Journal of Molecular Structure 1123 (2016) 300-304

Contents lists available at ScienceDirect

Journal of Molecular Structure

journal homepage: http://www.elsevier.com/locate/molstruc

Preparation, characterization and structure determination of CpFe(CO)(EPh₃)SeCO-het complexes

ABSTRACT

Mohammad El-khateeb

Chemistry Department, Jordan University of Science and Technology, Irbid, 22110 Jordan

ARTICLE INFO

Article history: Received 8 May 2016 Received in revised form 14 June 2016 Accepted 14 June 2016 Available online 16 June 2016

Keywords: Iron Selenocarboxylates Substitution Heterocycle Complexes Structures

1. Introduction

Cyclopentadienyl dicarbonyl iron complexes of the general formula $Cp'Fe(CO)_2X$ (Cp' = substituted or unsubstituted cyclopentadienyl; X = uni-negative ligand) undergo CO-substitution in the presences of two electron donor ligands under either photolytic or thermal conditions [1-10]. The type of the products depends on the Cp', the ligand X and the reaction conditions [1-10]. The silyl complex $CpFe(CO)_2SiH_3$ reacted with various donors (L = PMe₃, PPh₃, MeNC, t-BuNC) to give CpFe(CO)(L)SiH₃ and CpFe(L)₂SiH₃ via stepwise CO substitution [4,5]. Photolysis of CpFe(CO)₂Me in hydrocarbon solvents in the absence of ligand gave the dimer $[CpFe(CO)]_2$, while in the presence of PR₃ (R = Me, OMe), the COsubstituted products CpFe(CO)(PR₃)Me are formed [6]. Similarly, the photolysis of CpFe(CO)₂C(OMe)=CH₂ with PMe₃ yielded CpFe(CO)(PMe₃)C(OMe)=CH₂ [7]. The complex CpFe(CO)₂SPh reacted with AIX_3 (X = halide) to form adducts that reacted with nucleophiles ($L = PBu_3$, PPh₃, P(OEt)₃, cyclohexene) to form ionic products [CpFe(CO)₂L][PhS(AlX₃)₂] [8].

We [9-14] and others [15-17] studied the photolytic COsubstitution reactions of iron complexes containing sulfur or selenium ligands Cp'Fe(CO)₂Q (Q = SCOR, SeCOR, SeSO₂R, SCSOEt). The

http://dx.doi.org/10.1016/j.molstruc.2016.06.043 0022-2860/© 2016 Elsevier B.V. All rights reserved. reaction of the latter complexes with EPh₃ ligands were reported to produce the mono-substituted complexes Cp'Fe(CO)(EPh₃)Q [9–11,14–17]. The analogous reactions of the thiocarboxylate complexes with Ph₂P(CH₂)_nPPh₂ (n = 1–6) gave either the mono-substituted complexes CpFe(CO)(κ P-Ph₂P(CH₂)_nPPh₂)SCOR for n = 1–6 and the disubstituted complexes CpFe(κ ²P,P-Ph₂P(CH₂)_nPPh₂)SCOR only for n = 1 and 2 [12,13].

The mixed CO/ER3 iron complexes bearing heterocyclic selenocarboxylato group CpFe(CO)(ER3)SeCO-het

 $[het = 2-C_4H_3S (1), 2-C_4H_3O (2), -CH_2-2-C_4H_3S (3), E = P, R = Ph (a), OC_2H_5 (b); E = As (c), Sb (d), C_2H_5 (c), C_$

R = Ph] are synthesized by the reactions of CpFe(CO)₂SeCO-het with ER₃ under photolytic conditions.

The new complexes have been characterized by spectroscopic analysis (UV-Vis, IR, ¹H, ³¹P NMR) and

elemental analysis. The structures of CpFe(CO)(PPh₃)SeCO-2-C₄H₃S (1a), CpFe(CO)(AsPh₃)SeCO-2-C₄H₃S

(1c) and CpFe(CO)(SbPh₃)SeCO-2-C₄H₃S (1d) have been determined by X-ray crystal structure analysis.

The importance of chalcogenocarboxylato complexes of thiophene and other related heterocycles in thin film industry and hydrodesulfurization process [18–22], prompted scientists to synthesize these complexes. Complexes of Cu, Cd, Zn and Ag containing thiophene thiocarboxylates are reported and their conversion to metal-sulfide thin films are demonstrated [19–22].

In this paper, we report the CO-substitution reactions of iron selenocarboxylates bearing heterocyclic group $CpFe(CO)_2SeCO$ -het by ER_3 donors. The molecular structures of three representative samples are presented.

2. Experimental

2.1. Materials and methods

The synthesis and separation of the complexes were carried out under an atmosphere of nitrogen using standard Schlenk line techniques. Tetrahydrofuran, diethyl ether, hexane (sodium/





© 2016 Elsevier B.V. All rights reserved.



E-mail address: kateeb@just.edu.jo.

M. El-khateeb / Journal of Molecular Structure 1123 (2016) 300-304

Table 1

Crystallographic data and refinement parameters of CpFe(CO)(PPh₃)SeCO-2-C₄H₃S (1a), CpFe(CO)(AsPh₃)SeCO-2-C₄H₃S (1c) and CpFe(CO)(SbPh₃)SeCO-2-C₄H₃S (1d).

CCD No. 141778 141777 141779 Empirical formula weight (g/mol) 63pH23Fe02PSSe $C_{29}H_{23}Fe02PSSe C_{29}H_{23}Fe02PSSeSe Formula weight (g/mol) 10.35 645.26 652.09 Temperature (K) 150.0 100.01 149.99 Wavelength (Å) 0.71073 0.71073 0.71073 Crystal system Monoclinic Monoclinic Monoclinic Space group P_2/n V_2/n Unit cell dimensions a (Å) 10.3778(10) 10.3778(13) 10.4793(6) b (Å) 145558(14) 145337(18) 14538(9) c (Å) 17.3019(17) 17.581(2) 18.0826(11) a (7) 90 90 90 g (5) 10.5852(19) 10.2021(3) 10.26714(11) y (5) 90 90 90 90 Volume (Å3) 2562.1(4) 2593.5(6) 2596.2(3) 24 Z 4 4 50 50.1 50.1 Volume (Å3) 15.80 1 × 0.1<$		1a	1c	1d
Empirical formula $C_{20}H_{20}FeO_2NSSe$ $C_{20}H_{20}FeO_2NSSe$ $C_{20}H_{20}FeO_2NSSe$ Formula weight (g/mol)601.35645.26692.09Temperature (K)150.0100.01449.99Wavelength (Å)0.710730.710730.71073Wavelength (Å)0.710730.710730.71073Crystal systemMonoclinicMonoclinicMonoclinicSpace groupP2.1/nP2.1/nP2.1/nUnit cell dimensions10.3778(10)10.3775(13)10.4793(6)c (Å)11.5858(14)14.533(18)14.5838(9)c (Å)10.5852(19)9090g(`)909090y (`)909090y (`)909090Volume (Å ³)2562.1(9)102.6213(3)12.6714(11)y (`)90909090Volume (Å ³)2562.1(9)33572992f(00)12.841288.01360.0Crystal size mm ³ 0.15 × 0.1 × 0.10.15 × 0.1 × 0.1Absorption coefficient mm ⁻¹ 2.1 ≤ 13-13 ≤ h ≤ 13-13 ≤ h ≤ 13-13 ≤ h ≤ 13-13 ≤ h ≤ 13-19 ≤ k ≤ 19-19 ≤ k ≤ 19-19 ≤ k ≤ 19-23 ≤ 1 ≤ 23-23 ≤ 1 ≤ 23-24 ≤ 1 ≤ 24Reflections collected49877410274148Independent reflections6390 (Rain 0.0296, Raigma = 0.0193)6542 (Rain 0.1188, Raigma = 0.0357]6698 (Rain 0.0518, Raigma = 0.0351]Independent reflections6390 (Rain 0.0296, Raigma = 0.019	CCDC No.	1417778	1417777	1417779
	Empirical formula	C ₂₉ H ₂₃ FeO ₂ PSSe	C ₂₉ H ₂₃ FeO ₂ AsSSe	C ₂₉ H ₂₃ FeO ₂ SbSSe
Temperature (K)150.0100.01149.99Wavelength (Å)0.710730.710730.71073Wavelength (Å)0.710730.710730.71073Space group P_{21}/n P_{21}/n P_{21}/n Unit cell dimensions P_{21}/n P_{21}/n P_{21}/n a (Å)10.3778(10)10.3775(13)10.4793(6)b (Å)14.5658(14)14.5337(18)14.5838(9)c (Å)17.3019(17)17.581(2)18.0826(11) α (°)909090 β (°)101.1852(19)102.013(3)102.6714(11) γ (°)909090Volume (Å ³)2562.1(4)2593.5(6)2696.2(3)Z444Density (calculate) Mg/m ³ 1.55891.6531.705Absorption coefficient mm ⁻¹ 2.1793.3572.992F(000)1218.41288.01360.0Crystal size mm ³ 0.15 × 0.1 × 0.10.15 × 0.1 × 0.1 $n = 0 \leq k \leq 19$ $-13 \leq k \leq 13$ $-13 \leq k \leq 13$ $-13 \leq k \leq 19$ $-19 \leq k \leq 19$ $-19 \leq k \leq 19$ $-23 \leq 1 \leq 23$ $-23 \leq 1 \leq 23$ $-24 \leq 1 \leq 24$ Reflections collected498774102749148Independent effections6390 [N ₁₁ = 0.0296, N ₆₁₀₀ = 0.0139]6542 [N ₁₁₁ = 0.1188, N ₆₁₀₀₀ = 0.00587]Data/restraints/parameters6390 [N ₁₁ = 0.0296, N ₆₂₀ = 0.05121R_1 = 0.00414, N ₆₂ = 0.0590R_1 = 0.0266, N ₆₂ = 0.0456Rindices (all data) ^{1,6} R_1 = 0.0311, N ₆₂ = 0.0554R_1 =	Formula weight (g/mol)	601.35	645.26	692.09
$ \begin{array}{llllllllllllllllllllllllllllllllllll$	Temperature (K)	150.0	100.01	149.99
Crystal system Monoclinic Monoclinic Monoclinic Monoclinic Space group P_{21}/n P_{21}/n P_{21}/n P_{21}/n P_{21}/n P_{21}/n A $10.3778(10)$ $10.3775(13)$ $10.4793(6)$ b (Å) $14.5658(14)$ $14.5337(18)$ $14.5838(9)$ c (Å) $17.3019(17)$ $7.581(2)$ $18.0826(11)$ α (°) 90 90 90 α (°) 90 $90.0263(1)$ $102.6714(11)$ γ (°) 90 $90.0263(3)$ $20.6714(11)$ γ (°) 90.000 $90.0263(3)$ $90.0263(3)$ γ (°) 90.0000 $90.00000000000000000000000000000000000$	Wavelength (Å)	0.71073	0.71073	0.71073
Space group $P2_1/n$ $P2_1/n$ $P2_1/n$ Unit cell dimensions	Crystal system	Monoclinic	Monoclinic	Monoclinic
$ \begin{array}{lll} Unit cell dimensions \\ a (A) & 10.3778(10) & 10.3775(13) & 10.4793(6) \\ b (A) & 14.5658(14) & 14.5337(18) & 14.5838(9) \\ c (A) & 17.3019(17) & 17.581(2) & 18.0826(11) \\ a (^{\circ}) & 90 & 90 \\ f (^{\circ}) & 90 & 90 \\ Volume (Å^3) & 2562.1(4) & 2593.5(6) & 2696.2(3) \\ Z & 4 & 4 & 4 \\ Density (calculate) Mg/m^3 & 1.5589 & 1.653 & 1.705 \\ Absorption coefficient mn^{-1} & 2.179 & 3.357 & 2.992 \\ F (000) & 1218.4 & 1288.0 & 1360.0 \\ Crystal size mm^3 & 0.15 \times 0.1 \times 0.1 & 0.15 \times 0.12 \times 0.1 & 0.15 \times 0.1 \times 0.1 \\ Theta range for data & 3.68-56.72 & 3.67-57.078 & 3.624-56.67 \\ collection (^{\circ}) & & & & & & & & & & & & & & & & & & &$	Space group	P2 ₁ /n	$P2_1/n$	P2 ₁ /n
$ \begin{array}{llllllllllllllllllllllllllllllllllll$	Unit cell dimensions			
$ \begin{array}{llllllllllllllllllllllllllllllllllll$	a (Å)	10.3778(10)	10.3775(13)	10.4793(6)
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	b (Å)	14.5658(14)	14.5337(18)	14.5838(9)
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	c (Å)	17.3019(17)	17.581(2)	18.0826(11)
$\begin{array}{llllllllllllllllllllllllllllllllllll$	α (°)	90	90	90
$\begin{array}{llllllllllllllllllllllllllllllllllll$	β(°)	101.5852(19)	102.021(3)	102.6714(11)
$ Volume (Å^3) 2562.1(4) 2593.5(6) 2696.2(3) \\ Z 4 4 4 4 4 \\ Density (calculate) Mg/m^3 1.5589 1.653 1.705 \\ Absorption coefficient mm^{-1} 2.179 3.357 2.992 \\ F(000) 1218.4 1288.0 1.600 \\ Crystal size mm^3 0.15 \times 0.1 \times 0.1 0.15 \times 0.12 \times 0.1 0.15 \times 0.12 \times 0.1 0.15 \times 0.1 \times 0.1 \\ Theta range for data 3.68 - 56.72 3.67 - 57.078 3.624 - 56.67 \\ collection (°) 1 \\ Index ranges - 13 \le h \le 13 - 19 \le k \le 19 - 19 \le k \le 19 \\ -23 \le l \le 23 - 23 \le l \le 23 - 23 \le l \le 23 - 24 \le l \le 24 \\ Reflections collected 49877 41027 49148 \\ Independent reflections 6390 [R_{int} = 0.0296, R_{sigma} = 0.0193] 6542 [R_{int} = 0.1188, R_{sigma} = 0.0857] 6698 [R_{int} = 0.0518, R_{sigma} = 0.0334] \\ Data/restraints/parameters 6390/0/316 6542/0/317 6698 [N_{int} = 0.0296, R_{sigma} = 0.0193] \\ Rindices [l > 2cf(l)] R_1 = 0.0228, wR_2 = 0.0521 R_1 = 0.0441, wR_2 = 0.0590 R_1 = 0.0266, wR_2 = 0.0456 \\ R indices [l > 2cf(l)] R_1 = 0.0228, wR_2 = 0.0521 R_1 = 0.0930, wR_2 = 0.0683 R_1 = 0.0266, wR_2 = 0.0495 \\ Largest diff. peak and hole (e, Å^{-3}) 0.44/-0.34 0.04 0.06(-0.64 0.044) 0.0NE \\ NONE \\ $	γ (°)	90	90	90
Z4444Density (calculate) Mg/m³1.55891.6531.705Absorption coefficient mm ⁻¹ 2.1793.3572.992F(000)1218.41288.01360.0Crystal size mm³0.15 × 0.1 × 0.10.15 × 0.12 × 0.10.15 × 0.1 × 0.1Theta range for data3.68-56.723.67-57.0783.624-56.67collection (°)-13 ≤ h ≤ 13-13 ≤ h ≤ 13-13 ≤ h ≤ 13Index ranges-13 ≤ h ≤ 13-19 ≤ k ≤ 19-19 ≤ k ≤ 19-23 ≤ l ≤ 23-23 ≤ l ≤ 23-24 ≤ l ≤ 24Reflections collected498774102749148Independent reflections6390 [R _{int} = 0.0296, R _{sigma} = 0.0193]6542 [R _{int} = 0.1188, R _{sigma} = 0.0857]6698 [R _{int} = 0.0518, R _{sigma} = 0.0334]Data/restraints/parameters6390/0/3166542/0/3176698/0/317Goodness-of-fit on F21.0420.9891.002Final R indices (1 > 2σ(l)]R ₁ = 0.0228, wR ₂ = 0.0521R ₁ = 0.0441, wR ₂ = 0.0590R ₁ = 0.0266, wR ₂ = 0.0456R indices (all data) ^{1,b} R ₁ = 0.0311, wR ₂ = 0.0554R ₁ = 0.0903, wR ₂ = 0.0683R ₁ = 0.0424, wR ₂ = 0.0495Largest diff. peak and hole (e.Å ⁻³)0.44/-0.340.66/-0.640.44/-0.35Absorption methodNONENONENONENONE	Volume (Å ³)	2562.1(4)	2593.5(6)	2696.2(3)
$\begin{array}{llllllllllllllllllllllllllllllllllll$	Z	4	4	4
$\begin{array}{llllllllllllllllllllllllllllllllllll$	Density (calculate) Mg/m ³	1.5589	1.653	1.705
$\begin{array}{llllllllllllllllllllllllllllllllllll$	Absorption coefficient mm ⁻¹	2.179	3.357	2.992
$ \begin{array}{c} \dot{C}rystal size mm^3 & 0.15 \times 0.1 \times 0.1 & 0.15 \times 0.12 \times 0.1 & 0.15 \times 0.1 \times 0.1 & 0.15 \times 0.1 \times 0.1 \\ Theta range for data & 3.68-56.72 & 3.67-57.078 & 3.624-56.67 \\ collection (°) & & & & & & & & & & & & & & & & & & &$	F(000)	1218.4	1288.0	1360.0
$ \begin{array}{llllllllllllllllllllllllllllllllllll$	Crystal size mm ³	0.15 imes 0.1 imes 0.1	$0.15 \times 0.12 \times 0.1$	$0.15 \times 0.1 \times 0.1$
	Theta range for data	3.68-56.72	3.67-57.078	3.624-56.67
$ \begin{array}{llllllllllllllllllllllllllllllllllll$	collection (°)			
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	Index ranges	$-13 \leq h \leq 13$	$-13 \le h \le 13$	$-13 \leq h \leq 13$
$ \begin{array}{cccc} -23 \leq l \leq 23 & -23 \leq l \leq 23 & -24 \leq l \leq 24 \\ \mbox{Reflections collected} & 49877 & 41027 & 49148 \\ \mbox{Independent reflections} & 6390 [R_{int} = 0.0296, R_{sigma} = 0.0193] & 6542 [R_{int} = 0.1188, R_{sigma} = 0.0857] & 6698 [R_{int} = 0.0518, R_{sigma} = 0.0334] \\ \mbox{Dat}/restraints/parameters & 6390/0/316 & 6542/0/317 & 6698/0/317 \\ \mbox{Godness-of-fit on F2} & 1.042 & 0.989 & 1.002 \\ \mbox{Final R indices [l > 2\sigma(l)] } & R_1 = 0.0228, wR_2 = 0.0521 & R_1 = 0.0441, wR_2 = 0.0590 & R_1 = 0.0266, wR_2 = 0.0456 \\ \mbox{R indices (all data)}^{a,b} & R_1 = 0.0311, wR_2 = 0.0554 & R_1 = 0.0903, wR_2 = 0.0683 & R_1 = 0.0424, wR_2 = 0.0495 \\ \mbox{Largest diff. peak and hole (e.Å^{-3}) } & 0.44/-0.34 & 0.66/-0.64 & 0.44/-0.35 \\ \mbox{Absorption method} & NONE & NONE & NONE \\ \end{array}$	-	$-19 \leq k \leq 19$	$-19 \leq k \leq 19$	$-19 \leq k \leq 19$
Reflections collected498774102749148Independent reflections6390 [$R_{int} = 0.0296, R_{sigma} = 0.0193$]6542 [$R_{int} = 0.1188, R_{sigma} = 0.0857$]6698 [$R_{int} = 0.0518, R_{sigma} = 0.0334$]Data/restraints/parameters6390/0/3166542/0/3176698/0/317Goodness-of-fit on F21.0420.9891.002Final R indices [$I > 2\sigma(I)$] $R_1 = 0.0228, wR_2 = 0.0521$ $R_1 = 0.0441, wR_2 = 0.0590$ $R_1 = 0.0266, wR_2 = 0.0456$ R indices (all data) ^{a,b} $R_1 = 0.0311, wR_2 = 0.0554$ $R_1 = 0.093, wR_2 = 0.0683$ $R_1 = 0.0424, wR_2 = 0.0495$ Largest diff. peak and hole (e.Å ⁻³)0.44/-0.340.66/-0.640.44/-0.35Absorption methodNONENONENONE		$-23 \le 1 \le 23$	$-23 \le 1 \le 23$	$-24 \leq l \leq 24$
	Reflections collected	49877	41027	49148
$ \begin{array}{llllllllllllllllllllllllllllllllllll$	Independent reflections	6390 $[R_{int} = 0.0296, R_{sigma} = 0.0193]$	6542 $[R_{int} = 0.1188, R_{sigma} = 0.0857]$	6698 $[R_{int} = 0.0518, R_{sigma} = 0.0334]$
Goodness-of-fit on F21.0420.9891.002Final R indices $[I > 2\sigma(I)]$ $R_1 = 0.0228$, $wR_2 = 0.0521$ $R_1 = 0.0441$, $wR_2 = 0.0590$ $R_1 = 0.0266$, $wR_2 = 0.0456$ R indices (all data) ^{a,b} $R_1 = 0.0311$, $wR_2 = 0.0554$ $R_1 = 0.0903$, $wR_2 = 0.0683$ $R_1 = 0.0424$, $wR_2 = 0.0495$ Largest diff. peak and hole (e.Å ⁻³) $0.44/-0.34$ $0.66/-0.64$ $0.44/-0.35$ Absorption methodNONENONENONE	Data/restraints/parameters	6390/0/316	6542/0/317	6698/0/317
Final R indices $[I > 2\sigma(I)]$ $R_1 = 0.0228, wR_2 = 0.0521$ $R_1 = 0.0441, wR_2 = 0.0590$ $R_1 = 0.0266, wR_2 = 0.0456$ R indices (all data) ^{a,b} $R_1 = 0.0311, wR_2 = 0.0554$ $R_1 = 0.0903, wR_2 = 0.0683$ $R_1 = 0.0424, wR_2 = 0.0495$ Largest diff. peak and hole (e.Å ⁻³) $0.44/-0.34$ $0.66/-0.64$ $0.44/-0.35$ Absorption methodNONENONENONE	Goodness-of-fit on F2	1.042	0.989	1.002
R indices (all data) ^{a,b} $R_1 = 0.0311, wR_2 = 0.0554$ $R_1 = 0.0903, wR_2 = 0.0683$ $R_1 = 0.0424, wR_2 = 0.0495$ Largest diff. peak and hole (e.Å ⁻³) $0.44/-0.34$ $0.66/-0.64$ $0.44/-0.35$ Absorption method NONE NONE NONE	Final R indices $[I > 2\sigma(I)]$	$R_1 = 0.0228$, $wR_2 = 0.0521$	$R_1 = 0.0441$, $wR_2 = 0.0590$	$R_1 = 0.0266, wR_2 = 0.0456$
Largest diff. peak and hole (e.Å ⁻³) 0.44/-0.34 0.66/-0.64 0.44/-0.35 Absorption method NONE NONE NONE	R indices (all data) ^{a,b}	$R_1 = 0.0311, wR_2 = 0.0554$	$R_1 = 0.0903, wR_2 = 0.0683$	$R_1 = 0.0424, wR_2 = 0.0495$
Absorption method NONE NONE NONE NONE	Largest diff. peak and hole $(e.Å^{-3})$	0.44/-0.34	0.66/-0.64	0.44/-0.35
	Absorption method	NONE	NONE	NONE

^{a)} Definition of the *R* indices: $R_1 = (\Sigma ||F_0| - |F_c||)/\Sigma |F_0|$; $wR_2 = \{\Sigma [w(F_0^2 - F_c^2)^2]/\Sigma [w(F_0^2)^2]\}^{1/2}w^{-1} = \sigma^2(F_0^2) + (aP)^2 + bP$; $P = [2F_c^2 + Max(F_0^2)]/S = \{\Sigma [w(F_0^2 - F_c^2)^2]/(N_0 - N_p)\}^{1/2}$.

benzophenone) and CH₂Cl₂ (P₂O₅) were dried following standard procedure. The compounds CpFe(CO)₂SeCO-het were prepared by reported procedures [23]. The ligands triphenylphosphine, triethylphosphite, triphenylarsine, triphenylantimony were used as

received (Acros). For column chromatography, silica gel of particle size 0.063-0.200 mm (70-230 mesh) was employed and the reaction steps were monitored by thin layer chromatography (TLC).



Fig. 1. UV–Vis spectrum of CpFe(CO)(P(OEt)₃)SeCO-2-C₄H₃S (1b) 4.4 \times 10⁻⁶ M in acetonitrile.



Fig. 2. Molecular structure of CpFe(CO)(PPh₃)SeCO-2-C₄H₃S, (1a).

Download English Version:

https://daneshyari.com/en/article/1404740

Download Persian Version:

https://daneshyari.com/article/1404740

Daneshyari.com