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Statistical Analysis of Aluminum Doped Titanium Dioxide

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ABSTRACT

In the present research, titanium dioxide and Al nanoparticles were purchased from a Chinese company, then the aluminum materials were added in five ratios that are (0, 1, 2, 3, 5) wt.%. The dry press method was used through a hydraulic press from one direction, using a mold of diameter 10 mm to obtain a ceramic compressed dimension that was firing at a temperature of 900 °C. The thermal conductivity is studied for all samples that include pure with the added proportions and compared between them when adding the proportions for aluminum. The ratio of 2 wt.% is the highest conductivity among the used ratios. The mechanical properties included the hardness when adding percentage from aluminum toTiO_2 2 wt. % ratio showed is the highest hardness value between other ratios, the samples surface, taking surface pictures of the samples through an optical microscope.

MSC. 41A25; 41A35; 41A36

1. Introduction

Mineral elements are present in the periodic and controversy between metals and transitional minerals and are considered weak metals or minerals Post-transport. Among the advantages of these minerals are they contain a few melting points and also a few boiling points and are ductile with higher electronegativity. Metals "post-transition", including, "Aluminum (Al)", "Gallium (Ga)", "Indium (In)", "Tin (Sn)", "Thalium (TI)", "Lead (Pb)" and "Bismuth (Bi)".

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Aluminum is one of the most present elements in the Earth's crust. It is a white silver chemical component and there is no negation in nature, but it is present in soil, clay, and rocks, and also in all the Earth's water. When adding Aluminum to Titanium dioxide, a phase delay phase is shifted anatase from to the rutile by stabilizing the surface state of Titanium dioxide of molecules and preventing the molecule's growth. (Al-doped TiO2) excellent photodegradation. Titanium dioxide can be used for several applications such as electrochemical property [1], photocatalytic activity [2-4], physicochemical [5-6], and mesoporous [7, 8], for more application [9-48].

The aim of this project is to investigate the use of the dopant aluminum with the titanium dioxide nanomaterials, then study the characterization of the materials obtained. The basic contributions in this paper are enumerated as follows:

1. Preparation of Al:TiO_2 (0, 1, 2, 3 and 5) wt.%.
2. Investigate the mechanical properties (Hardness) of Al:TiO_2 (0, 1, 2, 3 and 5) wt.%.
3. Demonstrate the thermal properties of Al:TiO_2 (0, 1, 2, 3 and 5) wt.%.
4. Study the surface morphology of Al:TiO_2 (0, 1, 2, 3 and 5) wt.%.
5. Study the standard deviation of the samples.

2. Experimental work

2.1. Materials

In this section, the practical part of the project will be presented, where it deals with a description of the materials and devices used in the analysis of the measurement of samples such as thermally conductive, hardness, optical microscope images, and standard deviation of the values measurements.

The instruments have been used in the Table 1.

Table 1: Instruments used in the measurements of thin films.

No	Instrument	Model	Company
1	Thermal Conductivity	Giffia, George Ltd	UK
2	Shore-D	ISO 14577-1	UK
4	HOT-Plate+ Magnetic Stirrer	T2-HS390	UK
5	Analytical Balance	OHAUS	France
6	Hydraulic Press	XJU-145	UK

Samples were placed in the device between two temperature probes, with a temperature change measured through the thermometer placed in the device for an hour.

The amount of heat transferred through the specimen was calculated from the following equation

$$H=I\times V=\pi r^2 \quad e(T_A+T_B)+2\pi re[d_A \quad T_A+d_s \quad (1/2)(T_A+T_B)+d_B \quad T_B+d_c \quad T_C] \tag{1}$$

where: I×V: Thermal energy, which passed through the heating coil after reaching to equilibrium thermal state, I: Current (0.25 A), V: Voltage (6 V), Time (1 h), e: Temperature amount (thermal energy) passed through a unit area of disc material for each second (W\m^2.k), d_s: Thickness of the sample (mm), d_A, d_B, and d_C: thickness of the disc (A, B and C) respectively, r: disc's radius (mm), T_A, T_B, T_C: temperatures of the disc (A, B and C), respectively.

From calculated (e), (K) can be calculated as in following equation:

$K((T_A-T_B)/d_s) = e[T_A+2/r (d_A+1/4 d_s) T_A+1/(2rd_s) d_s T_B]$ (2)

K: coefficient of thermal conductivity for specimen (W\m.k).

The Shore Hardness meter was used to measure material hardness. Material hardness is defined as measuring material resistance to a permanent change in the shape when applying a force with hardness at constant pressure. Hardness is related to the soft deformation of the surface. There are mechanical properties related to hardness, such as soft strength and resistance to fatigue. Hardness testing scales are defined by ISO 14577-1.

The simplified optical wave path of a conventional optical microscope. The modern optical microscope is able to magnify an object by 1600 times with the 0.2 m limit in spatial resolution.

3. Mechanism of the work

1. The materials were mixed with ethanol of 99% purity and then placed on the magnetic mixing device to ensure homogeneity between the materials and prevent agglomeration from occurring in the material.

2. After the mixing process, the mixture is placed in a drying oven at a temperature of 60 °C, after which the grinding process is done to obtain a homogeneous powder.

3. In this step, the dry press is used using a one-way hydraulic press with a pressure of 3 tons, after forming, coal was applied to the samples to reduce oxidation and the samples were placed in the oven at a temperature of 900 °C for two hours. As for the sintering process, the temperature was raised within two hours and kept at 900 °C.

4. Results and Discussion

Table 2 shows the results obtained through the equation 1 and 2 the temperature passing through the material was measured to measure the material's ability of thermal conductivity and that the highest heat conductivity is the 3 wt. % ratio. Figure 1 shows the relationship between TiO2, the percentage of Al added to it and thermal conductivity.

Table 2: The values of the change in thermal conductivity after adding Cu (0, 1, 2, 3) wt.%.

Sample (%)	T_AºC	T_BºC	T_CºC	ds(mm)	e (W/m².ºC)	K(W/m.ºc)
Al:TiO_2-0	30	33	33	1.30	6.551291436	0.198992231
Al:TiO_2-1	30	32	32	1.90	6.531209158	0.201593831
Al:TiO_2-2	27	28	28	1.88	7.381452549	0.404967073
Al:TiO_2-3	24	27	27	1.40	7.901519939	0.101758019

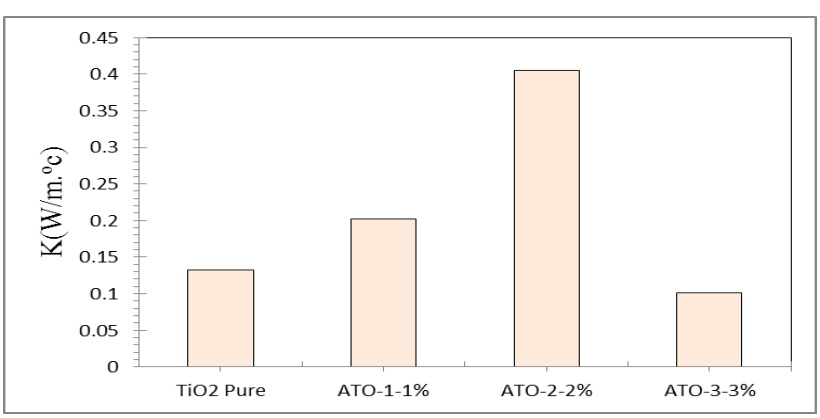

Figure 1: Thermal conductivity of Al:TiO2 after adding Al (0, 1, 2, 3) wt.% samples.

In Figure 1, the thermal conductivity property of the material and Aluminum additives is shown: it was noticed through the results that Titanium dioxide nanoparticles were less conductive of heat between the ratios used because the thermal conductivity decreases with the decrease of the material particle size. The mechanism of heat transfer by electrons was more efficient than the contribution of a phonon. The 3 wt.% ratio was considered the lowest thermal conductivity.

In the hardness test, material ability to be implemented or scratched evaluated, and it's hardness measured. Generally, the hardness is greatly improved with decreasing d. Table 3 shows the hardness results obtained within Shore during the extra hard range and the highest hardness is TiO2. Figure 2 shows the relationship between TiO2, the percentage of Al added to it and hardness.

Table 2: The values of the change in hardness after adding Al (0, 1, 2, 3) wt.%.

Samples (%)	Hardness
TiO2 pure-0	90.2
Al:TiO2-1	76.4
Al:TiO2- 2	81.3
Al:TiO2-3	77.1

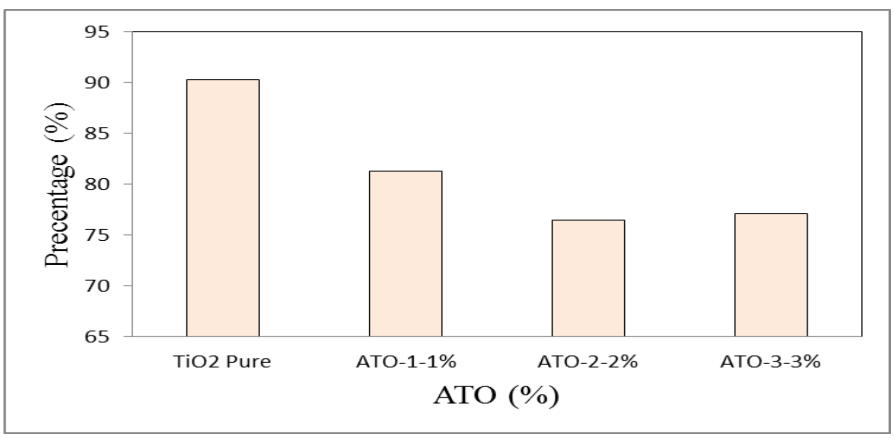

Figure 2: Hardness values of Al:TiO_2 samples.

Optical Microscope magnification power compound depends on the ocular and the objective lenses. It is equal to the product of the powers of these lenses, the final magnification is 1600X). Figure 3 show the optical microscope images of Al doped TiO2 with concentrations (0, 1, 2, 3 and 5) wt.%.

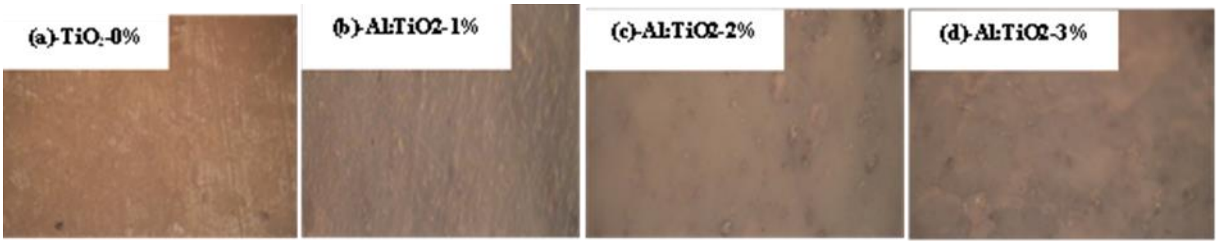

Figure 3: Surface by optical microscope to TiO2 with percentage Al (0, 1, 2 and 3 (wt.%) (1600X) respectively.

Through a light microscope, the surface of a material TiO2 pure was observed. The homogeneity of the particles with each other and that the surface did not contain cracks, when adding the proportions of Al to TiO2, note that there are Al particle that are molten and linked with TiO2 particles, which means that there is a strong bond between TiO2 and Al practical, which reduces the cracks and holes in the material.

4.1. Standard Deviation (SD)

It is common in science to report both the standard deviation of the data and the standard error of the estimate as a measure. Effects greater than two standard errors away from a null expectation are considered statistically significant and are a protection against false inference that is really due to an error in random sampling measurements. To measure the extent of statistical dispersion and the most widely used among the measures of statistical dispersion, the standard deviation of a variable was calculated from the arithmetic mean using the following relationships:

$$\bar{x} = \frac{\sum x}{N} = \frac{x1+x2+\cdots+xN}{n} = \frac{325}{4} = 81.25$$

(1)

$$\bar{x} = \frac{\sum x}{N} = \frac{x1+x2+\cdots+xN}{n} = \frac{28.36547308}{4} = 7.091368271$$

(2)

$$\bar{x} = \frac{\sum x}{N} = \frac{x1+x2+\cdots+xN}{n} = \frac{0.907311154}{4} = 0.226827789$$

(3)

where $\bar{x}$ the mean or mean, x the percentage of addition, N the number of samples prepared.

Table 4, 5 and 6 represent the SD of the values for Tables 2 and 3.

Table 4: The SD of the sample's value for Hardness measurement.

x	$x-\bar{x}$	$(x-\bar{x})^2$
90.2	8.95	80.1025
76.4	-4.85	23.5225

81.3	0.05	0.0025
77.1	-4.15	17.2225

In the latter, you write the deviation relationship as follows:

$$\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(\boldsymbol{x}-\bar{\mathbf{x}})^2} = 2.837692725$$

Table 5: The SD of the sample's value for e measurement.

x	$x - \bar{\mathbf{x}}$	$(\boldsymbol{x}-\bar{\mathbf{x}})^2$
6.551291436	0.291682987	-0.540076835
6.531209158	0.313778231	-0.560159112
7.381452549	0.084148889	0.290084279
7.901519939	0.656345726	0.810151669

In the latter, you write the deviation relationship as follows:

$$\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(\boldsymbol{x}-\bar{\mathbf{x}})^2} = 0.580076683$$

Table 6: The SD of the sample's value for k measurement.

x	$x - \bar{\mathbf{x}}$	$(\boldsymbol{x}-\bar{\mathbf{x}})^2$
0.198992231	0.000774818	-0.027835558
0.201593831	0.000636753	-0.025233958
0.404967073	0.031733605	0.178139285
0.101758019	0.015642447	-0.12506977

In the latter, you write the deviation relationship as follows:

$$\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(\boldsymbol{x}-\bar{\mathbf{x}})^2} = 0.110439602$$

5. Conclusion

After explaining the process mechanism and working on the results, they can be summarized in the conclusion

1. 1. Titanium dioxide were purchased from a Chinese company.

2. The proportions of aluminum (1, 2, 3 and 5) wt.% respectively, were added to titanium dioxide.

3. The hardness of the samples was measured and it was noticed that the pure Titanium dioxide sample has the highest hardness and that the highest hardness of the added proportions of the aluminum material is 3 wt.%.

4. The surface of the sample was observed by an optical microscope. It was observed that the metal particles were dissolved between the titanium dioxide particles, it was observed with an optical microscope at a capacity of 1600X magnification.

5. The standard deviation value for the samples measured have been calculated.

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