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STRING THEORY APPROACH TO THE ABSORPTION COEFFICIENT: RELATIONSHIP WITH ATOMIC AND OXIDATION NUMBERS FOR SELECT ELEMENTS

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ABSTRACT

In this work classical Maxwell's equations with complex wave number are used to related absorption coefficient to the conductivity and refractive index. Treating electrons as strings the absorption coefficient is shown to be inversely related to the atomic number and directly related to the oxidation number. The experimental work in which the absorption spectra of $Fe, Ni, Co, and Cr$oxides is in agreement with this theoretical relation.

Keywords: Absorption coefficient, string theory, atomic number, oxidation number.

I. INTRODUCTION

Material is important in everyday life because of their physical Properties. Other than these Properties, they do play an important role because of their applications in technology. Prime physical properties of materials include electrical properties, thermal properties, magnetic properties, and optical properties the optical properties of materials are useful in different applications. For example they can be used in electronic devices, sensors and detectors basic solar cells. Optical property of a material is defined as its interaction with electro-magnetic radiation in the visible. Electromagnetic spectrum of radiation spans the wide range from x-rays with wavelengthas$10^{-12}m$, through x-rays, ultraviolet, visible, infrared, and finally radio waves with wavelength as along as $10^{5}m$.Interaction of photons with the electronic or crystal structure of a material Leads to a number of phenomena. The photons may give their energy to the material. In the absorption process, when reflection takes place photons give their energy, but photons of identical energy are immediately emitted by material. When photons may not interact with the material structure transmission takes place. But transmission photons are changes in velocity refraction is observed [1, 2, 3, and 4].Different attempts were made to find the physical parameters that effect absorption coefficient [5, 6]. But so far no great attention was prayed to the effect of atomic and oxidation number.

II. ABSORPTION COEFFICIENT

The optical properties of matter depend mainly on the interaction of electromagnetic Light waves with matter. Therefore consider a travelling electromagnetic wave $(e.m.\omega)$[7,8].

$$E = E_0 e^{i(kx-\omega t)} \quad (1)$$

The absorption of $e.m.\omega$ by matter can be easily desoribed writing the wave number in a complex form

$$k = k_1 + ik_2 \quad (2)$$

A direct substitution of (2) in (1) yields

$$E = E_0 e^{-k_2 x} e^{i(k_1 x-\omega t)} \quad (3)$$

The light intensity of initial intensityI_0, passing through matter of thickness x is given by:

$$I = |E|^2 = E_0^2 e^{-2k_2 x} = I_0 e^{-\alpha}$$
$$= I_0 e^{-\alpha x} \quad (4)$$

Thus the absorption coefficient αandI_0 are given by:

$$\alpha = 2k_2$$
$$I_0 = E_0^2 \quad (5)$$

The wave number is related to the refractive index n according to relation

$$k = k_1 + ik_2 = \frac{2\pi}{\lambda} = \frac{2\pi f}{\lambda f} = \frac{\omega}{v}$$
$$= \frac{\omega}{c}\frac{c}{v} = \frac{\omega}{c} n \quad (6)$$

Writing n in a complex form yields

$$k = k_1 + ik_2 = \frac{\omega}{c} n = \frac{\omega}{c}(n_1 + in_2) \qquad (7)$$

Therefore

$$k_1 = \frac{\omega}{c} n_1$$
$$k_2 = \frac{\omega}{c} n_2 \qquad (8)$$

Enquiring both sides of (7) gives

$$k^2 = (k_1 + ik_2)^2 = \frac{\omega^2}{c^2}(n_1 + in_2)^2$$
$$= (\omega v)^2 = \omega\mu\varepsilon \qquad (9)$$

Writing the electric permittivity in a complex from yields:

$$n_1^2 - n_2^2 + n_1 n_2 i = c\mu\varepsilon = c\mu(\varepsilon_1 + i\varepsilon_2)$$

Enquiring real and imaginary parts on both sides gives:

$$n_1^2 - n_2^2 = c\mu\varepsilon_1$$
$$n_1 n_2 = c\mu\varepsilon_2 \qquad (10)$$

The absorption coefficient can be related to conductivity by considering the displacement current density

$$J_a = \frac{\partial D}{\partial t} = \varepsilon \frac{\partial E}{\partial t} = -i\omega\varepsilon E \qquad (11)$$

Using the formal definition of conductivityσ, this is also assumed to be complex, and using equation (11) yields:

$$J = \sigma . E = (\sigma_1 + i\sigma_2)E$$
$$= -i\omega(\varepsilon_1 + \varepsilon_2)E \qquad (12)$$

Comparing real and imaginary parts yields

$$\sigma_1 = \omega\varepsilon_2 \sigma_2 = -\omega\varepsilon_1 \qquad (13)$$

A direct substitution of equations (10), (13) in equation (8) gives

$$k_2 = \frac{\omega}{c} n_2 = \frac{c\mu\varepsilon_2\omega}{2cn_1}$$
$$\frac{c\mu\varepsilon_2\omega}{2n_1} = \frac{\mu\sigma_1\omega}{2n_1\omega}$$
$$k_2 = \frac{\mu\sigma_1}{2n_1} \qquad (14)$$

With the aid of equation (5) and (14) one gets

$$\alpha = 2k_2 = \frac{\mu\sigma_1}{n_1} \qquad (15)$$

The ordinary conductivity expression is given by

$$\sigma_1 = \frac{ne^2 c}{m} \qquad (16)$$

One can find the relation between absorption coefficient and atomic number by using the definition of conductivity in terms of $E$and J,i.e.

$$\sigma = \frac{J}{E} = \frac{nev}{E} \qquad (17)$$

For treating particles as oscillating string

$$x = xe^{i\omega t} v = i\omega t$$

The kinetic and potential energy are equal since

$$T = \frac{1}{2}m|v|^2 = \frac{1}{2}m\omega^2 x^2 = 0$$

$$V = \frac{1}{2}kx^2 = \frac{1}{2}m\omega^2 x^2 = T$$

Hence for strings

$$E = T + v = 2T = mv^2 \quad (18)$$

Inserting (18) in (17) yields

$$\sigma = \frac{nev}{mv} = \frac{ne}{mv} = \frac{ne}{\hbar k} \quad (19)$$

Assuming electrons moving around atoms as string and using the hydrogen atom energy

$$\frac{P^2}{m} = \frac{\hbar^2 k^2}{m} = \frac{m^2 v^2}{m} = \frac{|E|}{m} = \frac{Z^2 e^4}{8\varepsilon_0^2 h^2 n^2} (20)$$

$$\hbar = \frac{h}{2\pi} = Blank's constant$$

Thus

$$\hbar k = \frac{e^2 Z}{2\varepsilon_0^2 hn\sqrt{2}} = C_1 Z \quad (21)$$

Therefore the conductivity and absorption coefficients in equation (19) and (15) are given by

$$\sigma_1 = \sigma = \frac{ne}{C_1 Z} = \frac{C_0}{Z} \quad (22)$$

$$\alpha = \frac{\mu C_0}{n_1 Z} \quad (23)$$

Thus the absorption is inversely proportional to atomic number$Z$. It is also directly proportional to oxidation number n_x according to equations (15) and (16) beside the relation

$$n = n_0 n_x \quad (24)$$

With no stands for atomic density, n_x is the oxidation number which is proportional to the number of free carriers that can be removed from each atom. Thus equations (15), (16) and (24) give:

$$\alpha = \frac{\mu e^2 T n_0 n_x}{n_1 m} = C_2 n_x \quad (25)$$

Hence α is directly proportional to oxidation numbern_x.

III. MATERIALS AND METHODS

Silicon material which acts as a substrate was doped with iron oxide, cobalt oxide, Nicel oxide and chromium oxide.

The visible spectrum of each sample was displayed by using UV was found also. These relations were used to determine reflection coefficient SR extinction coefficient $SK$and absorption coefficients for all materials used.

Table (--) data sheet of Atomic number and Oxide number verses Absorption Coefficient and Refractive Index for the sample that make At wavelength 514 nm

Element	Atomic Number	Oxide Number	Absorption coefficient (cm^{-1})	Refractive Index
Chrome	24	6	2321847.51	2.24
Iron Cobalt	26 27	3 2	2293255.13 2197947.21	2.13 2.03
Nice	28	2	2140762.46	1.94
Copper	29	1	2064516.13	1.85

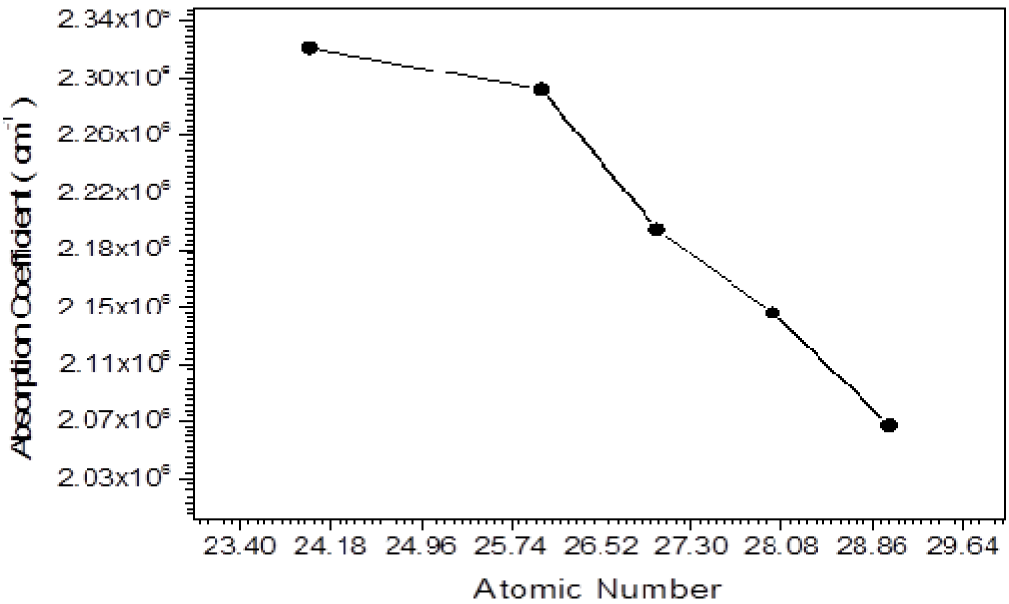
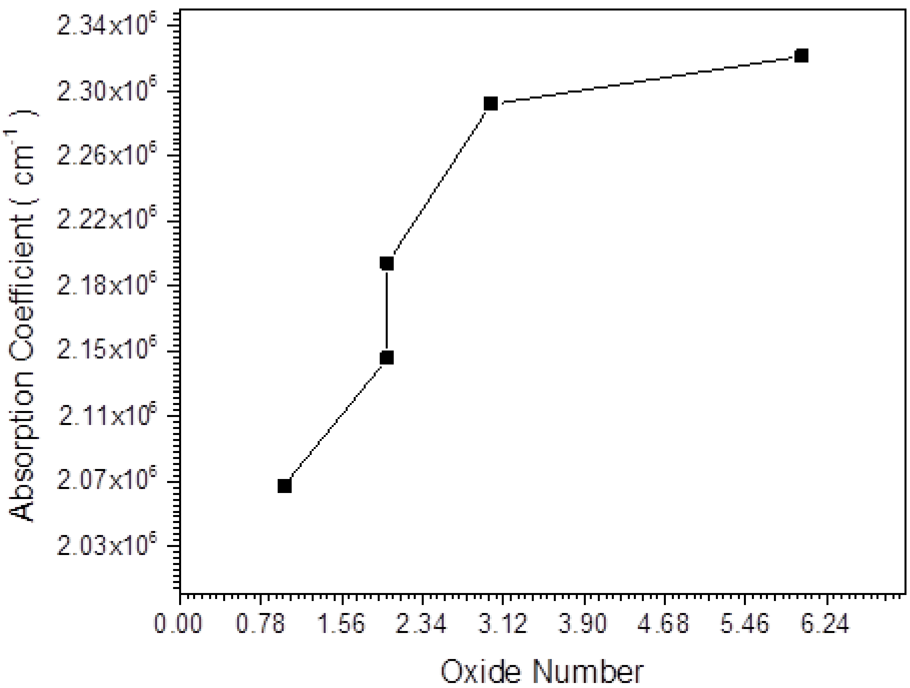
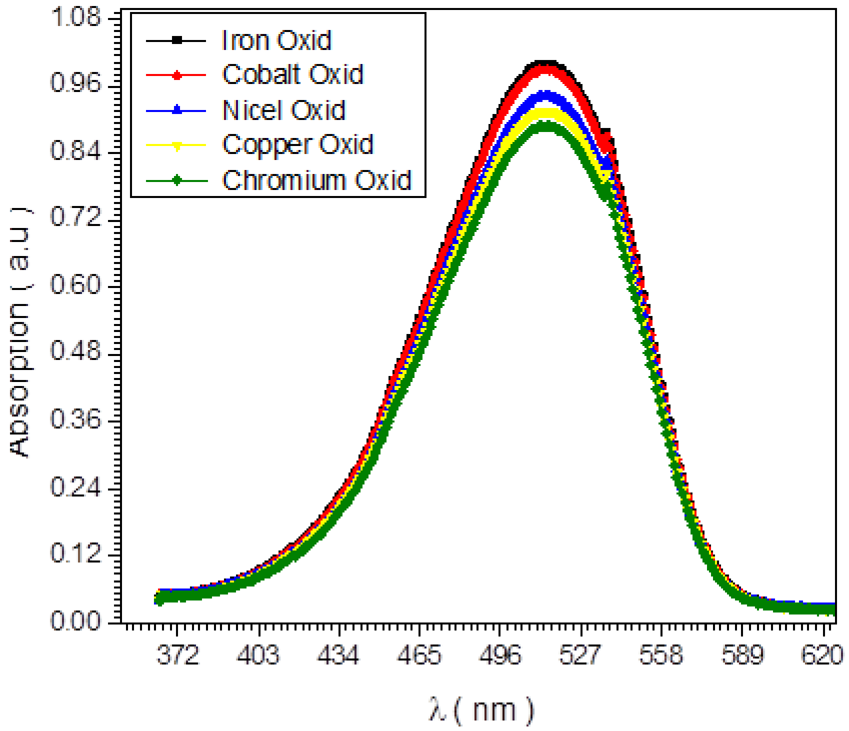


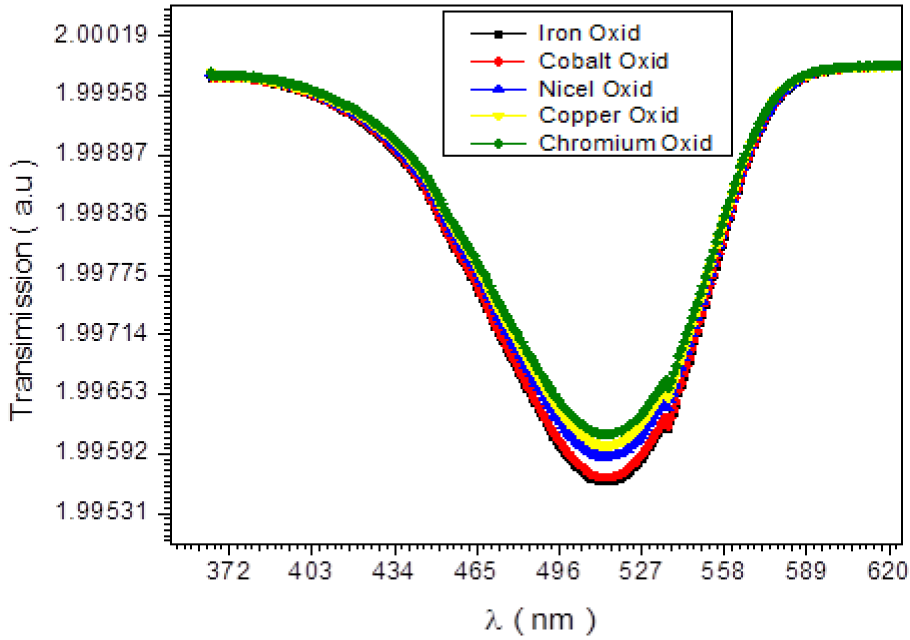
Fig (1) Relation sheep between Atomic number and Absorption Coefficient at wavelength 514 nm



Fig(2)Relationship btween oxidation number Absorption Coefficient at wavelength 514nm



Fig(3) Absorption Intensity I versus wavelength λ near UV



Fig(4) Transmittion intensity I versus wave length λ for UV

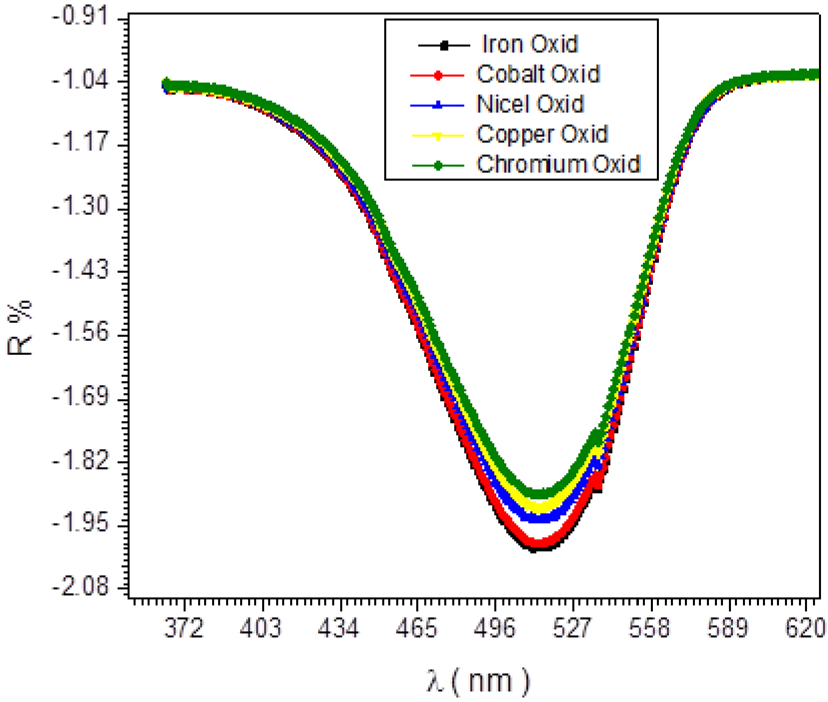


Fig (5) Reflection Coefficient versus wave length

IV. DISCUSSION

The absorption coefficient α is found by using electromagnetic electric wave equation. The wave number is splinted into real and imaginary part. The imaginary part k_2 is related to the refractive index and to the electric permittivity as shown by relations (1-10). The relation between current density and conductivity beside its relation with polarization and electric permittivity [see equation (11-13)] are used to find the absorption coefficient α in farms of conductivity and refractive index as shown by equation (15).Treating electrons as strings the conductivity is found by using quantum expressions for momentum and energy. These relations shown that the conductivity is directly proportional to the atomic number Z[see equation(21)]. The absorption coefficient was found to be inversely proportional to Z as equation (23) shown.The relation between the absorption coefficient and conductivity, beside conductivity and oxidation number, are used to relate α to oxidation number. Equation (25) shows that the absorption coefficient is directly proportional to the oxidation number. The experimental work done in this research relates the absorption coefficient α to the atomic number Z[see Figure (6)]. This empirical relation shows that α decrease as Z increases which agrees with relation (23). Surprisingly the empirical relation in Figure (7) shows that α is directly proportional to n_x which conforms also which theoretical relation (25).

V. CONCLUSION

A theoretical model based on classical electromagnetic theory for complex wave number and conductivity shows that the absorption coefficient depends on oxidation number and atomic number when electrons are treated as strings

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