Extended X–ray, K-absorption Fine Structural Studies of Cobalt, Nickel Ferrites

P K Malviya[1], P Sharma[2*] and A. Mishra[1]

[1]*School of Physics, DAVV, Indore (M.P)- India*
[2*] *Department of Physics, Govt. Holkar Science College, Indore (M.P)- India*

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Abstract - The Co-Ni ferrites with general formula $Co_{1-x}Ni_x Fe_2O_4$ (where x=0.0, 0.05, 0.10, 0.15, 0.20) were prepared by solid state root method. X-ray, K- absorption fine structural measurements were carried out. EXAFS spectra have been recorded at the K-edge of Fe using the dispersive EXAFS (DEXAFS) beam line at 2.5GeV Indus-2 synchrotron radiation source RRCAT, Indore, India. The EXAFS data have been analysed using the computer software Athena. These have been used to determine the bond lengths in these ferrites with the help of four different methods, namely, Levy's, Lytle's and Lytle, Sayers and Stern's (LSS) methods.

Key Words - Ferrite, XRD, XANES

I. INTRODUCTION

Ferrites have gained technological important due to their high electrical resistivity ,low eddy current and low dielectric loss These material are extensively used in microwave device , computer memory chips , magnetic recording media ,transformer cores, rod antennas etc. Usually ferrites have spinel structure (AB_2O_4), where A is a divalent and B is a trivalent metal ion. Additives play an important role in controlling the magnetic and electrical properties of ferrites. Co-Ni ferrites belong to the group of soft ferrite materials characterized by high magnetic permeability's and low losses and have numerous electronic applications [1, 2].In Co-Ni ferrites, the minor additions of bivalent ions decrease the electrical conductivity .However; higher valent additive ions received very little attention [3, 4].Co –Ni ferrites are mixed ferrites and the co-ordination of the Fe+3 ion in the system is very little affected by the changes in compositional parameters [5].It is reported that the vacancy concentration of Oxygen is important parameter in the sintering process of spinel ferrites. It is also reported that electrical resistance of Co ferrites decreases whit increasing quenching temperature, which is mainly attributed to the decrease of grain boundary resistance in Fe-excess Co- ferrites [6, 7].Extended X- ray absorption fine structure, which start approximately from 50 eV to continue up to 1000 eV above the edge. XANES is strongly sensitive to formed oxidation state and coordination chemistry of the absorbing atom while the EXAFS is used to determine the bond distance, Coordination number and species of the neighbours of the absorbing atom [8].

II. PREPARATION OF CO(1-X)NI(X)FE2O4 COMPLEXES

The low cost parent oxides (Fe_2O_3, CoO, NiO) were used are raw materials. The ferrites of different composition [$Fe_2Co_{(1-x)}Ni_{(x)}O_4$,x=0.00,0.05,0.10] were prepared using conventional solid state method. Powder was thoroughly mild and mixed by hand grinding tool. The sample heated for 8 hours in $900^0C$by furnace.

III. EXPERIMENT

The X-ray absorption spectra have been recorded using synchrotron radiation source .The X- ray spectroscopy setup is available at Raja Ramanna Centre for Advanced Technology (RRCAT) and is called beam line .This beam line BL-8 has been recently commissioned at the 2.5 GeV Indus-2 synchrotron radiation source.

IV. RESULTS AND DISCUSSION :-

We have determined the bond lengths for the Co-Ni ferrite complexes with the help of Levy's [2] method and graphical methods [3]. We have determined bond lengths using the slope of n Vs k Plots, which gives the value of (R – α) where R is the bond length. The parameter α depends to a large extent on the central absorbing atom. It is found that for chemically similar system, the value of α remains more or less the same. The values obtained for R are given in Table 1. We have also calculated the bond lengths by Levy's method and these are also included in Table 1. It is important to note here that the distance R-α should be equal to the distance found from the L.S.S. graphical method outlined above. Hence, both the L.S.S. method and the Fourier transformation method give the value R-α, i.e., both the methods give the value of bond lengths which have not been corrected for the phase shifts. We have called this distance as the phase uncorrected bond length. It is seen from this table 01 that the value of R-α as determined from L.S.S. method and that determined from the Fourier transformation method are in good agreement with each other, i.e., both the L.S.S. method and Fourier transformation method give nearly

Corresponding Author: P Sharma,
psharma29762@gmail.com

the same value of the phase uncorrected bond length, i.e., R-α. The figure shown in 1, 2 and 3.

V. CONCLUSION

It has been observed that the value of the phase uncorrected bond length, i.e., R-α as determined from L.S.S. method and that determined from the Fourier Transformation methods are in good agreement with each other, i.e., both the L.S.S. method and Fourier transformation method give nearly the same value of the phase uncorrected bond length.

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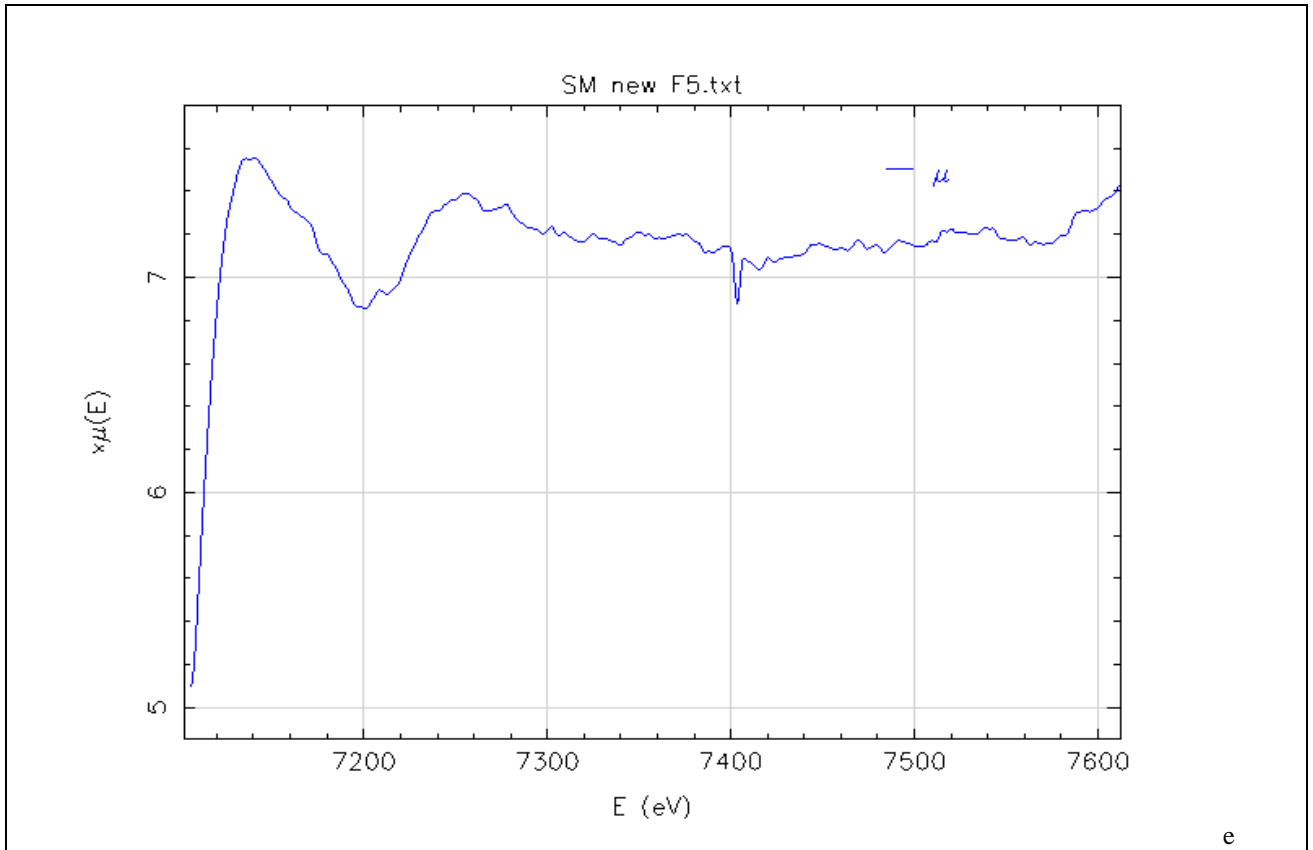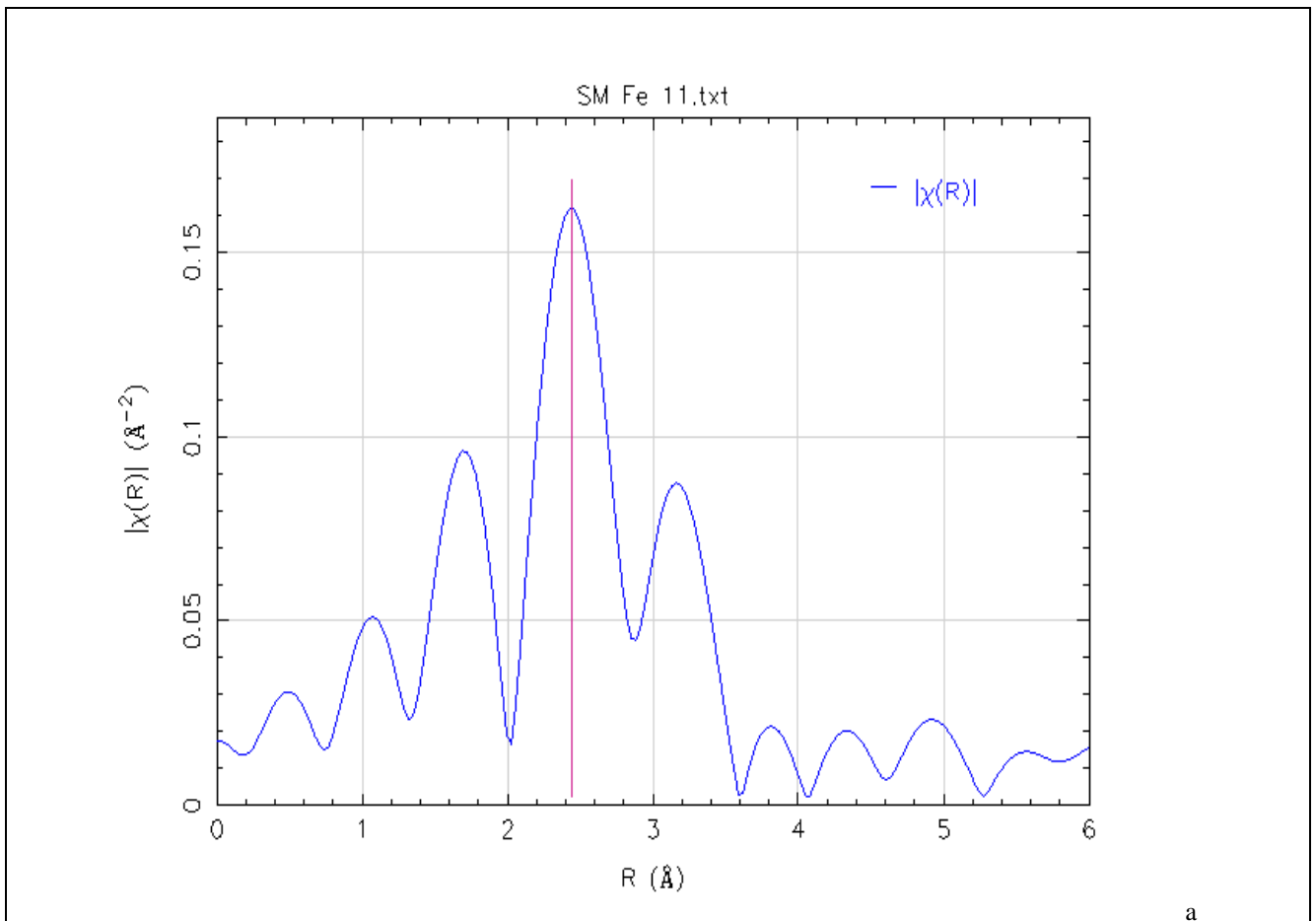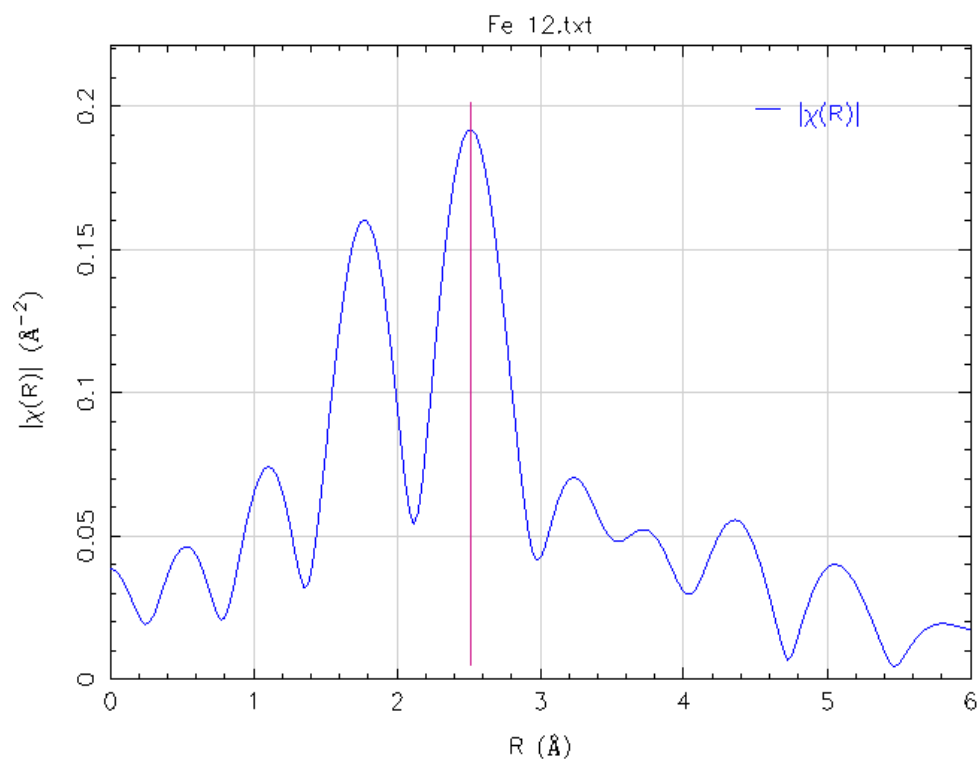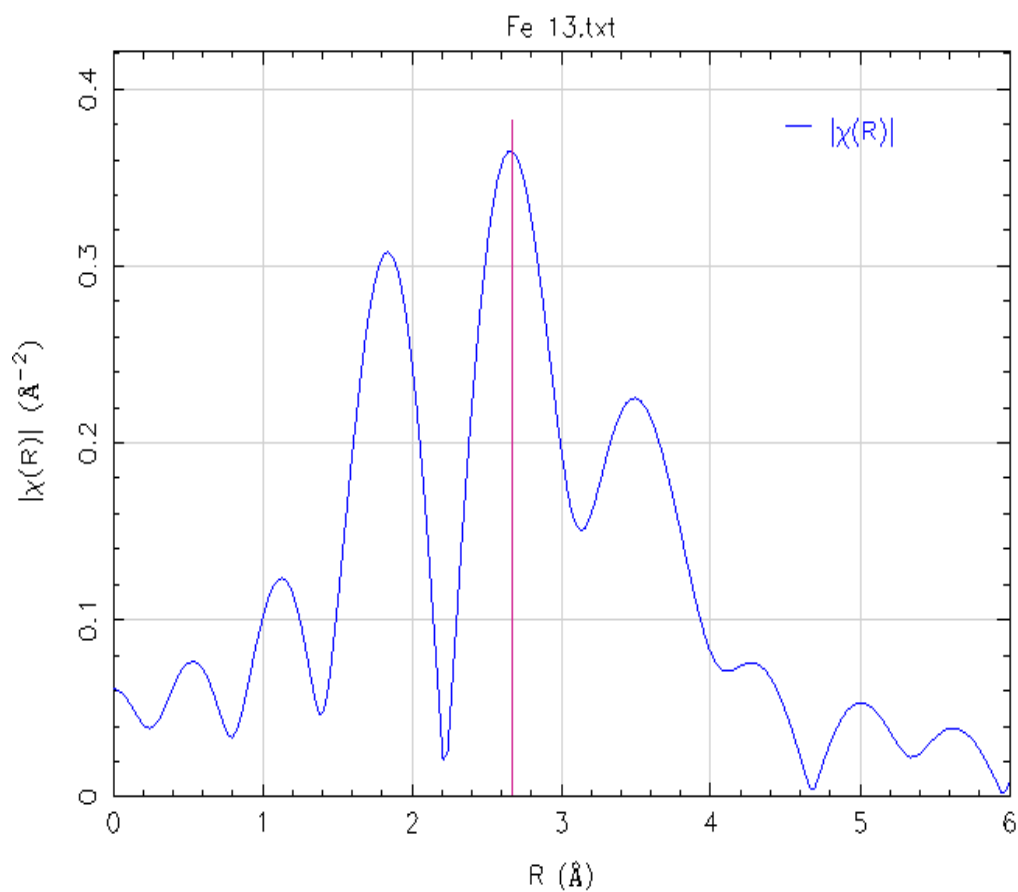[7]. Teo, B.K. and Lee, P.A., J.Am.Chem.Soc. **101, 2815** (**1979**).
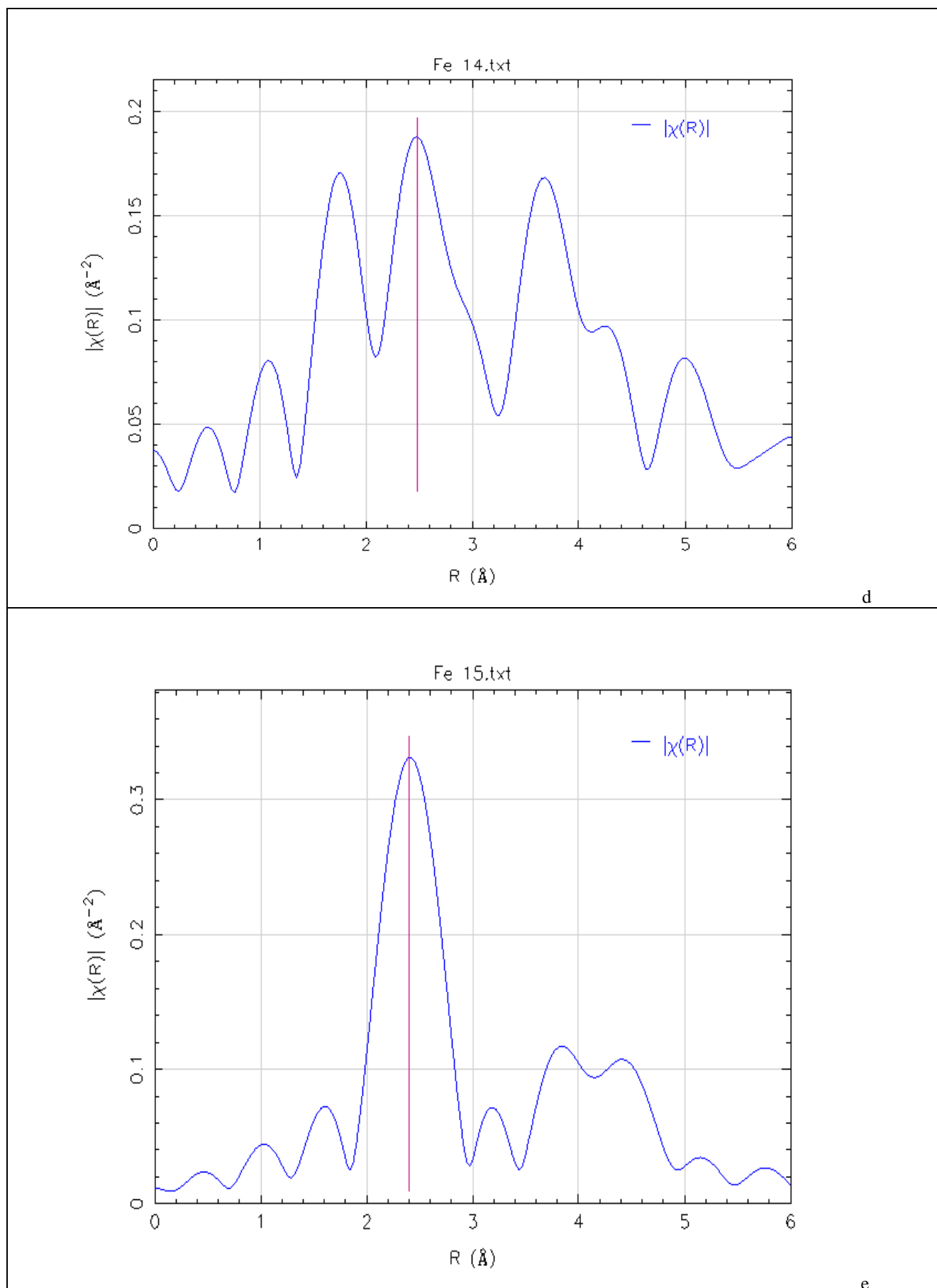
a

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c

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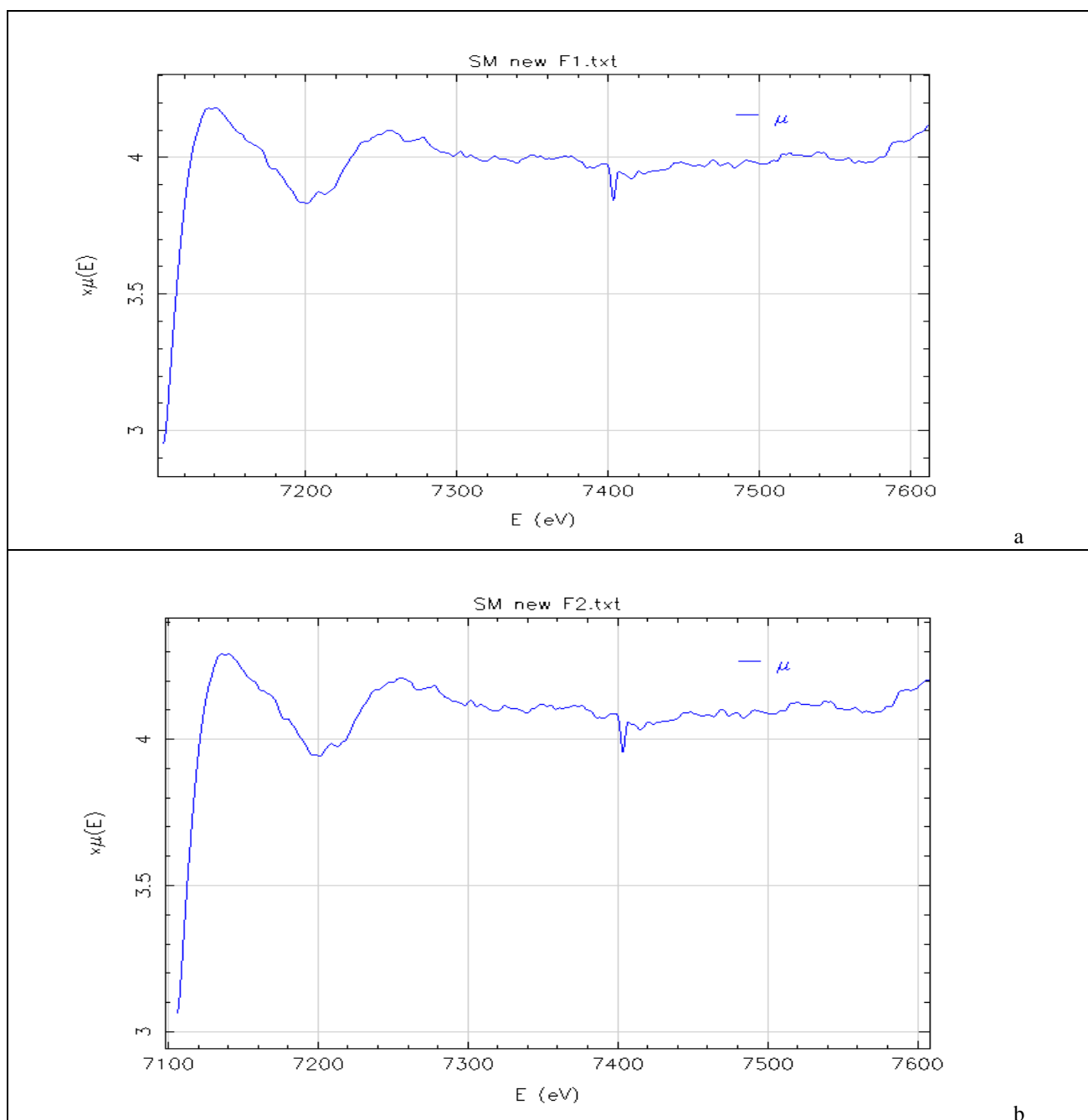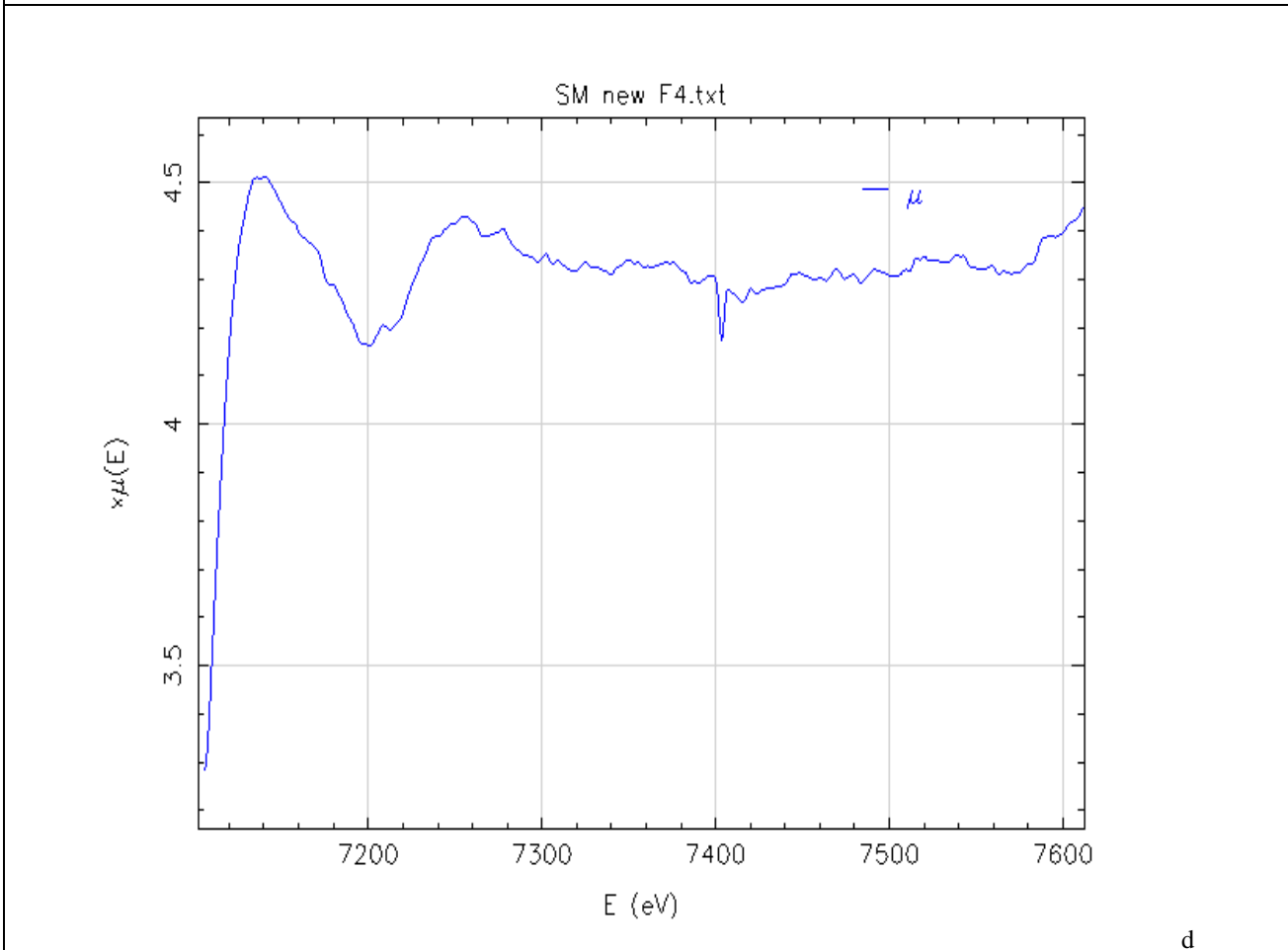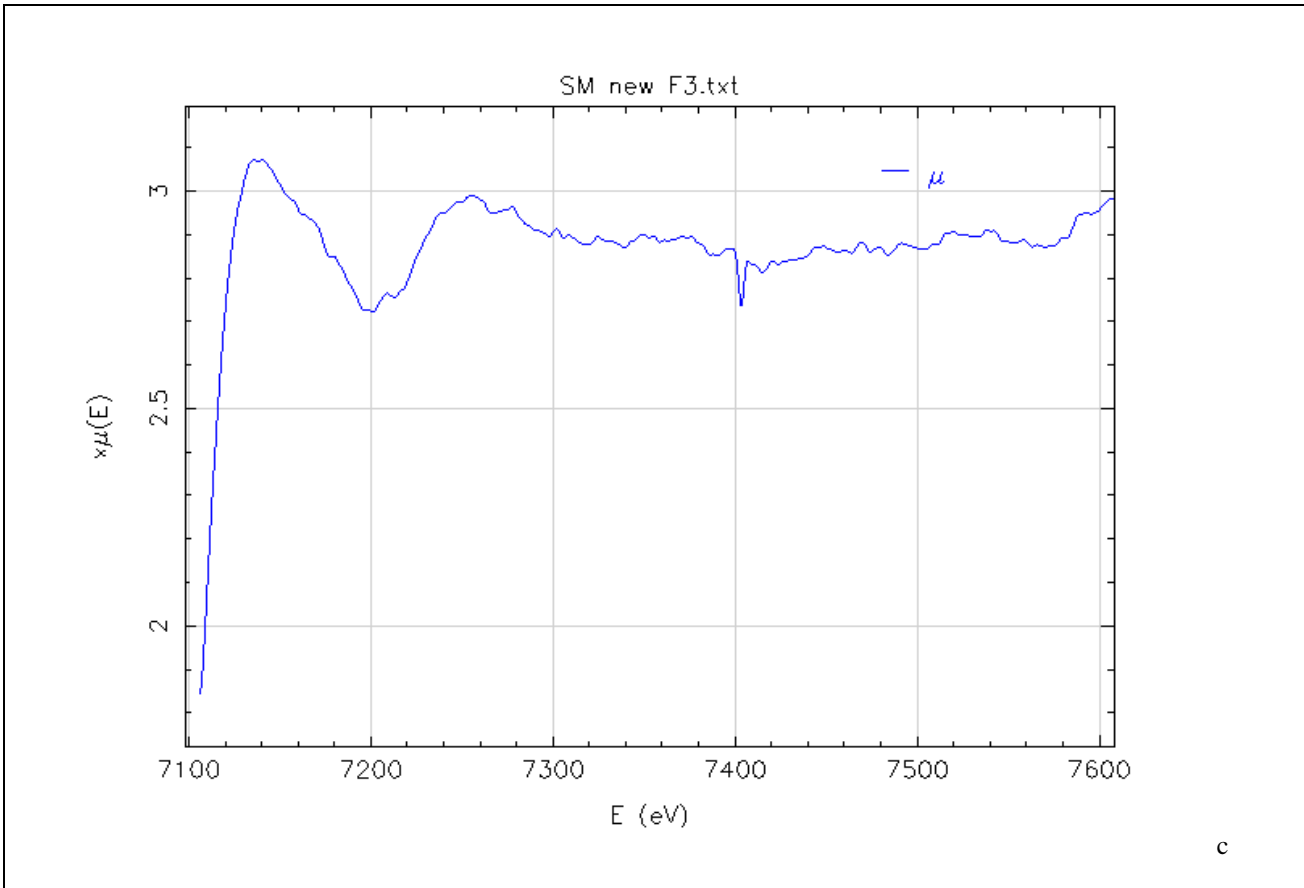
Fig: 1 EXAFS structure of Co –Ni Ferrites
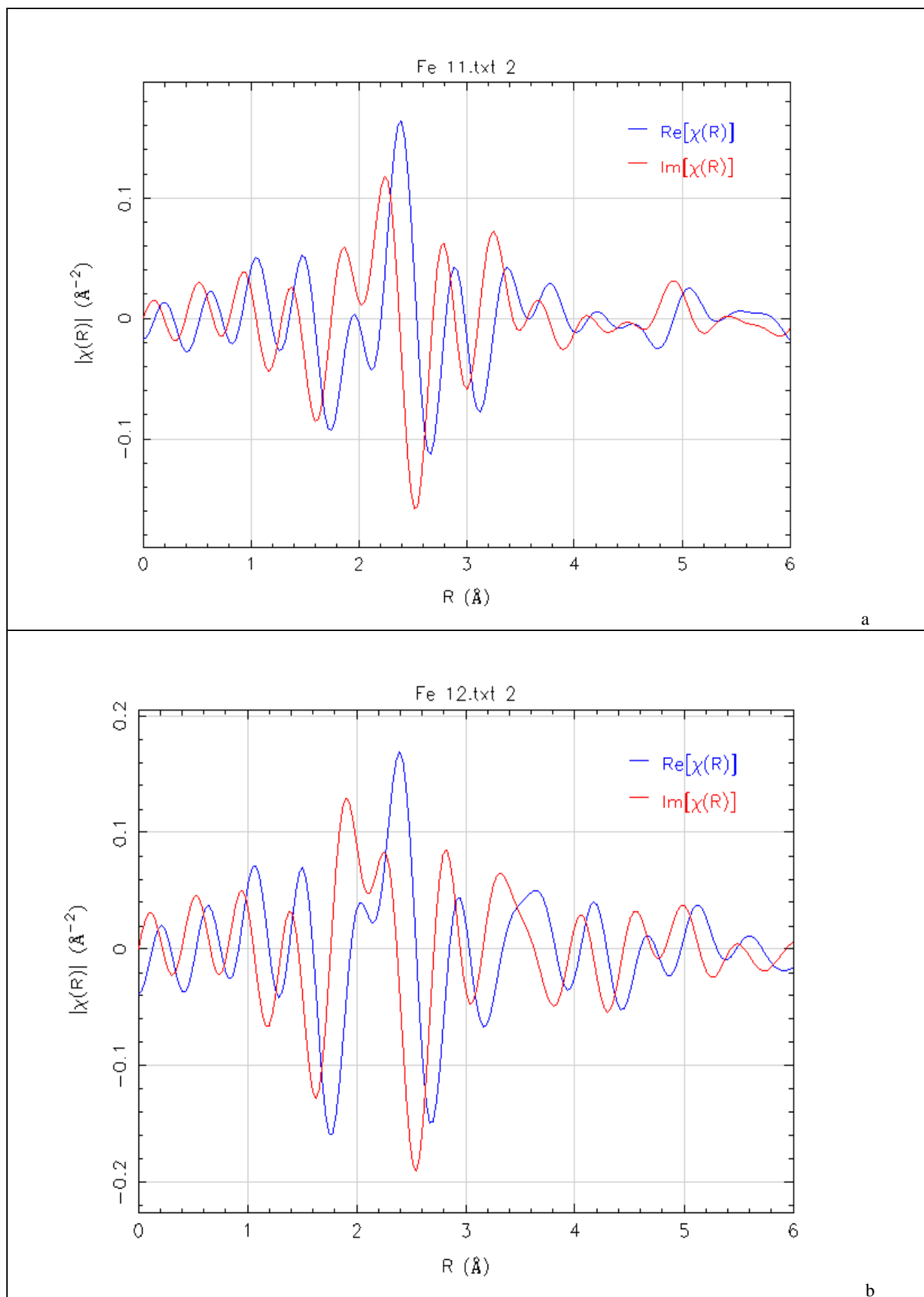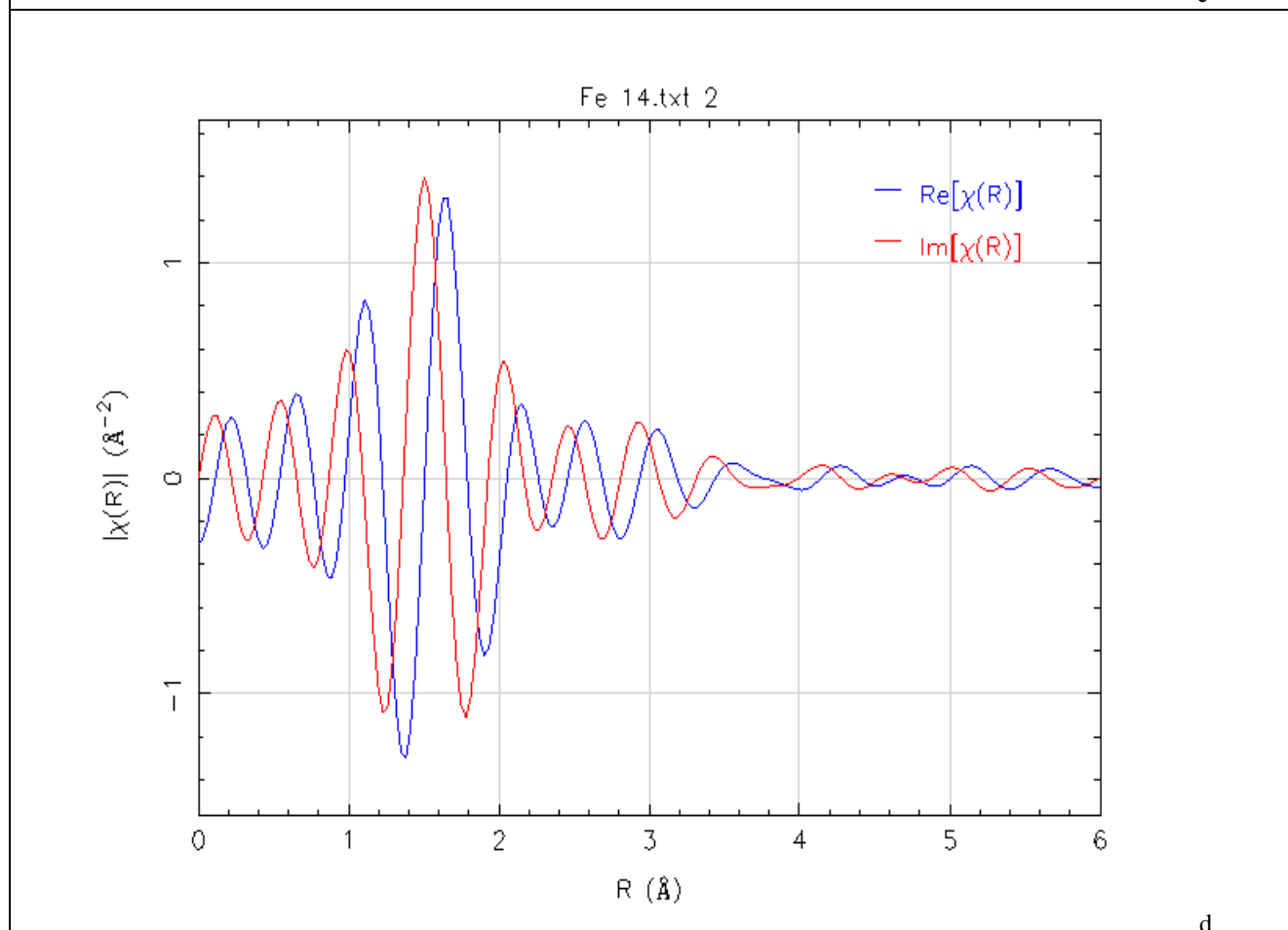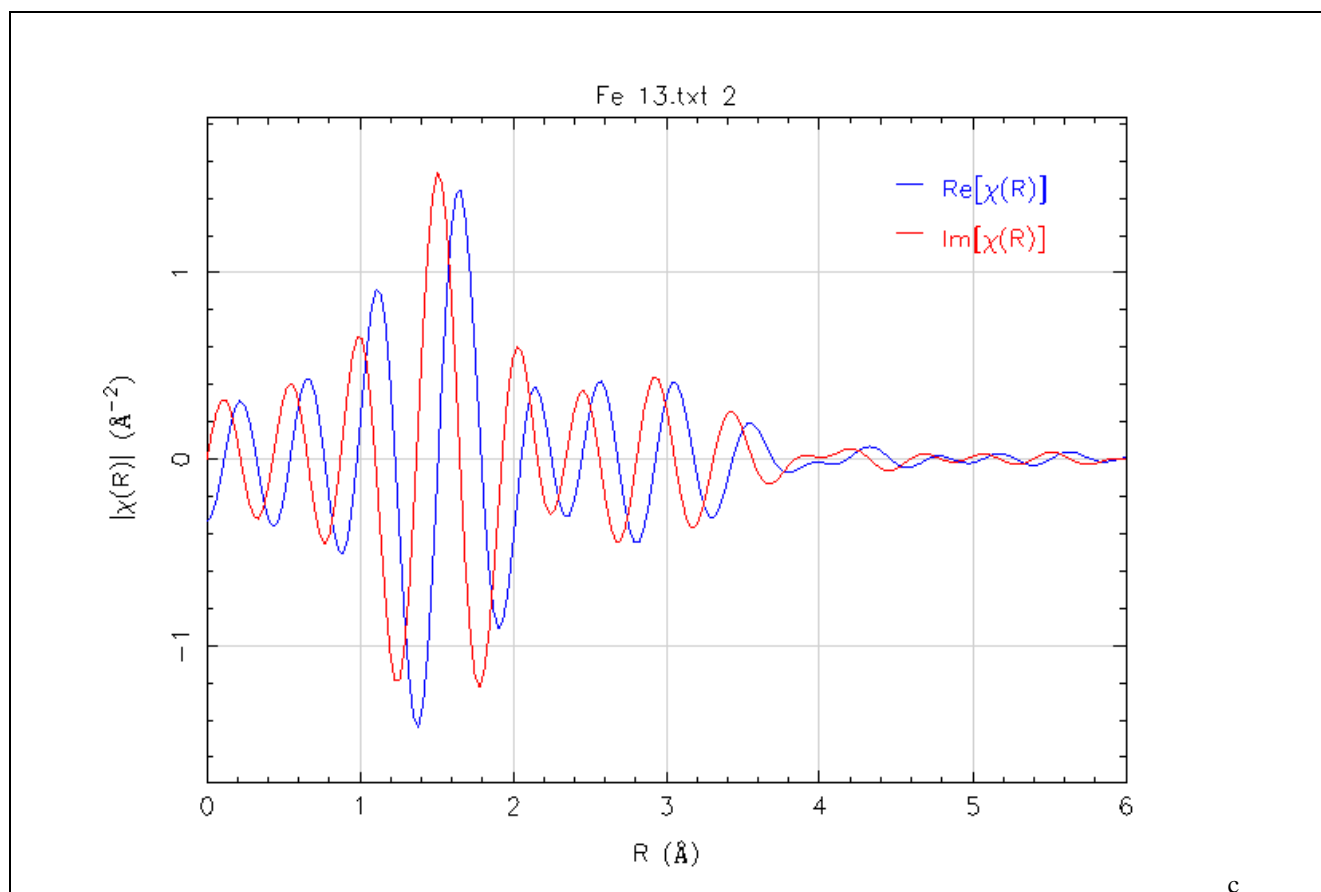
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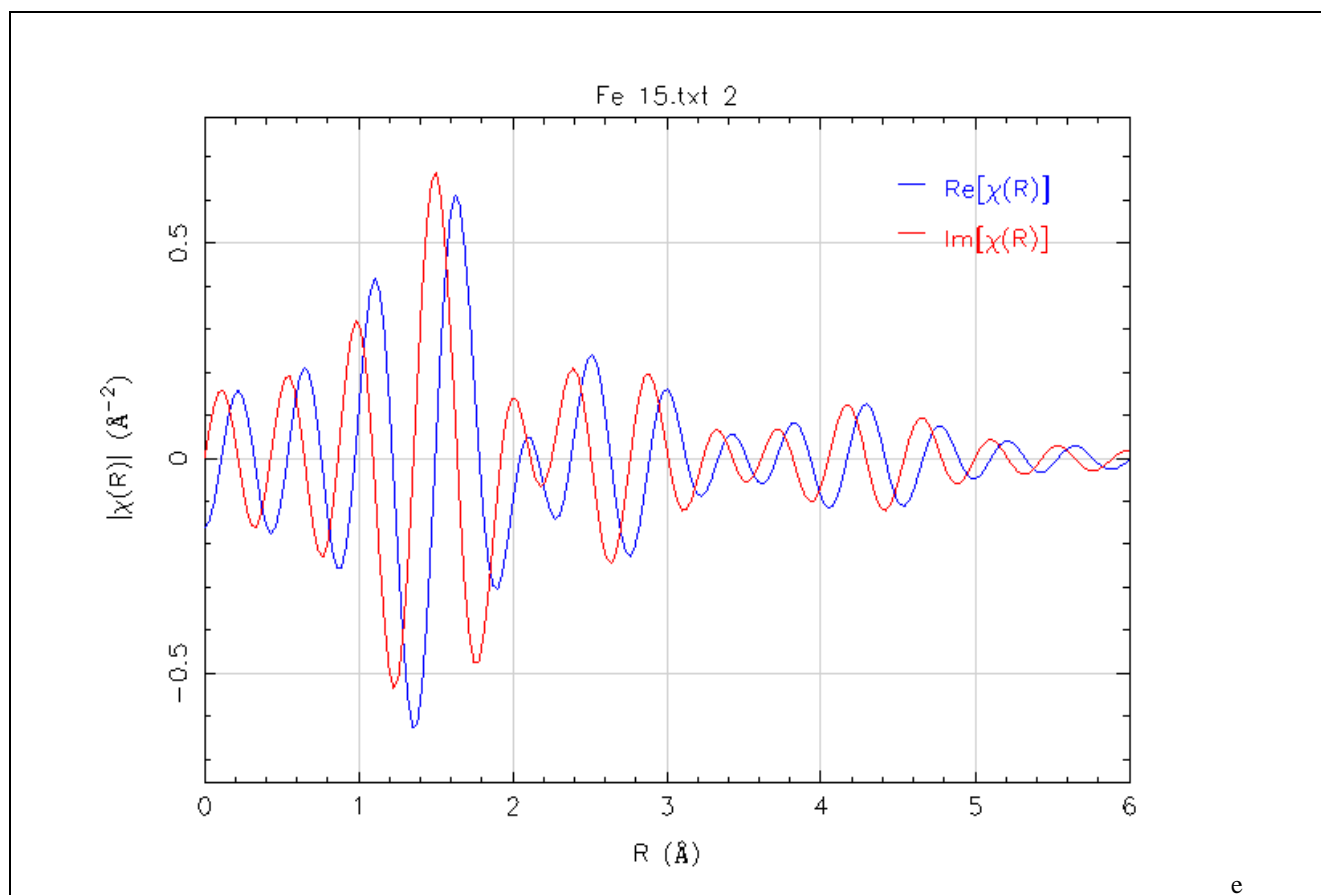Fig: 2 Fourier transformations of complexes

a

b

c

d

Fig 3 Real and Imaginary part of complexes

Table 1
Values of bond lengths calculated from LSS , Levy's , Lytle's and Fourier transformation method

Complexes	R LSS[a]	R Levy's[c]	R Lytle's [b]	F.T[d]
Fe$_2$O$_4$Co	2.49	2.43	2.31	2.21
Fe$_2$O$_4$Co $_{(.05)}$Ni$_{(.05)}$	2.55	2.49	2.15	2.33
Fe$_2$O$_4$Co $_{(.09)}$Ni$_{(.10)}$	2.54	2.16	2.13	2.34
Fe$_2$O$_4$Co $_{(.85)}$Ni$_{(.15)}$	2.46	2.49	2.14	2.46
Fe$_2$O$_4$Co $_{(.8)}$Ni$_{(.20)}$	2.45	2.52	2.38	2.29