DECLARATION

I have submitted the research work in this thesis entitled, "Studies on coordination compounds of cobalt and tungsten, having biochemical relevance to pterin-containing metalloenzymes", under the supervision of Professor Parag Sinchan Roy, Department of Chemistry, University of North Bengal. The research data represented in the thesis are new and original based on experiments in our research laboratory and not submitted anywhere neither for award nor fellowship.

Samir Sen 09.12.2015
(SAMIR SEN)

SUPERVISOR'S CERTIFICATE

It is a pleasure for me to write a few lines about my Ph.D. student Sri Samir Sen, on the occasion of his submission of Ph.D. thesis for evaluation purpose entitled, "Studies on coordination compounds of cobalt and tungsten, having biochemical relevance to pterin-containing metalloenzymes".

The work embodied in the above thesis is concerned with redox non-innocent pterin ligands and bulk of the compounds reported here involve the tungsten(IV) oxidation state. Sri Sen proved his mettle in synthesizing such air-sensitive compounds under inert atmosphere and purifying them through flash chromatography under dinitrogen flow. Some of the synthetic procedures have to be repeated several times, for getting the correct microanalytical, mass spectral and spectroscopic data (IR, NMR, etc.). Some of the spectral data reported here will speak for themselves. He has been tested to the limit of endurance for achieving such precise experimental data.

I hope the sympathetic reader will find this thesis a fountain of joy and intellectual inspiration.

I wish Sri Sen every success in life.

Parag Sinchan Roy

09-12-2015

Parag Sinchan Roy
Professor of Chemistry
University of North Bengal

DEDICATION

I have dedicated my little work to my friends and also to the restless innovators in science for providing inspirations on multi-dimensional thinking.

ACKNOWLEDGEMENT

I express my gratitude to Professor Parag Sinchan Roy, Department of Chemistry, University of North Bengal for the research opportunity and continuous guidance throughout the research period. I am also grateful to all my teachers of the Department of Chemistry, University of North Bengal. I acknowledge the valuable help received from the officers, research scholar, non-teaching Staff and members.

I appreciate my research team members Dr. Md. Afsar Ali, Baidyanath Ghosh and Siddhartha S. Baisya for their outstanding discussions and co-operation. We have studied, correlated the theoretical background and the experimental data in the best possible way. I represent the thesis with true care for interested readers in science.

I express my gratitude also to the CSIR, New Delhi for a senior research project [01(1829)/02/EMR-II] fellowship (2004 - 2005); UGC, New Delhi for financial support (SAP - DRS); DST, New Delhi for a FIST programme, providing a Bruker 300 MHz NMR instrument; CSMCRI, Bhavnagar, India for X-ray structural data; SAIF, CDRI, Lucknow for ESIMS, NMR and some microanalytical data; SAIF, IIT, Bombay for EPR data; IICB, Kolkata for some fluorescence data; University of North Bengal for infrastructural facility; Professor Junhua Yan for Isotope Pattern Calculator (v,

4.0). The microanalytical data were obtained from SAIF, Punjab University, Chandigarh and SAIF, North Eastern Hill University, Shillong.

Valuable technical support have been received from M/s. Lab Instruments and Chemical Works, Siliguri – 734001, who promptly supplied glass apparatus as per design and repaired equipments reliably.

I will gratefully receive comments concerning errors of typography, omission might have crept in inspite of all precautions.

Samir Sen 09.12.2015

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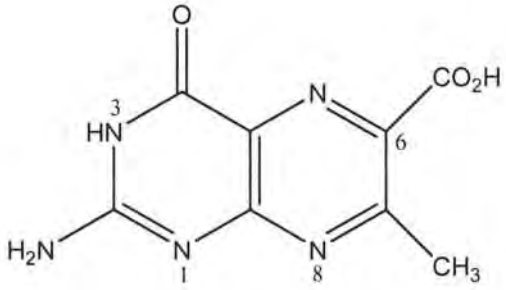
PREFACE

The research work embodied in this thesis entitled, "*Studies on coordination compounds of cobalt and tungsten, having biochemical relevance to pterin-containing metalloenzymes*", has been carried out in the laboratory of Professor Parag S. Roy, Department of Chemistry, University of North Bengal. The thesis consists of six chapters. In Chapter I, a general introduction stresses the importance of the works reported here, along with the highlights of the available knowledge in these fields and the necessary references (indicated by superscript numbers), which are grouped together at the end of this treatise. The aims and objectives of this work as described in chapter I (Introduction), points out the scope of the present work, research goals to be achieved and the outlines of the experimental techniques used for realizing them. Chapters II, III are concerned with the investigation on coordination compounds of cobalt and chapters IV, V and VI include the studies on coordination compounds of tungsten with the following pterin ligands (schematic structures of both keto and enol forms, IUPAC and trivial nomenclatures, together with their abbreviations used here, are indicated below). The ancillary liagnds are also indicated here.

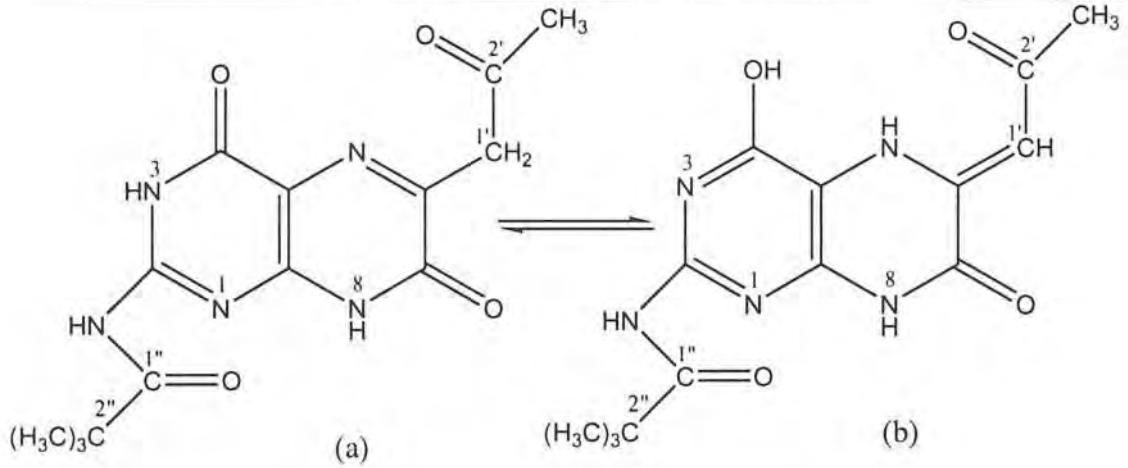


Scheme -1

2 - Amino -7- methyl - 4- oxidopteridine – 6- carboxylic acid (IUPAC)

7 - Methylpterin - 6 - carboxylic acid (Trivial)

$[H_2L^1]$ (abbreviation)



(a) (b)

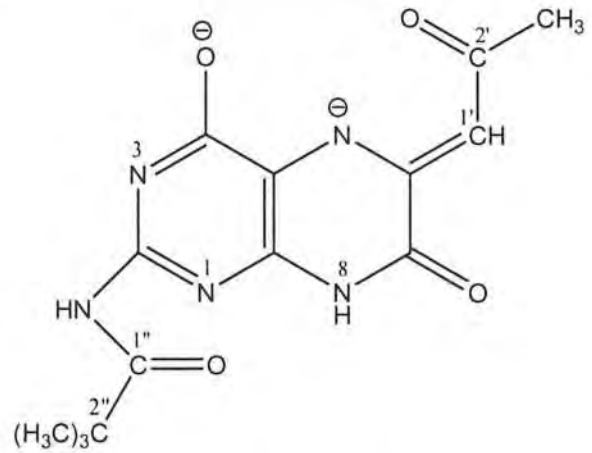
Keto – imine form vinylogous amide form

Scheme -2

N2-pivaloyl- 6- (2 - oxopropyl) pteridin – 4,7(3H, 8H) – dione (IUPAC)

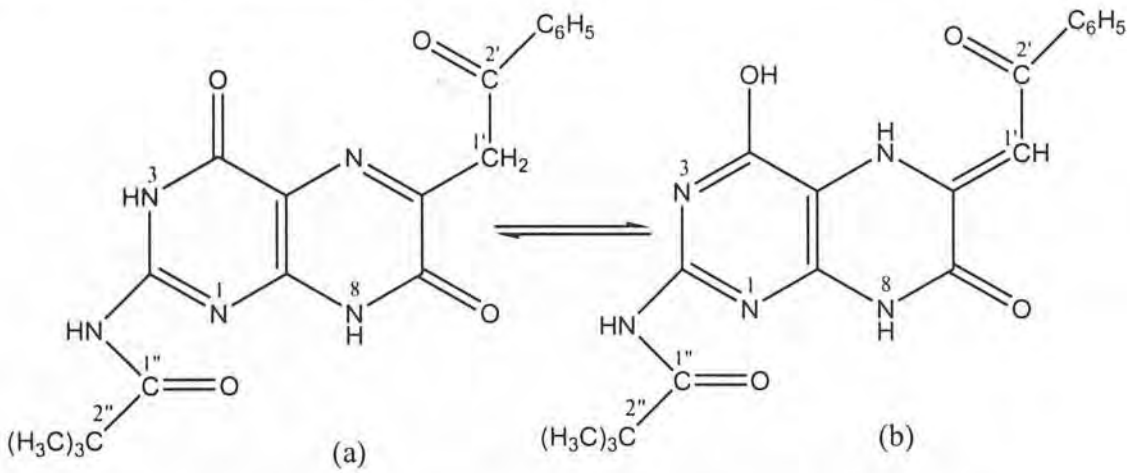
2 - Pivaloylamino - 6 - acetonylisoxanthopterin (Trivial)

$[H_2L^2]$ (abbreviation)



Scheme -3

ligand anion derived from Scheme -2(b) with deprotonated OH(4) and NH(5) groups as well as oxidized pyrimidine ring, $[L^2]^{2-}$



(a) (b)

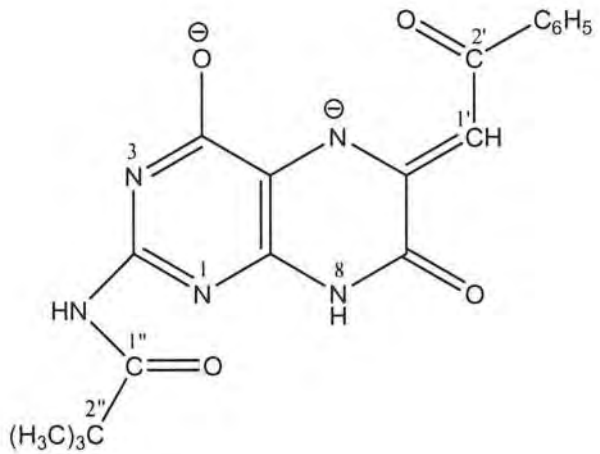
Keto – imine form vinylogous amide form

Scheme -4

N2-pivaloyl- 6- (2 – oxo-phenylethyl) pteridin – 4,7(3H, 8H) – dione (IUPAC)

2 - Pivaloylamino - 6 - phenacylisoxanthopterin (Trivial)

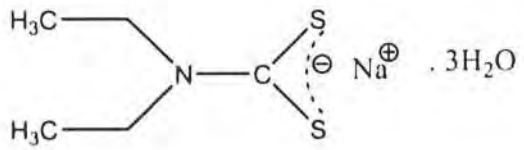
$[H_2L^3]$ (abbreviation)



Scheme -5

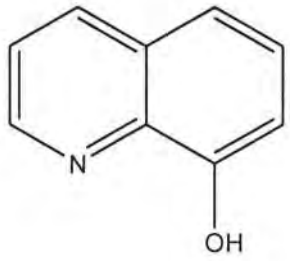
ligand anion derived from Scheme -4(b) with deprotonated OH(4) and NH(5) groups as well as oxidized pyrimidine ring, $[L^3]^{2-}$

Ancillary ligands



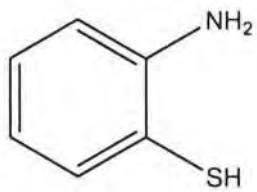
Sodium diethyldithiocarbamate trihydrate (Trivial name)

$[Na(dedtc)].3H_2O$ (Abbreviation)



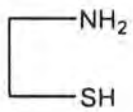
8-Hydroxyquinoline or oxine (Trivial name)

[H(ox)] (Abbreviation)



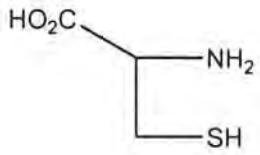
2 – Aminothiophenol (Trivial name)

[H_2(atp)] (Abbreviation)



2 – Aminoethanethiol (Trivial name)

[H_2(aet)] (Abbreviation)



Cysteine (Trivial name)

[H_2(cys)] (Abbreviation)

dihapto disulphide anion (Trivial name)

$\eta_2 - S_2^{2-}$ (Abbreviation)

Tables, Figures and Schemes in each chapter have been numbered using a combination of Roman and Arabic numericals; for example, the first Table of Chapter I is numbered (I-1), the second Table is numbered (I-2), whereas the first Table of Chapter II is numbered (II -1), the second Table as (II-2) and so on. In each Chapter the compounds have been assigned serial numbers (in bold letters within first bracket) and referred to them by these numbers during discussion.

The multiplicities of NMR spectral signals are indicated by the usual abbreviations, e.g., 's' for singlet ; 'bs' for broad singlet, 'ss' for sharp singlet, 'd' for doublet, 'dd' for doublet of doublet, 't' for triplet, 'o' for octet, 'm' for multiplet, 'br' for broad and 'wb' for weak broad.

The pterin ring numbering system has been used for the Schemes related to the schematic structures as well and utilized in discussion part. The optimized (lowest steric energy) computational models (CHEM3D) of the pertinent ligands and complex compounds obtained here through molecular mechanics calculations (MM2) are numbered as per the program used [Chem3D ultra, version 8.0 (2004) and the higher version, Cambridge Soft Corporation, U.S.A.]. A correspondence between the two above-mentioned sets of numbering systems has been indicated in the relevant Tables of CHEM3D data. The same applies for the ORTEP diagram obtained through X-ray crystallography for (**1**) of Chapter II. The CHEM3D model of this compound has also been obtained in order to compare the two sets of bond length (Å) and bond angle (deg.) data obtained through the MM2 calculations and single crystal X-ray diffraction study respectively; good agreement (discussed later in Chapter II) between the two sets of data, stresses the reliability of the MM2 method, which has been used here extensively. For most of the compounds discussed here, the optimized (MM2) bond length (Å) and bond angle (deg.) data, have been compared with the available literature X-ray structural data of related systems, for checking the efficacy of the MM2 method in obtaining the CHED3D models of the present cobalt – pterin as well as the tungsten – pterin complexes. The following colour code has been used for labeling the different atoms of CHEM3D models:

ash, green, deep blue (larger size), blue, red, yellow and dark ash (larger size) coloured ball represent the carbon, chlorine, cobalt, nitrogen, oxygen, sulphur and tungsten atom respectively;

References are mentioned at the end of this thesis following standard international conventions. In spite of taking utmost care, very few number of references are repeated and the author expresses regret for this.

Preliminary reports involving parts of this work have been submitted to CSIR, New Delhi as annual progress reports as well as final technical report. Four papers have already been published out of the subject matters of Chapters II, III, IV and V. Such publications on coordination compounds of pterin ligands reflect the continuing interest of this laboratory on this subject.

Samir Sen

(SAMIR SEN)
December, 2015