

Contents

	Page
บทคัดย่อ	(3)
Abstract	(4)
Acknowledgement	(5)
The relevancy of the research work to Thailand	(7)
Contents	(8)
List of Tables	(10)
List of Figures	(12)
List of Scheme	(16)
List of Abbreviations and Symbols	(17)
1. Introduction	1
Introduction	1
Review of Literatures	8
Objectives	28
2. Method	29
Chemicals	29
Preparation of Complexes	29
Melting Point Measurement	31
X - ray Fluorescence Spectrometry	31
Infrared Spectroscopy	31
Elemental Analysis	32
Single crystal X - ray diffractometry	32

Contents (continued)

	Page
3. Results	46
Preparation of Complexes	46
X - ray Fluorescence Spectrometry	47
Infrared Spectroscopy	52
Elemental Analysis	55
Single crystal X - ray diffractometry	55
4. Discussion	83
Preparation of Complexes	83
X - ray Fluorescence Spectrometry	84
Infrared Spectroscopy	84
Elemental Analysis	90
Single crystal X - ray diffractometry	90
5. Conclusion	99
Reference	99
Appendix	111
Appendix A	112
Appendix B	114
Appendix C	115
Vitae	140

List of tables

Table		Page
1	The condition of preparation the studied complexes	46
2	The physical properties of ligands and the studied complexes	47
3	Elemental analysis data of complexes	55
4	The crystallographic data for $[\text{Cu}(\text{etu})_3]_2\text{SO}_4$	57
5	Non - hydrogen interatomic distances of $[\text{Cu}(\text{etu})_3]_2\text{SO}_4$	58
6	Non - hydrogen interbond angles of $[\text{Cu}(\text{etu})_3]_2\text{SO}_4$	59
7	The crystallographic data for $[\text{Cu}_2(\text{detu})_6](\text{NO}_3)_2$	62
8	Non - hydrogen interatomic distances of $[\text{Cu}_2(\text{detu})_6](\text{NO}_3)_2$	63
9	Non - hydrogen interbond angles of $[\text{Cu}_2(\text{detu})_6](\text{NO}_3)_2$	65
10	The crystallographic data for $[\text{Cu}(\text{detu})_3]_2\text{SO}_3$	68
11	Non - hydrogen interatomic distances of $[\text{Cu}(\text{detu})_3]_2\text{SO}_3$	69
12	Non - hydrogen interbond angles of $[\text{Cu}(\text{detu})_3]_2\text{SO}_3$	70
13	The crystallographic data for $[\text{Cu}_2(\text{detu})_6](\text{ClO}_4)_2$	73
14	Non - hydrogen interatomic distances of $[\text{Cu}_2(\text{detu})_6](\text{ClO}_4)_2$	74
15	Non - hydrogen interbond angles of $[\text{Cu}_2(\text{detu})_6](\text{ClO}_4)_2$	76
16	The crystallographic data for S_8	79
17	Non - hydrogen interatomic distances of S_8	80
18	Non - hydrogen interbond angles of S_8	81
19	The infrared spectra of ligand etu, detu and the studied complexes	88
20	The result of X- ray photograph of $[\text{Cu}(\text{etu})_3]_2\text{SO}_4$	91
21	Non - hydrogen atom coordinates and isotropic thermal parameters of $[\text{Cu}(\text{etu})_3]_2\text{SO}_4$	119

List of tables (continued)

Table		Page
22	Hydrogen atom coordinates and isotropic thermal parameters of $[\text{Cu}(\text{etu})_3]_2\text{SO}_4$	120
23	Non - hydrogen thermal parameters of $[\text{Cu}(\text{etu})_3]_2\text{SO}_4$	121
24	Non - hydrogen atom coordinates and isotropic thermal parameters of $[\text{Cu}_2(\text{detu})_6](\text{NO}_3)_2$	122
25	Hydrogen atom coordinates and isotropic thermal parameters of $[\text{Cu}_2(\text{detu})_6](\text{NO}_3)_2$	124
26	Non - hydrogen thermal parameters of $[\text{Cu}_2(\text{detu})_6](\text{NO}_3)_2$	126
27	Non - hydrogen atom coordinates and isotropic thermal parameters of $[\text{Cu}(\text{detu})_3]_2\text{SO}_3$	128
28	Hydrogen atom coordinates and isotropic thermal parameters of $[\text{Cu}(\text{detu})_3]_2\text{SO}_3$	129
29	Non - hydrogen thermal parameters of $[\text{Cu}(\text{detu})_3]_2\text{SO}_3$	131
30	Non - hydrogen atom coordinates and isotropic thermal parameters of $[\text{Cu}_2(\text{detu})_6](\text{ClO}_4)_2$	132
31	Hydrogen atom coordinates and isotropic thermal parameters of $[\text{Cu}_2(\text{detu})_6](\text{ClO}_4)_2$	134
32	Non - hydrogen thermal parameters of $[\text{Cu}_2(\text{detu})_6](\text{ClO}_4)_2$	136
33	Non - hydrogen atom coordinates and isotropic thermal parameters of S_8	138
34	Non - hydrogen thermal parameters of S_8	139

List of figures

Figure		Page
1	Idealized coordination geometries of copper complexes	3
2	The structure of thiourea and substituted thioureas	7
3	The structure of $[\text{Cu}(\text{tu})_3]\text{ClO}_4$	9
4	The structure of $[\text{Cu}(\text{dmTu})_3]\text{Cl}$	10
5	The structure of $[\text{Cu}(\text{tu})_3]\text{BF}_4$	11
6	The structure of $[\text{Cu}(\text{dmTu})_3]\text{BF}_4$	11
7	The structure of $[\text{Cu}(\text{etu})_4]\text{NO}_3$	12
8	The structure of $[\text{Cu}_2(\text{etu})_4]\text{Cl}_2$	12
9	The structure of $[\text{Cu}(\text{detu})_3]1/2\text{SO}_4$	13
10	The structure of $[\text{Cu}(\text{tpt})_2]\text{Cl}$	13
11	The structure of $[\text{Cu}(\text{mimtH})_2(\text{NO}_3)]$	14
12	The structure of $[\text{Cu}_2(\text{mimtH})_4]\text{Cl}_2$	14
13	The structure of $[\text{Cu}(\text{dmTu})_2(\text{NO}_3)]$	15
14	The structure of $[\text{Cu}(\text{pptu})_2]\text{Cl}$	16
15	The structure of $[\text{Cu}(\text{Hmpt})_2]\text{Cl}$	16
16	The structure of $[\text{Cu}(\text{mimtH})_3(\text{BF}_4)]$	17
17	The structure of $[\text{Cu}(\text{mimtH})\text{CN}]_n$	18
18	The structure of $[\text{Cu}_2(\text{imdtH}_2)_6](\text{ClO}_4)_2$	18
19	The structure of $[\text{Cu}_4(\text{H}_4\text{pymtH})_6](\text{ClO}_4)$	19
20	The structure of $[\text{Cu}_6(\text{Me}(\text{OH})\text{pymt})_6]$	19
21	The structure of $[\text{Cu}(\text{etu})_3]_2(\text{SO}_4)$	20
22	The structure of $[\text{Cu}(\text{etu})_4](\text{NO}_3)$	20
23	The ladder arrangement structure of $(\text{CuCN})_2(\text{tu})_3\text{H}_2\text{O}$	21

List of figures (continued)

Figure		Page
24	The structure of $(\text{CuCN})_2(\text{tu})_3(\text{H}_2\text{O})$	21
25	The ladder arrangement structure of $(\text{CuCN})_3(\text{dmtu})_2$	22
26	The structure of $(\text{CuCN})_3(\text{dmtu})_2$	22
27	The ladder arrangement structure of $(\text{CuCN})_2(\text{detu})(\text{H}_2\text{O})$	23
28	The structure of $(\text{CuCN})_2(\text{detu})(\text{H}_2\text{O})$	23
29	The ladder arrangement structure of $(\text{CuCN})(\text{tmtu})(\text{polymorph a})$	23
30	The structure of $(\text{CuCN})(\text{tmtu})(\text{polymorph a})$	24
31	The ladder arrangement structure of $(\text{CuCN})(\text{tmtu})(\text{polymorph b})$	24
32	The structure of $(\text{CuCN})(\text{tmtu})(\text{polymorph b})$	24
33	The ladder arrangement structure of $(\text{CuCN})_2(\text{etu})$	25
34	The structure of $(\text{CuCN})_2(\text{etu})$	25
35	The structure of $[\text{Cu}_4(\text{tu})_7](\text{SO}_4)_2(\text{H}_2\text{O})$	26
36	The structure of $4\text{CuCl}\cdot 6\text{all-NHCSNH}_2$	26
37	The structure of $[\text{CuCl}(\text{FeCONHCSNHR})_2]$	27
38	Crystal mounting	33
39	Goniometer head adjustment locations	34
40	The Weissenberg camera	35
41	X - ray diffraction on a film	35
42	SMART APEX system components	36
43	SMART APEX and goniometer module instrumentation	37
44	Fixed χ , 3 - axis goniometer	37
45	Flow chart	42
46	The $\text{Cu}(K_\alpha)$ spectrum of $[\text{Cu}(\text{etu})_3]_2\text{SO}_4$	48
47	The $\text{S}(K_\alpha)$ and $\text{S}(K_\beta)$ spectrum of $[\text{Cu}(\text{etu})_3]_2\text{SO}_4$	48

List of figures (continued)

Figure		Page
48	The Cu(K_α) spectrum of $[\text{Cu}_2(\text{detu})_6](\text{NO}_3)_2$	49
49	The S(K_α) and S(K_β) spectrum of $[\text{Cu}_2(\text{detu})_6](\text{NO}_3)_2$	49
50	The Cu(K_α) spectrum of $[\text{Cu}(\text{detu})_3]_2\text{SO}_3$	50
51	The S(K_α) and S(K_β) spectrum of $[\text{Cu}(\text{detu})_3]_2\text{SO}_3$	50
52	The Cu(K_α) spectrum of $[\text{Cu}_2(\text{detu})_6](\text{ClO}_4)_2$	51
53	The S(K_α) and S(K_β) spectrum of $[\text{Cu}_2(\text{detu})_6](\text{ClO}_4)_2$	51
54	The infrared spectrum of etu	52
55	The infrared spectrum of detu	52
56	The infrared spectrum of $[\text{Cu}(\text{etu})_3]_2\text{SO}_4$	53
57	The infrared spectrum of $[\text{Cu}_2(\text{detu})_6](\text{NO}_3)_2$	53
58	The infrared spectrum of $[\text{Cu}(\text{detu})_3]_2\text{SO}_3$	54
59	The infrared spectrum of $[\text{Cu}_2(\text{detu})_6](\text{ClO}_4)_2$	54
60	The oscillation photography of $[\text{Cu}(\text{etu})_3]_2\text{SO}_4$	56
61	The structure of $[\text{Cu}(\text{etu})_3]_2\text{SO}_4$. Ellipsoids are drawn at the 50 % probability level.	61
62	Unit cell contents of $[\text{Cu}(\text{etu})_3]_2\text{SO}_4$ projected down a	61
63	The structure of $[\text{Cu}_2(\text{detu})_6](\text{NO}_3)_2$. Ellipsoids are drawn at the 50 % probability level.	67
64	Unit cell contents of $[\text{Cu}_2(\text{detu})_6](\text{NO}_3)_2$ projected down c	67
65	The structure of $[\text{Cu}(\text{detu})_3]_2\text{SO}_3$. Ellipsoids are drawn at the 50 % probability level.	72
66	Unit cell contents of $[\text{Cu}(\text{detu})_3]_2\text{SO}_3$ projected down c	72
67	The structure of $[\text{Cu}_2(\text{detu})_6](\text{ClO}_4)_2$. Ellipsoids are drawn at the 50 % probability level.	78

List of figures (continued)

Figure		Page
68	Unit cell contents of $[\text{Cu}_2(\text{detu})_6](\text{ClO}_4)_2$ projected down c	78
69	The structure of S_8 . Ellipsoids are drawn at the 50 % probability level.	82
70	Unit cell contents of S_8 projected down c	82
71	The hydrogen bonding in $[\text{Cu}(\text{etu})_3]_2\text{SO}_4$	93
72	The hydrogen bonding in $[\text{Cu}_2(\text{detu})_6](\text{NO}_3)_2$	95
73	The hydrogen bonding in $[\text{Cu}(\text{detu})_3]_2\text{SO}_3$	96
74	The hydrogen bonding in $[\text{Cu}_2(\text{detu})_6](\text{ClO}_4)_2$	98
75	Bragg 's Law condition	113

List of schemes

Scheme		Page
1	Formation of SO_4^{2-} anion	93
2	Formation of SO_3^{2-} anion	96

List of abbreviations and symbols

°	=	degree
Å	=	Angstrom unit (1 Å = 10 ⁻¹⁰ metre)
A.R.	=	Analytical Reagent
cm ⁻¹	=	wave number
D_c	=	calculated density
D_m	=	measured density
g	=	gram
g/cm ³	=	gram per cubic centimetre
h	=	hour
K	=	Kelvin
keV	=	kilo electron volt
kg	=	kilogram
mL	=	millilitre
mm	=	millimetre
nm	=	nanometre
mmol	=	millimole
V	=	volume