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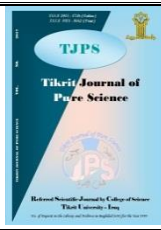

Determination of the effect of oxidation on attenuation coefficient of (X-ray) by Cu, Zn and their alloys

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Abstract

In this paper we study the effect of the oxidation on the values of total attenuation coefficient for the samples (Cu ,Zn and their alloys Brass (70%Cu +30%Zn), (60%Cu+40%Zn)) . The samples thicknesses chosen (0.02-0.1) cm, the Mo-X-ray tube used with the voltages (20-25-30-35) KV, the effect of oxidation on (μ_L , μ_m) were studied by using the graphic relations, where the effect of oxidation at temperature (100 ˚C) and oxidation time (1.5,6) hours on the linear and mass attenuation coefficients are studied .It is concluded that best results were achieved for (μ_L , μ_m) at (100 ˚C) after six hours where (μ_L) increased by the ratio (7.14%,5.76%,8.62%3.77%) respectively, while (μ_m) increased by (7.05%, 5.79%,10.05%,3.55%) respectively by comparing with oxidized samples for time (1.5) hours at voltage 20 KV, it is found a linear relation between the linear and mass attenuation coefficient with the oxidation time. While they are inversely related with increasing X-ray voltages. the effect of oxidation on the structural from of the studied materials was also examined using both the scanning electron microscope and the X-ray diffraction examination.

1. Introduction

Since the discovery of (X-ray) by Rotengen [1] many experiments especially that are related to its attenuation were conducted Thomson ,Held several experiments on the attenuation of (X-ray) by different Materials [2] .

The attenuation of (X-ray) occurs through its interaction with matter . Composite material may offer additional benefits in chemical resistance , physical durability ,and portability, the interaction of (X-ray) with matter is via three main processes photoelectric effect, Compton scattering and pair production. Pair production occurs only for very high energy (X-ray > 1022kev) , the sum of (photoelectric effect ,Compton scattering and pair production) per unit path length were the (X-ray) photon is removed from the beam is called linear attenuation coefficient (μ_L)

$$\mu_L = \sigma(\text{photoelectric}) + \sigma\,(\text{Compton}) + \sigma\,(\text{pair}) \quad (1)$$

σ = Area of the interaction .

μ_L can be described by the well known equation [6]:

$$\mu_L = \frac{\log^{I_\circ}/_{I}}{X} \qquad (2)$$

I = Transmitted intensity , I◦ = incident intensity and X = thickness of absorbent ,to find the μ_L for any alloy me may use the equation :

$$\mu_L(Alloy) = p_1\,\mu_L(s_1) + p_2\,\mu_L(s_2) \qquad (3)$$

Where :P_1 represents the percentage of the first pure sample (s_1)

$P_2 = 1-P_1$ represents the percentage of the second pure sample (s_2)

The fact that linear attenuation coefficient varies with the density of the absorbent limits its use, even if the absorber material is the same. therefore ,the mass attenuation coefficient (μ_m) is much more widely used and is defined as:

$$\mu_m = \frac{\mu_L}{\rho} \quad (cm^2 . gm^{-1}) \qquad (4)$$

Where (ρ) refer to the density of the absorbing medium.

We can introduce a half –thickness, $x_{1/2}$,as :

$$x_{1/2} = \frac{0.693}{\mu_L} \qquad (5)$$

Also the average distance or the mean free path for absorbing medium for a beam of (x-ray) is defined as[3,4,5,6,7]:

$\lambda = \frac{1}{\mu_L}$ (6)

2. Oxidation

Oxidation is a chemical reaction of metallic element with oxygen resulting in the damage of element, this in turn ,resulting in an increase in the element positive parity .when an element is combined with oxygen atom, it is noted that the metal loses electron which indicates that the oxidation reactions include oxygen federation with element and transfer of electron leading to the formation of the oxide layer on the surface of the element as described in the equation :

$M + \frac{1}{2} O_2 = MO$ (7)

The types of oxides depend on metal parity, whether single or multi- parity. The speed of the rate of oxidation depends on energy released freed from the process as the freed energy is large, the rate of oxidation is faster, the oxide layer which is formed on the surface of the metal working as a barrier that saves the metal and oxygen atoms away from each other to reduce the interaction of metal atoms with oxygen atoms to form the oxide .On this basis two types of oxidization is classified :-

- Protective Oxides
- Non - Protective Oxides

When the oxide layer is non-porous then it's called the protective oxide and will have a high adhesion with the surface of the metal and also have a small thickness while for the non-protective type will have a low adhesion, a large thickness and porosity. (pilling) and (Bedworth) have found that oxide layer depend on the ratio between the size of the membrane oxidized on the surface of the metal to the size of the originl metal are called (pilling – Bedworth ratio)(PBR) given as[8,9] :-

$PBR = \frac{V_{ox}}{V_m}$ (8)

Where V_{ox} and V_m : size of the membrane oxidized on the surface of the metal and the metal respectively . Since the measurement of the rate of oxidation is out of scope of this paper we may only mention to some references that give the lows controlled the oxidation [8-15] .

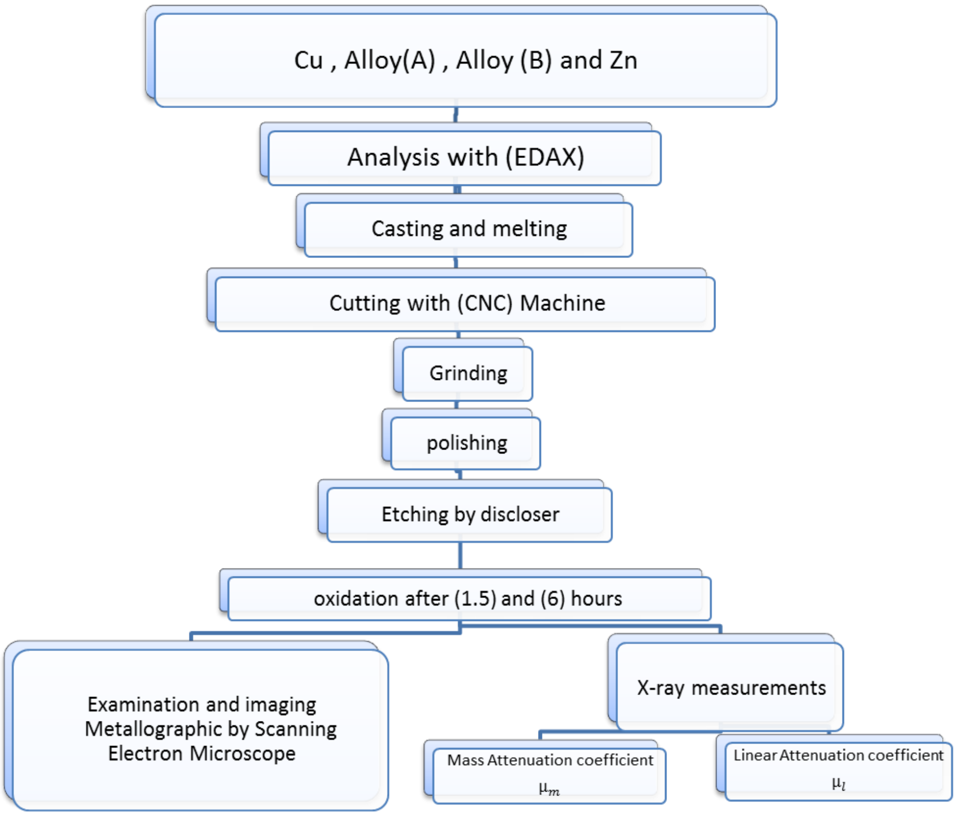
3- Experimental work

The experimental procedure is shown in flowchart (1), the samples used in experiment are (Cu ,Zn and their alloys, one of them (70% Cu+ 30% Zn) defined as alloy (A) and the second alloy is (60%Cu + 40% Zn), defined as alloy (B)). Oxidation of the samples takes place at (100) °C. Figures (2-5) show the analysis of the alloys before and after the oxidation at time (1.5) hour , all samples were imaged by (SEM) after oxidation at (1.5)and(6)hours, as it was observed that the surfaces of oxidizing samples have the same shape, figures (6-13) shows the microscopies imaging by (SEM) of the samples before and after the oxidation at time (1.5) hour and The figures (14-21) shows the pattern of (X-ray) diffraction for the samples at (1.5) hour and (6) hours after oxidation .

4- Calculations

4-1 The Calculations of linear (μ_L) and mass (μ_m) Attenuation Coefficients :

Equation (2) is used to calculate linear Attenuation Coefficients for pure sample while equation(3) for the two alloys, Figures (22 to 25) that show the logarithm of absorption versus (against) thickness for each samples oxidized at (100)°C and (1.5) hours. while we draw the figures (26-29) shows the logarithm of absorption versus equivalent thickness by unit (gm/cm^2) to the same samples by using equation (4) which is the mass attenuation coefficients, same procedure are done for samples after oxidation at (100)°C and time (6) hours, all are shown in figures (30-37).



Flowchart (1) of in Experimental work

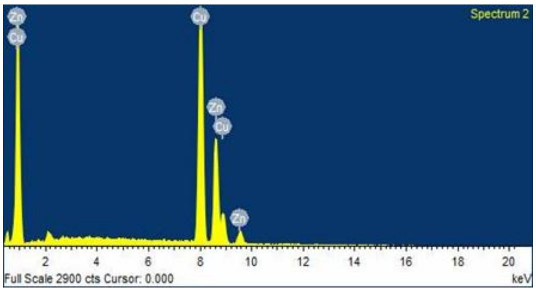


Figure 2 : shows the analysis of the alloy (B) before the oxidation

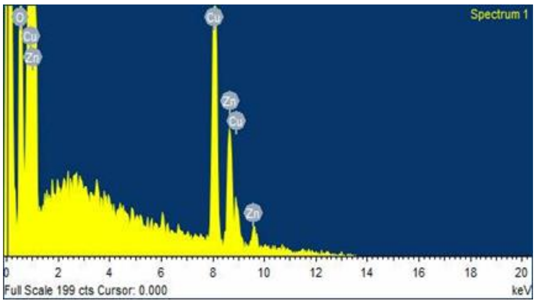


Figure 4 : shows the analysis of the alloy (B) after the oxidation at time (1.5)h.

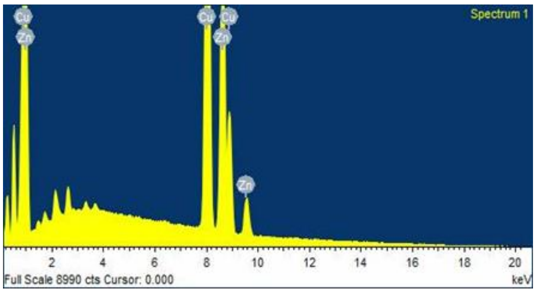


Figure 3 : shows the analysis of the alloy (A) before the oxidation

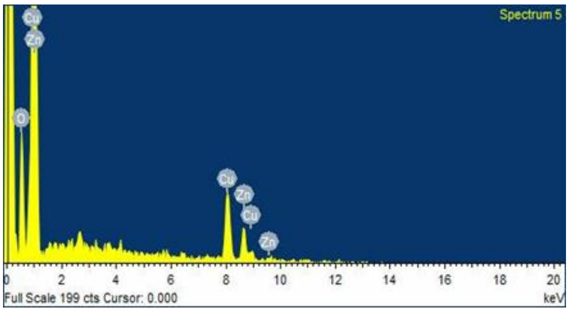


Figure 5 : shows the analysis of the alloy (A) after the oxidation at time (1.5)h.

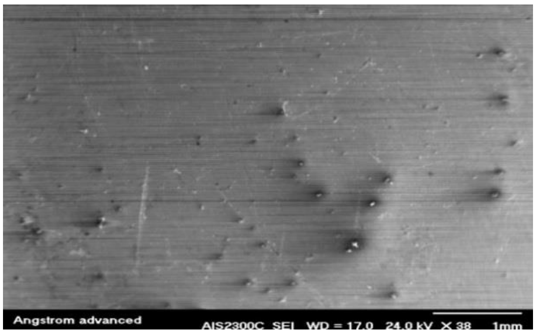


Figure 6:Microscope photograph by (SEM) which shows the structure of copper before the oxidation

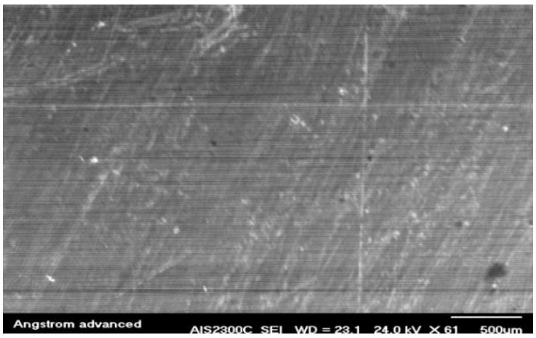


Figure 7: Microscope photograph by (SEM) which shows the structure of zinc before the oxidation

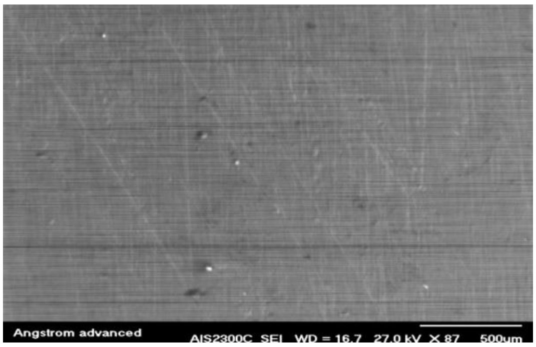


Figure 8:Microscope photograph by (SEM) which shows the structure of Alloy(A) before the oxidation

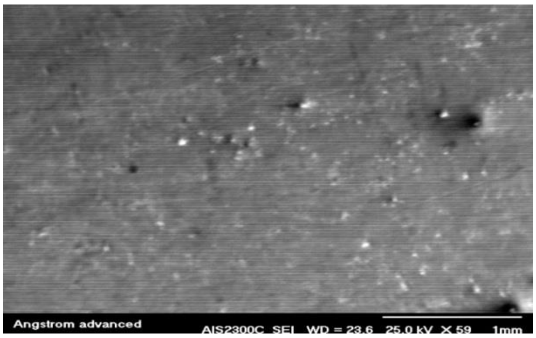


Figure 9:Microscope photograph by (SEM) which shows the structure of Alloy(B) before the oxidation

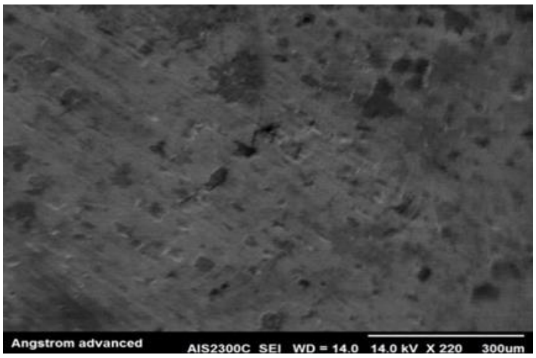


Figure 10:Microscope photograph by (SEM) which shows the structure of copper after the oxidation(1.5)h

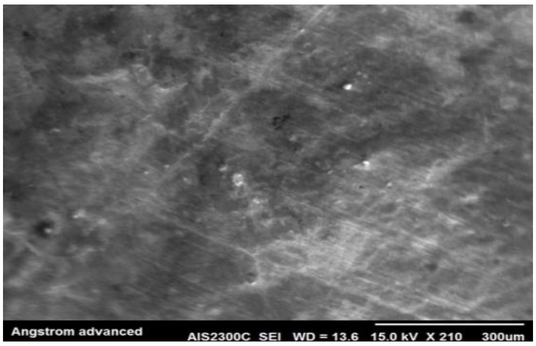


Figure 11:Microscope photograph by (SEM) which shows the structure of zinc after the oxidation(1.5)h.

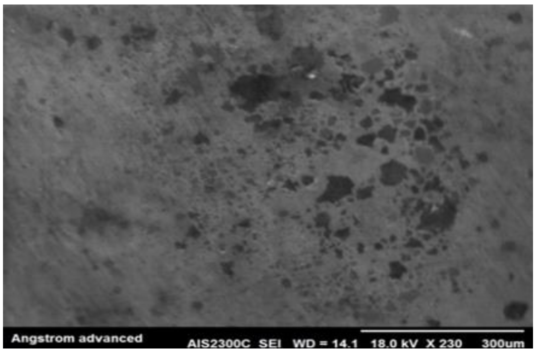


Figure 12:Microscope photograph by (SEM) which shows the structure of Alloy(A)after the oxidation(1.5)h

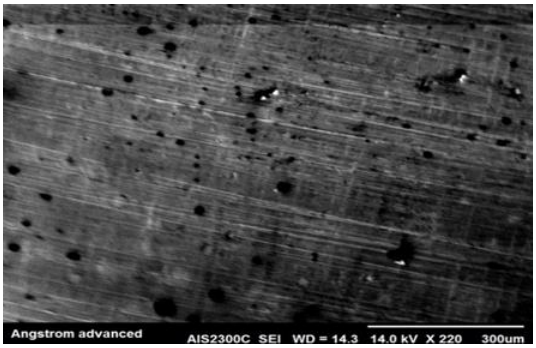


Figure13:Microscope photograph by (SEM) which shows the structure of Alloy(B)after the oxidation(1.5)h

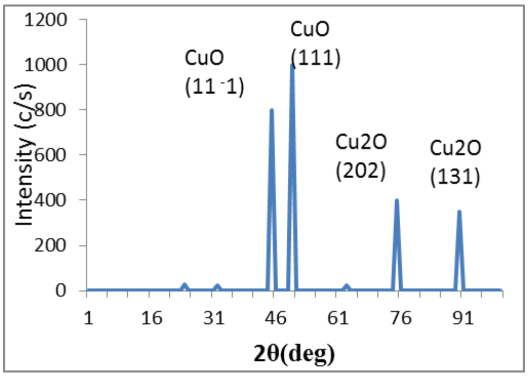


Figure 14 : Pattern of (X-ray) diffraction for copper oxidation after (1.5) hours

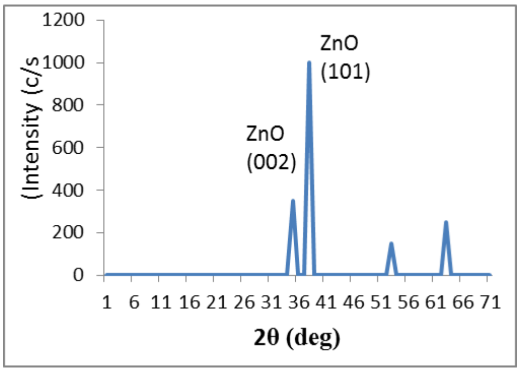


Figure 15 : Pattern of (X-ray) diffraction for zinc oxidation after (1.5) hours.

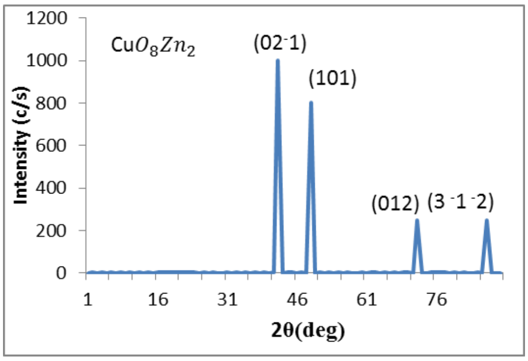


Figure 16 : Pattern of (X-ray) diffraction for Alloy(B) oxidation after (1.5) hours

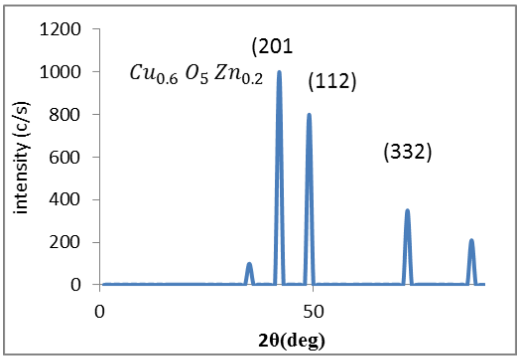


Figure 17 : Pattern of (X-ray) diffraction for Alloy(A) oxidation after (1.5) hours

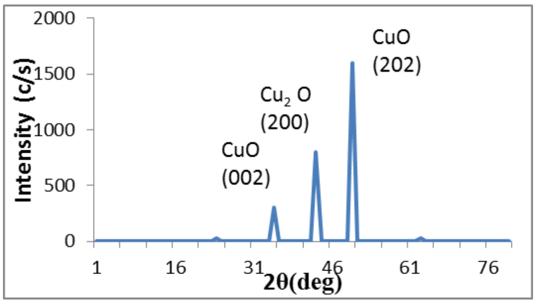


Figure 18 : Pattern of (X-ray) diffraction for copper oxidation after (6) hours

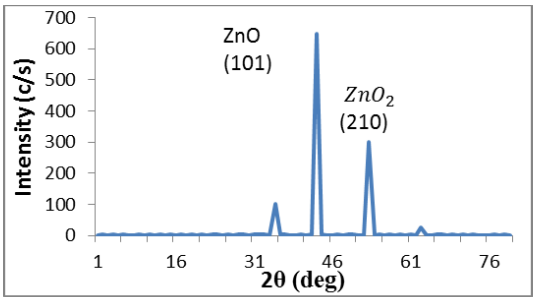


Figure 19 : Pattern of (X-ray) diffraction for zinc oxidation after (6) hours

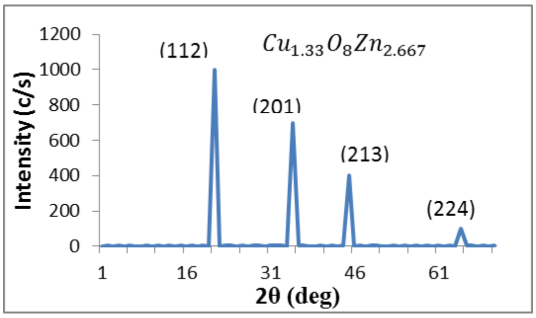


Figure 20 : Pattern of (X-ray) diffraction for Alloy(A) oxidation after (6) hours

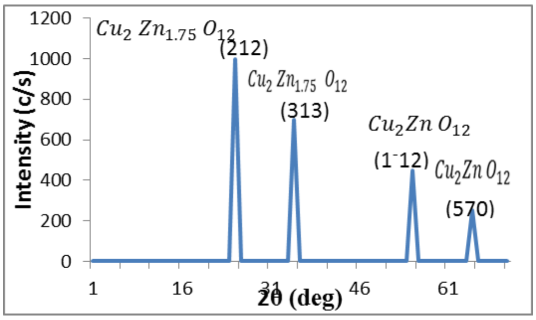


Figure 21 : Pattern of (X-ray) diffraction for Alloy(B) oxidation after (6) hours

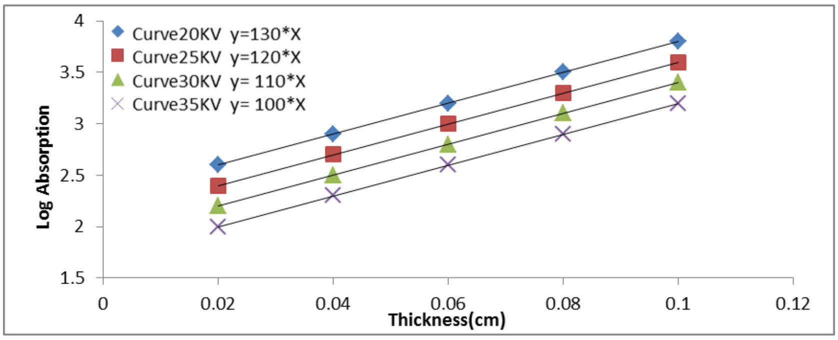


Figure 22 : The relation between Log absorption and Thickness for copper at 100 ˚C at (1.5)h.

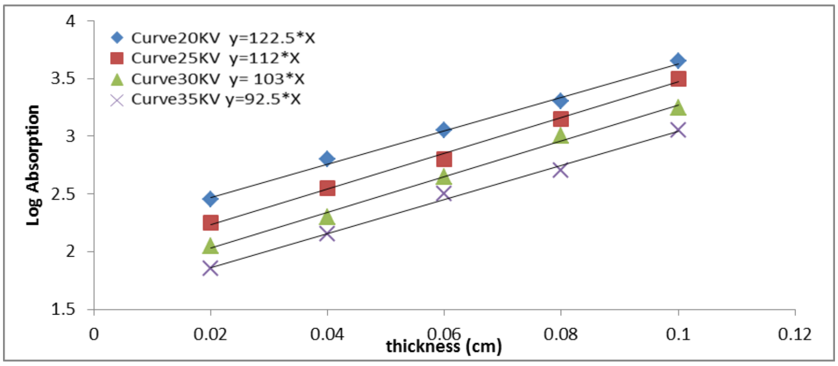


Figure 23 : The relation between Log absorption and Thickness for zinc at 100 ˚C at (1.5)h.

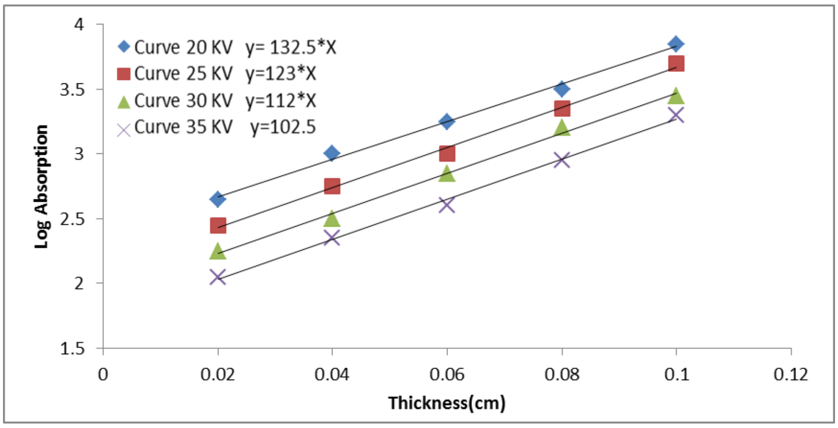


Figure 24 : The relation between Log absorption and Thickness for Alloy (A) at 100 ˚C at (1.5)h.

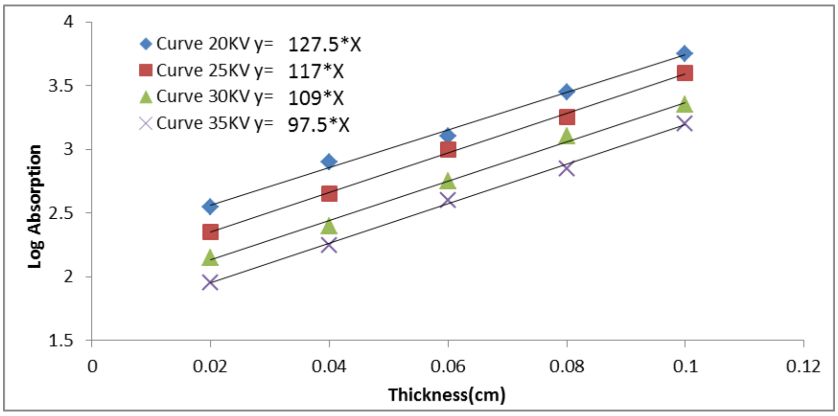


Figure 25 : The relation between Log absorption and Thickness for Alloy (B) at 100 ˚C at (1.5)h.

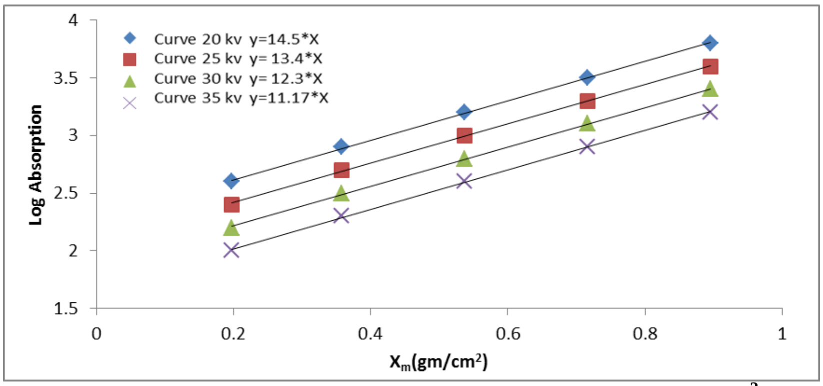


Figure 26 : The relation between Log absorption and equivalent thickness (gm/cm^2) for copper at 100 °C at (1.5)h.

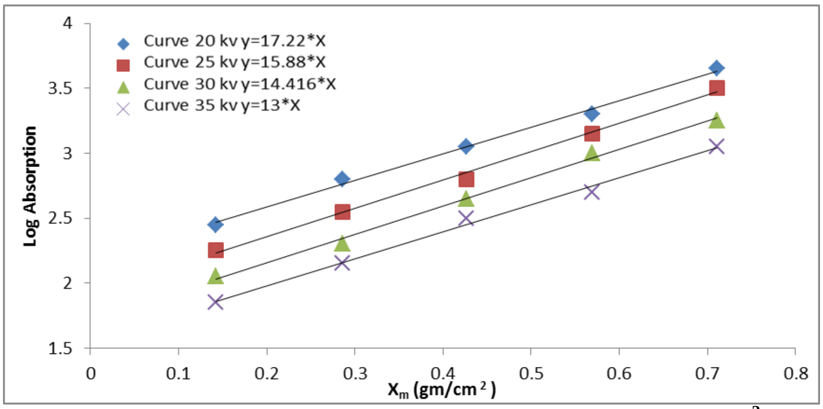


Figure 27 : The relation between Log absorption and equivalent thickness (gm/cm^2) for zinc at 100 °C at (1.5)h.

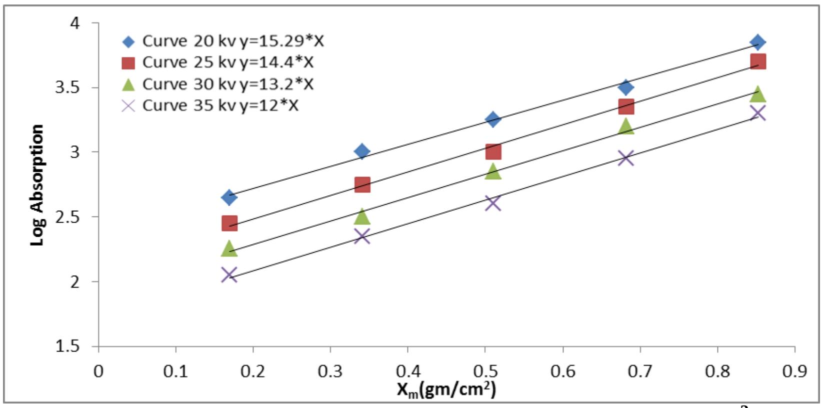


Figure 28 : The relation between Log absorption and equivalent thickness (gm/cm^2) for Alloy(A) at 100 °C at (1.5)h.

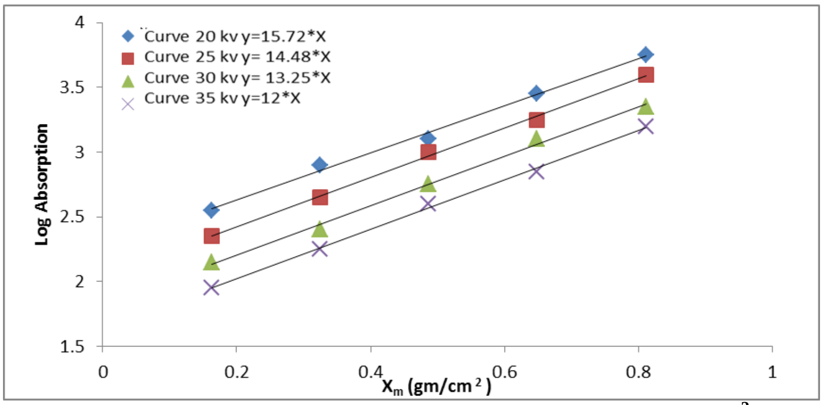


Figure 29 : The relation between Log absorption and equivalent thickness (gm/cm^2) for Alloy(B) at 100 °C at (1.5)h

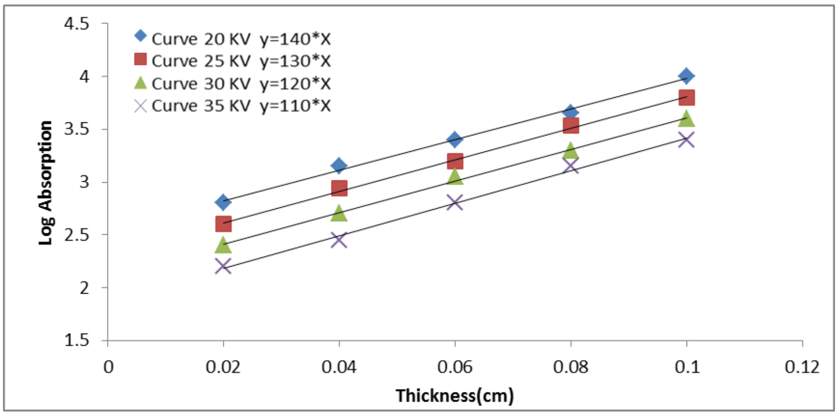


Figure 30 : The relation between Log absorption and Thickness for copper at 100 ˚C at (6)h.

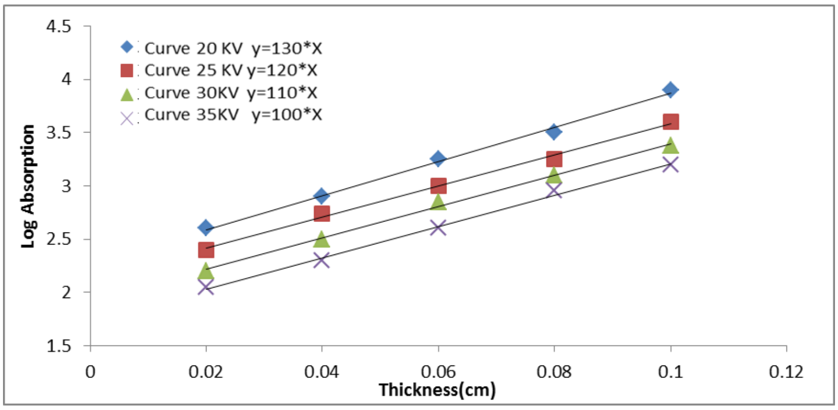


Figure 31 : The relation between Log absorption and Thickness for zinc at 100 ˚C at (6)h .

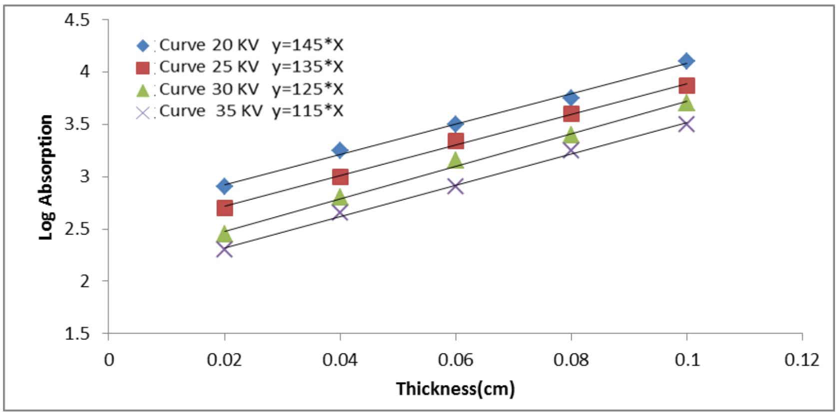


Figure 32 : The relation between Log absorption and Thickness for Alloy (A) at 100 ˚C at (6)h.

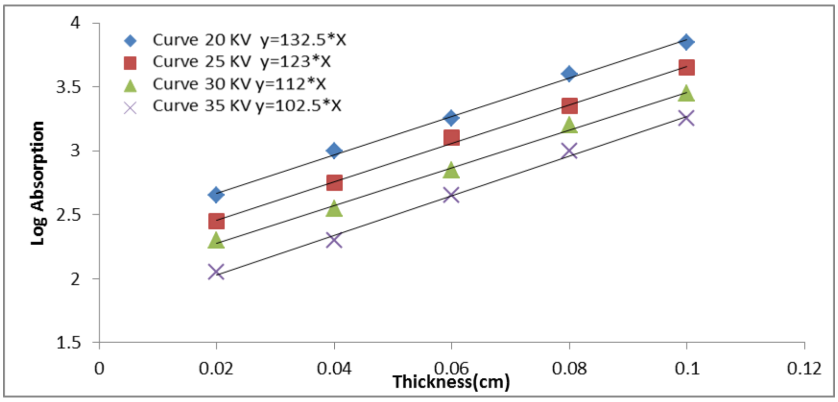


Figure 33 : The relation between Log absorption and thickness for Alloy (B) at 100 ˚C at (6)h .

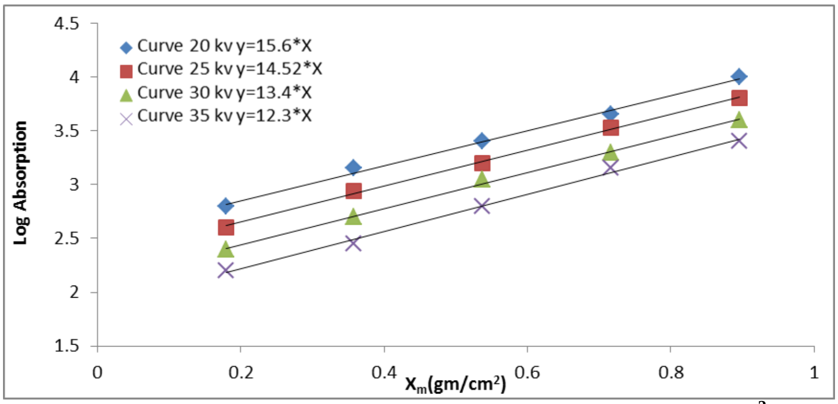


Figure 34 : The relation between Log absorption and equivalent thickness (gm/cm^2) for copper at 100 ˚C at (6)h.

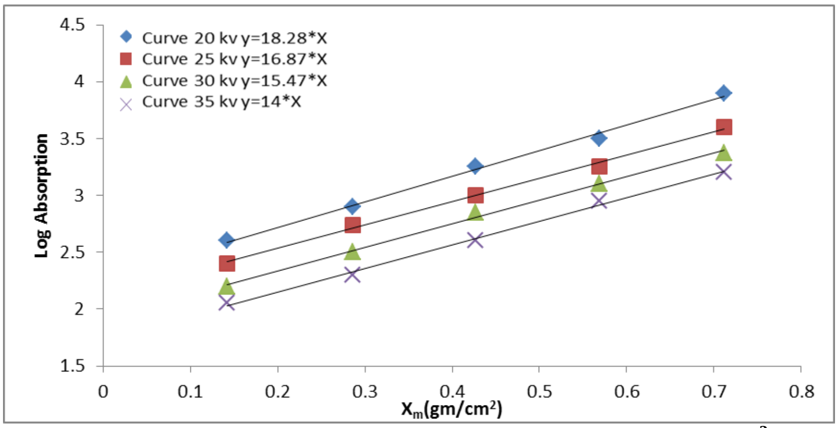


Figure 35 : The relation between Log absorption and equivalent thickness (gm/cm^2) for zinc at 100 ˚C at (6)h.

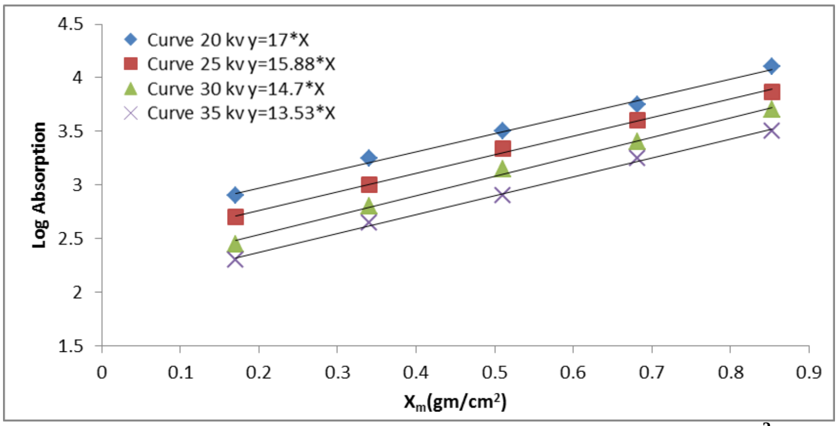


Figure 36 : The relation between Log absorption and equivalent thickness (gm/cm^2) for Alloy (A) at 100 ˚C at (6)h.

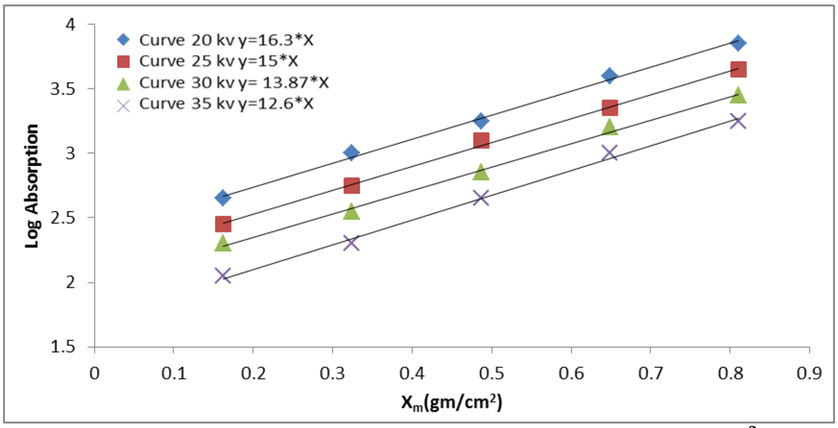


Figure 37 : The relation between Log absorption and equivalent thickness (gm/cm^2) for Alloy(B) at 100 ˚C at (6)h.

5- Discussion and Result

1. Figure (2,3,4,5) shows the analysis of the alloys brass (A) and (B) before and after the oxidation at time (1.5) hour by EDAX , it is clear from the figures the effect of oxidation on changing the shape, the shifts and the phase of the peaks while the phase of Cu and Zn will be changed by increasing the temperature to 100 °C and increasing the time period of oxidation we got the differences .
2. Figure (6-9) shows (SEM) photograph at the same magnification which indicates the decrease in grain size when the thicknesses decrease after cold working for the samples under study before oxidation while the figure (10-13) shows (SEM) photograph which indicate an occurs oxidation process for the same samples after oxidation at time (1.5) hour at temperature to 100 °C which conforms with [9] .
3. Figures (14-21) shows the X-ray diffractions for all samples after oxidations for time periods (1.5) and (6) hours it is noted that as the time period of oxidation increases the quality and the structure of the material seems to be more enhanced which are satisfying and agree with are earlier conclusions [16,17,18,19]
4. Figures (22-29) shows the relations between the logarithm of absorption versus the thicknesses and same with equivalent thicknesses by the unit of (gm/cm^2) for all samples after oxidation for the time (1.5) at (100)˚C and similar figure (30 -37) at (6) hours at (100)˚C ,all figures shows a direct and linear relations i.e. as the thicknesses and the equivalent thicknesses increases the logarithm of absorption increasing. While total attenuation coefficient are inversely related with increasing X-ray voltages .
5. The above figures shows also as the time period of oxidation increases the (μ_L) and (μ_m) increases .

6- Conclusions

1. The attenuation coefficients values (μ_L and μ_m) will be increased as the oxidation time increase , the best results were achieved for (μ_L , μ_m) at (100 ˚C) after six hours where (μ_L) for (Cu, Zn, Alloy (A) and Alloy (B) increased by ratio (7.14%, 5.76%, 8.62% 3.77%) respectively, while(μ_m) increased by (7.05%, 5.79%, 10.05%, 3.55%) respectively all result gamed are by comparing it with oxidized samples for time (1.5) hours at voltage 20 KV.
2. .The optimum temperature is (100) °C to get highest μ_L and μ_m of (X-ray) by the samples under study .
3. The μ_L for Alloy (A) at all periodic time of Oxidation are higher than any μ_L values of the remaining samples .
4. .The attenuation coefficients decreases by increasing the applied voltages .
5. Photograph (SEM) were explained the oxidation effect to the samples at temp.(100 ˚C) at (1.5) h .

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أيجاد تأثير الاكسدة على معاملات التوهين للأشعة السينية باستخدام النحاس والخارصين وسبائكهما

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الملخص

في هذا البحث تم دراسة تأثير الاكسدة على قيم معاملات التوهين الخطية (μ_L) ومعاملات التوهين الكتلية ((μ_m لنموذجي النحاس(Cu) والخارصين (Zn) واثنين من سبائكهما اذ تتكون السبيكة الاولى من (70 %Cu +30%Zn والسبيكة الثانية من(60 %Cu+40%Zn) حيث تم اختيار سمك العينات ما بين(0.02−0.1) سم. تم استخدام انبوبة الموليبدنيوم (Mo) المولدة للاشعة السينية للفولتيات (20−25−30−35) كيلو فولت. اذ تم حساب تأثير الاكسدة على معاملات التوهين (μ_L , μ_m)بوساطة العلاقات البيانية عند درجة حرارة (100) م˚ وفترات زمنية (1.5,6) ساعة. افضل النتائج التي تم الحصول عليها هي في درجة حرارة (100) م˚ عند زمن مؤكسد (6) ساعة اذا ازدادت قيم (μ_L)بالنسب (7.14%,5.76%,8.62%3.77%) بينما ازدادت قيم (3.55%,10.05%,% ,5.79% 7.05%) ((μ_m على التوالي عن قيم معاملات التوهين لنفس العينات المؤكسدة عند زمن (1.5) ساعة لنفس درجة الحرارة (100) م˚ عند الفولتية 20 كيلو فولت. وايضاً اوجدنا ان العلاقة تكون خطية طردية ما بين معاملات التوهين (μ_L , μ_m) مع زمن الاكسدة , بينما تكون العلاقة عكسية مع زيادة فرق الجهد لانبوبة الاشعة السينية. وتم ايضاً فحص تأثير الاكسدة على الشكل التركيبي للمواد تحت الدراسة وذلك باستخدام فحص كل من (SEM) المجهر الالكتروني الماسح وكذلك باستخدام فحص (XRD) جهاز حيود الاشعة السينية.

الكلمات الافتتاحية: معاملات التوهين, العناصر الانتقالية, انبوبة الاشعة السينية, المجهر الالكتروني الماسح, الاكسدة, برنامج تحليل العناصر.