# Thermal Transformation of Indigenous Diaspore

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**Abstract:** Indigenous diaspore is a high density hard mineral. It becomes harder on heating up to 550$^{o}$C. The dispore has been characterized thermally by thermal gravimetric analysis and x-ray diffraction. Results show that the indigenous mineral increases its density after heating at various temperatures for 1 hour. Increase in density points out the increase in hardness due to the formation of a more crystalline compact material corundum using as abrasive.

**Keywords:** Diaspore, Corundum, TGA, XRD.

## 1. INTRODUCTION

Pakistan is one of the countries that have been naturally gifted with huge quarries of minerals. Diaspore is one of these minerals, which is found at Abbottabad in Khyber Pakhtunkhwa province in the north west of Pakistan [1]. It is found mainly with bauxite [2]. Chemically it is a mixed oxide-hydroxide of aluminum having formula AlO(OH) and is available in assorted colors (colorless, white, pale yellow, brown, pink) and varies from opaque to transparent [3]. It possesses high density and hardness and consists of an orthorhombic crystal structure [4]. It was believed that high pressure and elevated temperature is required for the natural formation of this crystalline mineral, however, it has been synthesized below 370K by hydrothermal technique using aluminum hydroxide gel and co-precipitated iron [5].

The aim of this study is to assess the effect of the thermal treatment on the indigenous diaspore. During this study the diaspore samples were analyzed before and after thermal treatment in the context to ascertain the changes in the mineral in terms of the physical properties (density and bulk density), structure (XRD), and thermal behavior (TGA). This thermal conversion of diaspore and its subsequent characterization will greatly help in finding applications of this mineral and/or its thermal products.

## 2. EXPERIMENTAL

Indigenous diaspore was received as large lumps from the quarry. A ball mill was used to grind the rock and typical particle sizes (100-230 mesh) were chosen for the study. Raw diaspore was heated at 300-600$^{o}$C in a muffle furnace to find the variation in the density and the bulk density with respect to the temperature.

Thermal gravimetric analysis (TGA) of diaspore samples was preformed on Metter-Toledo TGA analyzer TGA/SDTA851e/LF using an air flow rate of 50 mL/min. The analyzer was temperature programmed (30-700$^{o}$C at 10$^{o}$C/min for 70 minutes). X-ray diffraction (XRD) analyses were carried out using Bruker AXS D8-Advance diffractometer operated at 40 kV and 30 mA with CuKα radiations. The analysis was performed from 5-75$^{o}$ with 0.02$^{o}$ interval. Step time was 1 s per interval and temperature was 25$^{o}$C.

## 3. RESULTS AND DISCUSSION

Properties of a mineral largely depend on the composition and nature of the impurities present in it. Diaspore is primarily aluminum oxide-hydroxide and may contain other aluminum containing minerals such as bauxite, gibbsite, boehmite along with other minerals of the elements like chromium, iron, silicon, calcium, magnesium as the minor constituents [3].

### 3.1. Density and Bulk Density

Diaspore particles (100-230 mesh) were heated in a furnace at different temperatures for 1 hour to find mass loss and bulk density whereas about 2 cm diameter lumps were selected to find the density. Figure **1** shows the increase in the mass loss (ML) by increasing the temperature. Three clear segments can be seen for this parameter. This increase in ML is quite slow up to a temperature of 300$^{o}$C which could be the result of the elimination of moisture and water of crystallization. From that point and up to a temperature of 500$^{o}$C the decrease in ML has a more abrupt trend suggesting that decomposition of the mineral occurs

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mainly in this region. The third segment starts beyond 500°C and has the least increase in ML because of the near completion of the decomposition. A similar trend is present in the density of the mineral. This increase in density with respect to the rise in temperature is pointing towards the increase in the hardness. On the other hand a minute rather insignificant increase in bulk density (BD) predicts a small increase in the compactness of the resulting structure.

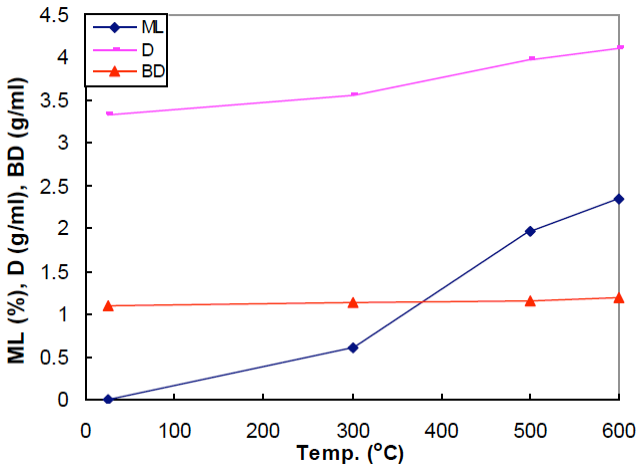


**Figure 1:** Variation in mass loss (ML), density (D) and bulk density (BD) with respect to temperature.

### 3.2. X-Ray Diffraction Analyses

X-ray diffraction (XRD) patterns of diaspore samples, before and after heating, can be seen in Figure **2**. Sample D matches with the typical pattern of diaspore [6] as it contains the characteristic peaks around 2θ = 19 (4.72 A°), 22 (3.99 A°), 28 (3.21 A°), 38 (2.35 A°), 35 (2.56 A°), 39 (2.31 A°), 42 (2.13 A°), 44 (2.07 A°), 53 (1.71 A°), 56 (1.63 A°), 61 (1.52 A°), 63 (1.48 A°), 66 (1.42 A°) and 68 (1.37 A°). XRD analysis shows that the sample contains 76.22% AlO(OH) and confirming orthorhombic crystalline system. Conversely the XRD pattern of sample C is totally different from that of sample D showing conversion of diaspore into another mineral after heat treatment. This may be corundum since its XRD pattern is closely equivalent to that of the corundum [7] as main peaks can be seen around 2θ = 25 (3.51 A°), 35 (2.55 A°), 37 (2.38 A°), 43 (2.08 A°), 52 (1.74 A°), 57 (1.60 A°), 66 (1.40 A°) and 68 (1.37 A°). Further XRD analysis predicts almost 79.93% corundum in sample C with closed pack rhombohedral system. Density and hardness of corundum are larger than that of the diaspore. And an increase in density and bulk density further endorse the XRD findings.

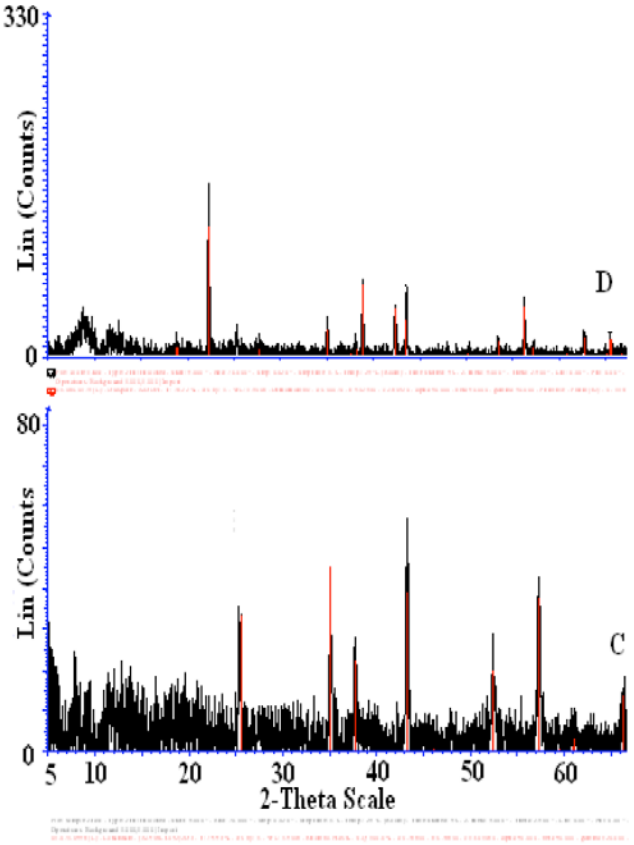


**Figure 2:** X-ray diffraction patterns of raw diaspore (D) and after heating for 1 hour at 600°C (C).

### 3.3. Thermo Gravimetric Analysis

Thermo gravimetric (TGA) profile of the diaspore sample (Figure **3**) shows a continuous mass loss from 25 to 700°C. This mass loss is very small up to 480°C. This is perhaps due to the elimination of moisture and water of crystallization that may be present with any hydrated constituent of the mineral. A steep loss in mass was observed from 480 to 550°C that persists for 7-8 minutes. Perhaps, this is the conversion period of diaspore to corundum in which dehydroxylation takes place [8]. The conversion of diaspore into corundum in this temperature range has also been reported elsewhere [9]. Decrease in mass is also small after this period. It may be due to the calcination of carbonates which may be present as small ingredient of mineral.

## CONCLUSION

Above findings prove that the under study mineral obtained from Abbottabad is diaspore having orthorhombic crystalline structure. The mineral is hard and its hardness increases with rise in temperature. Finally, it is converted into harder material corundum. This conversion starts from 480°C and completes at

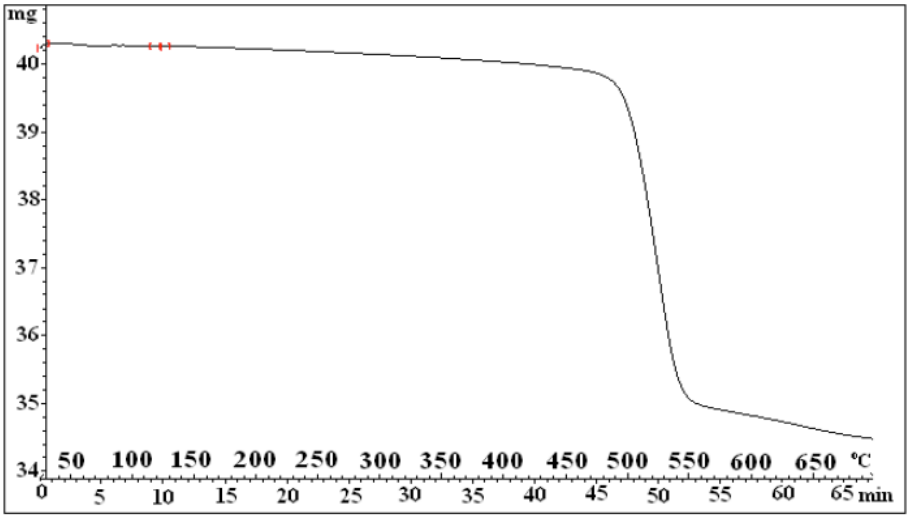


**Figure 3:** Thermal gravimetric analysis (TGA) of 100-230 mesh particles of diaspore.

550$^{o}$C. During this temperature range the mineral changes its crystalline structure and owns rhombohedral state. The corundum is world wide known as a good abrasive and used to prepare emery paper and grinding wheels.

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