acid (1/1), opipramol dihydrochloride and 2-(2-benzylphenyl)propan-2-ol have been reported.

Valyl benzyl ester chloride [Systematic IUPAC name: 1-(Benzyloxy)-3-methyl-1-oxobutan-2-aminium chloride], is a reactant for the synthesis of valsartan, which belongs to the class of angiotensin II receptor antagonists. This chapter reports its crystal structure.

In this context, the present work aims at the synthesis and crystal structure studies of some organic compounds which have wide importance. In the present work, the crystal and molecular structure studies of twenty three compounds have been reported, out of which fourteen compounds are synthesized and nine compounds are gift samples.
The work embodied in this thesis entitled “CRYSTAL AND MOLECULAR STRUCTURE STUDIES OF 4-(4-CHLOROPHENYL)PIPERIDIN-4-OL AND ITS SALTS, PICRATES OF BIOACTIVE COMPOUNDS, CHALCONES AND ALLIED COMPOUNDS” comprises of eight chapters.

Chapter I gives an introduction to single crystal X-ray diffraction and hydrogen bonding. Detailed aspects of single crystal X-ray diffraction are given in this chapter. In the present work, interest is focused on (a) the preparation of some of the organic compounds, (b) crystal data and other relevant parameters regarding data collection, data reduction, structure solution and refinement, (c) atomic co-ordinates of the non-hydrogen atoms with their equivalent displacement parameters, (d) anisotropic parameters, (e) bond lengths and bond angles involving non-hydrogen atoms (f) atomic co-ordinates of the hydrogen atoms, (g) bond lengths and bond angles involving hydrogen atoms, (h) torsion angles, (j) hydrogen bonded interactions, (k) ORTEP of the molecules and (l) packing of the molecules along the crystallographic axes. The structures of all the molecules were solved by direct methods and a discussion based on the above points from (a) to (l) is made individually for all the twenty compounds. Also, a detailed introduction to hydrogen bonding is given in this chapter. To understand the conformation and packing features of the above compounds, the crystal structure determinations are carried out.

Chapter II is divided into six sections. In section 2.1, introduction to piperidines and piperidinols is given. In section 2.2, the title compound (I), C_{11}H_{14}ClNO, crystallizes in an monoclinic space group P2_1/c with a = 11.3706 (10) Å; b = 9.5204 (8) Å; c = 10.6164 (9) Å; α = 90°; β = 108.458 (8)°; γ = 90°; V = 1090.13 (16) Å³; Z = 4; Dcal = 1.290 Mg/m³ at 295 K. The structure was solved by direct methods and refined by full-matrix least-squares procedures to final R1 = 0.038 and wR2 = 0.111; using 2190. In the crystal structure there are the hydrogen-bonded layers of molecules, created by interconnecting chains, in the bc plane. There are no directional interactions between neighbouring layers.

In section 2.3, for the title molecular salt 4-(4-chlorophenyl)-4-hydroxy-piperidinium maleate maleic acid solvate, C_{11}H_{15}ClNO^+. C_4H_3O_4-C_4H_4O_4, (II), the dihedral angle between the mean planes of the chlorine-substituted aromatic ring and
the 4-hydroxypiperidinium ring (C–C–C–C–N) is 61.9 (8)°. Intramolecular O—H···O and intermolecular O—H···O and N—H···O hydrogen bonding, as well as weak π-stacking interactions [centroid–centroid distance = 3.646 (5) Å] help to establish the packing. The title compound crystallizes in a monoclinic space group C2/c with a = 19.282 (7) Å; b = 7.867 (3) Å; c = 25.115 (9) Å; α = 90°; β = 91.545 (5)°; γ = 90°; V = 3808 (2) Å3; Z = 8; Dcal = 1.548 Mg/m3 at 100 K. The structure was solved by direct methods and refined by full-matrix least-squares procedures to final R1 = 0.034 and wR2 = 0.092; using 5841 reflections.

In section 2.4, the title salt bis[4-(4-chlorophenyl)-4-hydroxypiperidinium] dipicrate dimethylsulfoxide solvate, 2C11H15ClNO4+2C6H2N3O7−·C2H6OS, (III), contains two crystallographically independent 4-(4-chlorophenyl)-4-hydroxypiperidinium cations, two picrate anions and a dimethyl sulfoxide solvent molecule. In each cation, the piperidinium ring adopts a chair conformation. In the crystal structure, the cations, anions and solvent molecules are connected by intermolecular O—H···O, N—H···O and C—H···O hydrogen bonds, forming a three-dimensional network. The title compound crystallizes in a monoclinic space group P21 with a = 8.9207 (4) Å; b = 18.1230 (9) Å; c = 12.9886 (6) Å; α = 90°; β = 98.430 (1)°; γ = 90°; V = 2077.18 (17) Å3; Z = 2; Dcal = 1.533 Mg/m3 at 100 K. The structure was solved by direct methods and refined by full-matrix least-squares procedures to final R1 = 0.041 and wR2 = 0.140; using 15185 reflections.

In section 2.5, for the title molecular salt, 4-(4-chlorophenyl)-4-hydroxypiperidinium benzoate, C11H15ClNO4−·C7H5O2−, (IV), the dihedral angle between the mean planes of the chlorophenyl ring of the cation and the benzene ring of the anion is 74.4 (1)°. In the cation, the six-membered piperazine ring adopts a chair conformation. The crystal packing is stabilized by intermolecular N—H···O and O—H···O hydrogen bonds, and weak intermolecular C—H···O, C—H···Cl and C—H···π interactions. The title compound crystallizes in a triclinic space group P ı with a = 9.6235 (12) Å; b = 10.0971 (16) Å; c = 10.2251 (14) Å; α = 99.608 (12)°; β = 108.748 (13)°; γ = 113.357 (14)°; V = 812.7 (2) Å3; Z = 2; Dcal = 1.364 Mg/m3 at 173 K. The structure was solved by direct methods and refined by full-matrix least-squares procedures to final R1 = 0.046 and wR2 = 0.114; using 4184 reflections.
In section 2.6, for the title molecular salt, 4-(4-chlorophenyl)-4-hydroxyxypiperidinium 2-(2-phenylethyl)benzoate, C_{11}H_{15}ClNO^+\cdotC_{15}H_{13}O_2^-, (V), the piperidinium ring adopts a chair conformation. In the crystal, cations and anions are connected by intermolecular O—H⋯O and N—H⋯O hydrogen bonds, forming two-dimensional networks parallel to the bc plane. Furthermore, the crystal structure is stabilized by weak C—H⋯π interactions.

Chapter III describes the preparation and crystal structure studies of picrates of bioactive compounds is divided into six sections. Section 3.1 gives an introduction to organic picrates. In section 3.2, for the title compound (VI), C_{23}H_{31}N_{3}O_{2}^+\cdot2C_{6}H_{2}N_{3}O_{7}^-, the piperazine group in the Opipramol dication is protonated at both N atoms. Each picrate anion interacts with the protonated N atom in the cation through a bifurcated N—H⋯O hydrogen bond, forming an R^2_2(6) ring motif. In the cation, the dihedral angle between the mean planes of the two benzene rings is 50.81 (8) Å. Intermolecular O—H⋯O and weak C—H⋯O hydrogen bonds, and weak π-ring and π–π stacking interactions dominate the crystal packing. It crystallizes in an triclinic space group P\bar{1} with a = 7.3838 (8) Å; b = 12.0400 (13) Å; c = 22.074 (2) Å; α = 74.821 (1)°; β = 84.355 (2)°; γ = 73.866 (2)°; V = 1818.6 (3) Å\(^3\); Z = 2; Dcal = 1.501 Mg/m\(^3\) at 100 K. The structure was solved by direct methods and refined by full-matrix least-squares procedures to final R1 = 0.049 and wR2 = 0.109; using 10692 reflections.

In section 3.3, for the title compound (VII), C_{18}H_{24}NO^+\cdotC_{6}H_{2}N_{3}O_{7}^-, the phenyl rings of the orphenadrinum cation are disordered [occupancies = 0.662 (4) and 0.338 (4)]. The N atom in the orphenadrinum cation is protonated. The picrate anion interacts with the protonated N atom through a bifurcated N—H⋯O hydrogen bond, forming an R^2_1(6) ring motif with an adjacent cation. The mean planes of the two o-NO\(_2\) and single p-NO\(_2\) groups in the picrate anion are twisted by 23.0 (6), 31.3 (3) and 6.3 (2)° with respect to the mean planes of the six-membered ring. Weak
intermolecular C—H···O hydrogen bonds, C—H···π intermolecular interactions and weak π−π stacking interactions [centroid–centroid distances = 3.677 (2) and 3.515 (3) Å] stabilize the crystal packing, creating a three-dimensional network. It crystallizes in an triclinic space group Pî with a = 9.9434 (10) Å; b = 11.2216 (8)Å; c = 11.3523 (12)Å; α = 78.658 (7)°; β = 76.342 (9)°; γ = 87.660 (7)°; V = 1206.82 (19)Å³; Z = 2; Dcal = 1.372 Mg/m³ at 100 K. The structure was solved by direct methods and refined by full-matrix least-squares procedures to final R1 = 0.065 and wR2 = 0.178; using 4677 reflections.

In section 3.4, for the title compound (VIII), C₁₈H₂₄NO⁺·C₆H₂N₃O₇⁻·C₆H₃N₃O₇, contains one orphenadrinium cation, one picrate anion and one picric acid molecule. In the orphenadrine cation, the two aromatic rings form a dihedral angle of 70.30 (7)°. There is an intramolecular O—H···O hydrogen bond in the picric acid molecule, which generates an S (6) ring motif. In the crystal structure, the orphenadrine cations, picrate anions and picric acid molecules are connected by strong intermolecular N—H···O hydrogen bonds, π···π interactions between the benzene rings of cations and anions [centroid–centroid distance = 3.5603(9)Å] and weak C—H···O hydrogen bonds, forming a three-dimensional network. It crystallizes in an monoclinic space group P21/C with a = 11.1914 (9) Å; b = 12.4481(10) Å; c = 22.6127(19) Å; α = 90°; β = 93.601(1)°; γ = 90°; V = 3144.0 (4) Å³; Z = 4; Dcal = 1.537 Mg/m³ at 100 K. The structure was solved by direct methods and refined by full-matrix least-squares procedures to final R1 = 0.044 and wR2 = 0.127; using 9224 reflections.

In section 3.5, for the title compound (IX), C₂₂H₂₈F₃N₃OS₂⁺·2(C₆H₂N₃O₇). (CH₃)₂SO, the ionic fragments: the fluphenazinium dictation, and two picrate anions, are joined by means of strong N-H···O and weak C-H···O hydrogen bonds into the chains of alternating cations and anions, expanding along [010] direction. Within the chain, the picrates interact by means of short π···π interactions: the mean distance between the planes is 3.366 Å; additional interaction of the same type between one of the picrates and the phenyl ring of the phenothiazine ring system additionally strengthen the pattern. The phenothiazine ring exists in a typical, “butterfly-like” conformation, with two terminal rings planar and the central ring in a slightly flattened boat form. This conformation results in the dihedral angle between the terminal rings of 41.76(5)°. The
aliphatic chain which substitutes phenothiazine at N-position is not in an extended conformation, the torsion angles along this chain are 75.95(14)° and -163.96(10)°. The structure contains also the solvent—dimethylsulphoxide molecules, which are connected with the cation-anion structure by means of strong O-H···O hydrogen bonds.

Graphical Abstract
The ionic fragments of the title salt are joined by means of strong N-H···O and weak C-H···O hydrogen bonds into the chains of alternating cations and anions, expanding along [010] direction [IMAGE]. It crystallizes in a triclinic space group P ̅1 with a = 10.6333 (12) Å; b = 11.9696 (12)Å; c = 17.7036 (15)Å; α = 103.265 (9)°; β = 98.414 (9)°; γ = 102.702 (10)°; V = 2093.0(4)Å³; Z = 2; Dcal = 1.545 Mg/m³ at 100 (1) K. The structure was solved by direct methods and refined by full-matrix least-squares procedures to final R1 = 0.0317 and wR2 = 0.0825; using 8490 reflections.

In section 3.6, for in the title compound (X), C₁₆H₂₆NO₂⁺.C₆H₂N₃O₇⁻, the cation is protonated at the N atom. The cyclohexane ring adopts a chair conformation with the hydroxy substituent in an axial position. In the crystal, O—H···O and N—H···O hydrogen bonds link the cations and anions into supramolecular chains along [100]. It crystallizes in a triclinic space group P ̅1 with a = 8.5674 (10) Å; b = 12.3664 (12)Å; c = 13.2276(13)Å; α = 113.003 (9)°; β = 107.686 (10)°; γ = 95.541(9)°; V = 1191.4(2)Å³; Z = 2; Dcal = 1.373 Mg/m³ at 295 K. The structure was solved by direct methods and refined by full-matrix least-squares procedures to final R1 = 0.052 and wR2 = 0.135; using 4838 reflections.

Chapter IV is divided into five sections. Section 4.1 gives an introduction to chalcones. In section 4.2, in the title compound (XI), C₁₇H₁₆FNO, the mean planes of the two benzene rings are twisted slightly, making a dihedral angle of 7.8 (1)°. The prop-2-en-1-one group is also twisted slightly with a C—C—C—O torsion angle of -11.6 (3)°. In the crystal, weak intermolecular C—H···O interactions link pairs of molecules, forming Centrosymmetric dimers. It crystallizes in a monoclinic space group P2₁/c with a = 12.8334 (3) Å; b = 12.3560 (2) Å; c = 9.3922(2) Å; α = 90°; β = 105.965 (2); γ = 90°; V = 1431.87(5) Å³; Z = 4; Dcal = 1.249g/cm³ at 295 K. The structure was solved by direct methods and refined by full-matrix least-squares procedures to final R1 = 0.059 and wR2 = 0.181; using 2929 reflections.
In section 4.3, the title compound (XII), C_{17}H_{15}BrO_{2}, can be described by the dihedral angles between three planar fragments: 1-bromo-2-methoxyphenyl ring [maximum deviation = 0.003 (2) Å], the central prop-2-en-1-one chain [maximum deviation = 0.005 (2) Å], and the methylphenyl ring [maximum deviation = 0.004 (2) Å]. The terminal planes are twisted by 10.37 (12)° while the central plane is almost coplanar with the methylphenyl ring [3.30 (13)°], but the dihedral angle with the other phenyl ring is significantly larger [8.76 (16)°]. In the crystal, molecules are linked into chains along [001] by three C—H···O hydrogen bonds. These chains interact with each other by means of weak π···π contacts [centroid–centroid distances = 3.73 (1) and 3.44 (1) Å]. An intermolecular C—H···Br interaction also occurs. It crystallizes in an monoclinic space group P2_{1}/c with a = 11.680 (2) Å; b = 11.654 (2) Å; c = 10.834(2) Å; α = 90°; β = 93.07 (2)°; γ = 90°; V = 1472.6(4)Å³; Z = 4; Dcal = 1.494 Mg/m³ at 295 K. The structure was solved by direct methods and refined by full-matrix least-squares procedures to final R1 = 0.043 and wR2 = 0.0636; using 3003 reflections.

In section 4.4, for the title compound (XIII), C_{16}H_{12}BrFO_{2}, the dihedral angle between the aromatic rings is 23.75 (12)° and the dihedral angle between the prop-2-en-1-one fragment and the fluorobenzene ring is 20.9 (2)°. In the crystal, only Vander Waals interactions occur. It crystallizes in an monoclinic space group P2_{1}/c with a = 11.056 (2) Å; b = 4.1110 (15) Å; c = 30.825(5) Å; α = 90°; β = 96.76 (2)°; γ = 90°; V = 1391.3(6)Å³; Z = 4; Dcal = 1.600g/cm³ at 295 K. The structure was solved by direct methods and refined by full-matrix least-squares procedures to final R1 = 0.044 and wR2 = 0.0855; using 2887 reflections.

In section 4.5, for the title molecular salt, C_{29}H_{22}Br_{2}O_{3}, (XIV), the dihedral angles between the mean planes of the benzene rings within each biphenyl group are 26.7 (8) and 30.9 (8)°. The mean planes of the terminal and inner benzene rings of the biphenyl groups bonded through a propan-1-one group in the V-shaped molecule are oriented at angles of 66.1 (7) and 60.0 (8)°, respectively. The two Br atoms are opposite the propen-1-one group. Weak intermolecular C—H···O and C—H···π interactions are observed in the crystal structure. The title compound (XIV), crystallizes in a monoclinic space group P2_{1}/c with a = 12.0497(14) Å; b = 20.842(2) Å; c = 9.9482(10) Å; α = 90°; β = 98.743(10)°; γ = 90°; V = 2469.4(5) Å³; Z = 4;
Dcal = 1.278 Mg/m³ at 100 K. The structure was solved by direct methods and refined by full-matrix least-squares procedures to final R1 = 0.044 and wR2 = 0.123; using 10016 reflections.

Chapter V describes the preparation and crystal structure studies of allied compounds and divided into four sections. Section 5.1 gives an introduction to anthrones, anthracenes and benzhydrols. In section 5.2, for the title compound (XIV), C₁₆H₁₄O, where in the asymmetric unit consists of three crystallographically independent molecules. The anthracene units are essentially planar, with maximum deviations of 0.165 (1), 0.153 (1) and 0.045 (1) Å in the three molecules. In the crystal structure, molecules are linked via intermolecular C—H···O hydrogen bonds. Further stabilization is provided by C—H···π interactions. It crystallizes in an triclinic space group P\(^\overline{1}\) with a = 11.2438 (6) Å; b = 12.1105 (6)Å; c = 15.1025 (8)Å; \(\alpha = 107.955 (1)^{\circ}\); \(\beta = 98.734 (1)^{\circ}\); \(\gamma = 111.764 (1)^{\circ}\); V = 1732.47(16)Å³; Z = 6; Dcal = 1.278 Mg/m³ at 100 K. The structure was solved by direct methods and refined by full-matrix least-squares procedures to final R1 = 0.044 and wR2 = 0.123; using 10016 reflections.

In section 5.3, for the title compound (XV), C₁₆H₁₆, where in the central benzene ring adopts a boat conformation, with a dihedral angle of 34.7(9)° between the mean planes of the two fused benzene rings. The two methyl groups at the apex of the central benzene ring are in axial and equatorial conformations. The crystal packing is stabilized by weak C—H···π intermolecular interactions. It crystallizes in an monoclinic space group P\(2_1/c\) with a = 12.7042 (15) Å; b = 7.4882 (7) Å; c = 13.177 (2) Å; \(\alpha = 90^{\circ}\); \(\beta = 107.787 (14)^{\circ}\); \(\gamma = 90^{\circ}\); V = 1193.7 (3)Å³; Z = 4; Dcal = 1.159 Mg/m³ at 173 K. The structure was solved by direct methods and refined by full-matrix least-squares procedures to final R1 = 0.050 and wR2 = 0.114; using 2958 reflections.

In section 5.4, for the title compound (XVI), C₁₄H₁₄O, where in the two benzene rings are almost orthogonal [dihedral angle = 87.78 (8)°]. The hydroxyl group lies approximately in the plane of its attached benzene ring [O—C—C—C torsion angle = -17.47 (17)°], and the hydroxyl and methyl groups lie to the same side of the molecule and are gauche to each other. In the crystal, a hexameric aggregate mediated by a ring of six O—H···O hydrogen bonds occurs, generating an \(R_6^6(12)\) loop. The
compound is crystallizes in a trigonal space group R3 with a = 23.013(2) Å; b = 23.013(2) Å; c = 10.6067(11) Å; α = β = 90°; γ = 120°; V = 4864.8(7) Å³; Z = 18; Dcal = 1.218 Mg/m³ at 100 K. The structure was solved by direct methods and refined by full-matrix least-squares procedures to final R1 = 0.045 and wR2 = 0.115 using 2475 reflections.

Chapter VI describes the preparation and crystal structure studies of benzophenone compounds and divided into three sections. Section 6.1 gives an introduction to benzophenones. In section 6.2, for the title compound (XVII), C₁₅H₁₀Cl₃NO₂, an intramolecular N—H···O hydrogen bond forms a six-membered ring and enforces an almost coplanar conformation for the acetamido group, the central benzene ring and the bridging carbonyl C—C (=O)—C group: the dihedral angles between the benzene ring and the acetamide and carbonyl C—C O—C planes are 7.06 (11) and 7.17 (12)°, respectively. The dihedral angle between the two benzene rings is 67.43 (9)°. Because a strong hydrogen-bond donor is involved in the intramolecular interaction, the crystal packing is determined by weak C—H···O and C—H···Cl interactions. It crystallizes in a triclinic space group Pī with a = 7.5776 (9) Å; b = 10.1565 (10)Å; c = 10.7862 (12)Å; α = 70.069 (8)°; β = 77.604 (9)°; γ = 70.388 (8)°; V = 730.47(14)Å³; Z = 2; Dcal = 1.558 Mg/m³ at 295 K. The structure was solved by direct methods and refined by full-matrix least-squares procedures to final R1 = 0.043 and wR2 = 0.109; using 2917 reflections.

In section 6.3, the title compound (XVIII), C₁₆H₁₂CFN₂O₄, crystallizes with two molecules in the asymmetric unit in which the dihedral angles between the mean planes of the two benzene rings are 65.1 (7) and 65.6 (6)°. In each molecule, the nitro group displays rotational disorder over two orientations in a 0.503 (11): 0.497 (11) ratio and the Cl atom is disordered in a 0.432 (5): 0.568 (5) ratio. In one molecule, the F atom is statistically disordered over two positions. The crystal packing features weak intermolecular C—H···O and C—H···Cl interactions, which form a layered network. It crystallizes in triclinic space group Pī with a = 8.1339 (6) Å; b = 10.9639 (8) Å; c = 17.8690 (11) Å; α = 81.251 (6)°; β = 82.239 (6)°; γ = 87.937 (6)°; V = 1560.38 (19)Å³; Z = 4; Dcal = 1.159 Mg/m³ at 200 K. The structure was solved by direct methods and refined by full-matrix least-squares procedures to final R1 = 0.066 and wR2 = 0.333; using 3774 reflections.
Chapter VII describes the preparation and crystal structure studies of tramadol hydrochloride-benzoic acid (1/1), opipramol dihydrochloride and 2-(2-benzyl phenyl)propan-2-ol compounds and divided into four sections. An introduction to co-crystals, tramadol, opipramol and 2-(2-benzyl phenyl) propan-2-ol is given section 7.1. In section 7.2, for the title compound (XIX), C_{16}H_{31}NO_{2}^{+}·Cl^-·C_{7}H_{6}O_{2}, where in the N atom is protonated and the six-membered cyclohexane ring adopts a slightly distorted chair conformation. The dihedral angle between the mean planes of the benzene rings in the cation and the benzoic acid molecule is 75.5 (9)^o. The crystal packing is stabilized by weak intermolecular O—H···Cl, N—H···Cl and C—H···π interactions, forming a two dimensional chain network along the b axis. The benzoic acid molecule is not involved in the usual head-to-tail dimmer bonding, but instead is linked to the ammonium cation through mutual hydrogen-bonding interactions with the chloride anion. It crystallizes in an monoclinic space group P2_1/c with a = 8.9721 (2) Å; b = 10.4086 (2) Å; c = 12.5189 (3) Å; α = 90°; β = 101.646 (2)°; γ = 90°; V = 1145.03 (4) Å³; Z = 2; Dcal = 1.224 Mg/m³ at 173 K. The structure was solved by direct methods and refined by full-matrix least-squares procedures to final R1 = 0.043 and wR2 = 0.091; using 5354 reflections.

In section 7.3, the title compound (XX), C_{23}H_{31}N_{3}O_{2}^{2+}·2C_{6}H_{2}N_{3}O_{7}^-, is the dihydrochloride of a piperazine derivative bearing a bulky 3-(5H-dibenz [b,f]azepin-5-yl)propyl substituent. Protonation took place on both N atoms of the piperazine unit. The diazacyclohexane ring adopts a chair conformation. N—H···Cl, O—H···Cl and C—H···Cl hydrogen bonding as well as C—H···O contacts connect the components into a three-dimensional network in the crystal. Two C—H···π contacts are also observed. It crystallizes in an orthorhombic space group Pna2_1 with a = 33.6581 (6) Å; b = 9.4265 (2) Å; c = 6.8978 (1) Å; α = 90°; β = 90°; γ = 90°; V = 2188.52 (7) Å³; Z = 4; Dcal = 1.324 Mg/m³ at 200 K. The structure was solved by direct methods and refined by full-matrix least-squares procedures to final R1 = 0.027 and wR2 = 0.071; using 5253 reflections.

In section 7.4, for the title compound (XXI), C_{16}H_{18}O, there are two molecules in the asymmetric unit of the title compound, a tertiary alcohol featuring a 2-benzylphenyl substituent. Co-operative O—H···O hydrogen bonds connect the molecules into tetramers. The title compound crystallizes in a monoclinic space group.
Chapter VIII describes the crystal structure studies of valyl benzyl ester chloride. In section 8.1, for the title compound (XXI), C₁₂H₁₈NO₂⁺.Cl⁻, the ester group is approximately planar, with a maximum deviation of 0.040 (2) Å from the least-squares plane, and makes a dihedral angle of 28.92 (16)° with the phenyl ring. The crystal structure is organized by N—H···Cl hydrogen bonds which join the two components into a chain along the b axis. Pairs of chains arranged anti parallel are interconnected by further N—H···Cl hydrogen bonds, forming eight-membered rings. Similar packing modes have been observed in a number of amino acid ester halides with a short unit-cell parameter of ca 5.5 Å along the direction in which the chains run. It crystallizes in an monoclinic space group P2₁/c with a = 9.705 (1) Å; b = 5.406 (1) Å; c = 13.116(2) Å; α = 90°; β = 96.58 (1)°; γ = 90°; V = 683.60(18)Å³; Z = 2; Dcal = 1.184 Mg/m³ at 295 K. The structure was solved by direct methods and refined by full-matrix least-squares procedures to final R1 = 0.034 and wR2 = 0.073; using 2010 reflections.

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