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APPRAISAL OF MALAYSIAN AND NIGERIAN CRUDE KAOLIN RESOURCES FOR HEAT RESISTANCE APPLICATIONS

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ABSTRACT

At present, there has been a major increase in the development of green technologies and with the shortage of fossil energy around the globe, qualitative and quantitative improvement and effective application of natural resources are most keenly wished for, in terms of both the fundamental and industrial stands. In this study, we reported an effort towards internationalizing our endowed national resources through a comparative characterization of Malaysian (M-kaolin) and Nigerian (N-kaolin) crude kaolinite resources. The two kaolin resources hold similar crystallite structures with different thermal and pore size distribution properties, and the N-kaolin is containing a visible trace of Illite which presumably influenced the crystallinity of the crude kaolin. Thus, N-kaolin is highly promising for refractory applications.

Keywords: Kaolinite, Heat-resistance, Malaysia, Nigeria

INTRODUCTION

Discussion on the effective utilization of natural resources has debated on the issues of sustainability and economic viability within the context of national development. A global understanding of this phenomenon is centered on how these available natural resources can be developed into either suitable raw material for industrial, or further exploited for revenue generation for sustaining the nation's economic growth and development. This is based on the reality that Industrialization has proven to be the apparatus that promotes the economic growth and development of a nation. While the available natural resources and technology play the role of enablers, human and material resources drive and fuel the industrialization process (Alumona & Onwuanabile, 2019).

Miraculously, the global distribution of mineral resources was uneven among countries, giving birth to the reason why some nations appeared to be more richly endowed in resources than others. However, researchers such as (Abdullahi & Abdullah, 2015; Schilling & Chiang, 2011) argued that the presence of these resources does not translate into economic growth and development. This implies that these endowed natural resources need to be discovered and studied, and subsequently be developed and enriched for industrial consumption. As a result of that, nations with adequate deposits of natural resources are now keen on turning these resources for

industrialization or revenue generation (Zaidi et al., 2019). For the first time in a decade, the Nigerian government launched a campaign to expand the production, processing, and high-value industrial utilization of indigenous agricultural products and underutilized mineral resources. This research study is particularly concerned with non-metallic mineral and specifically interested in kaolin mineral resources.

Kaolin clay has been identified in abundance in parts of Malaysia (Abdullah, Zulkefli, Aziz, & Mat, 2016), and Nigeria (Abiodun, Sadiq, Adeosun, & Oyekan, 2019); it is used for ceramic manufacturing, paint, rubber, plastic, chemical industries and most especially in paper making industries. Our previous studies (Abdullahi et al., 2019) have identified much about the potentials of the Malaysian kaolinite therefore, a comparative investigation with the Nigerian indigenous kaolinite for heat resistance application will lead to internalization of our local kaolin deposit. Therefore, this study is important for adding value and for the commercial development of indigenous natural resources.

MATERIALS AND METHOD

The crude kaolin was obtained at a location where commercial mining activities were taking place in Sedeli Forest, about 36 kilometers along Jalan Kota Tinggi-Mersing, Kota Tinggi, Johor, Malaysia and at Alkaleri, 65km along Gombe-Bauchi road Bauchi, Nigeria. The kaolin lumps were ground into a fine powder, sieved according to ASTM E11-500, and kept in the oven overnight before use to remove any trace of moisture in it completely. Particle sizes analysis of the kaolin powder as shown in Fig. 1, was conducted according to Analysette 22 techniques.

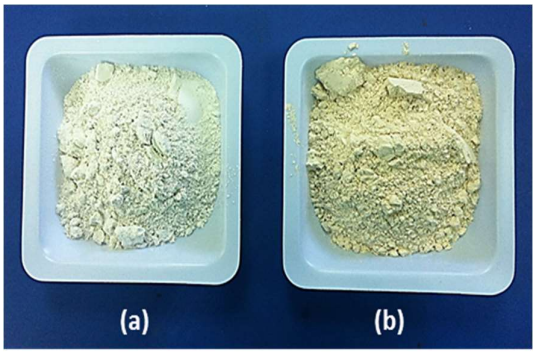

Figure 1: Pictorial view of (a) M-kaolin powder, (b) N-kaolin powder

After the preliminary preparation of the kaolin samples, the characterization tests were conducted to evaluate the integrity of the material. The quantification of the chemical composition was achieved via X-ray fluorescence (XRF) test of all clay deposits. While the mineralogical and the crystalline phases in each of the kaolin samples were analyzed using X-ray Diffractometer (XRD) and Scanning Electron Microscope (SEM).

RESULTS AND DISCUSSION

The result of the particle size distribution for M-Kaolin and N-Kaolin samples is illustrated in Fig. 2. A unimodal distribution was observed on both M-Kaolin and N-Kaolin. It is widely known that, the higher particle size distribution of kaolin results in less packing structure (Olalere, Yaru, & Dahunsi, 2019). The size ranges of M-Kaolin and N-Kaolin were found to be from 700 to 2000 nm and 950 to 2700 nm, respectively. The wide range of particle size of MK is presumably due to the presence of mixed oxides which composed of kaolinite and some impurities.

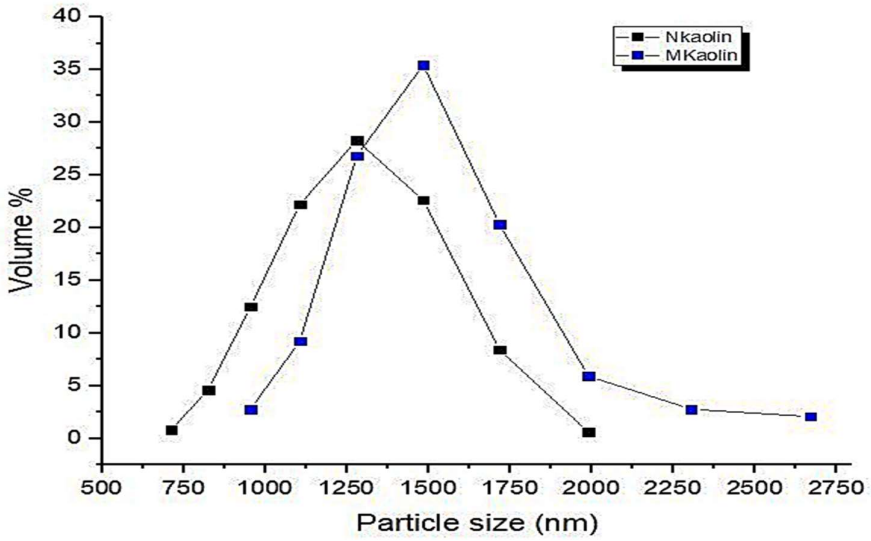

Figure 2: Particle size distribution of the two-kaolin sample

The results obtained after quantifying the elemental composition of the two crude kaolin as presented in Table 1 shows that the M-kaolin contains exchangeable cations that are found in Fe_2O_3, K_2O, and CaO in higher quantity compared to N-kaolin. These were referred here as the accompanied impurities originating from the geological history of the primary kaolinites formation of the Malaysian kaolin deposit. Such impurities according to Mokwa, Lawal, Abolarin, and Bala (2019) affect the stability of the aluminosilicate phases during sintering. And can be able to positively influence the desalination ability of the crude kaolin. This suggests that further beneficiation is highly recommended for the M-kaolin for managing the impurities.

Table 1: Elemental composition of the two-crude kaolin

Constituent	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	K_2O
M-kaolin	40.33	55.21	1.80	0.20	0.40	2.72
N-kaolin	56.76	41.97	0.60	0.00	0.00	0.40

The major phase of kaolinite is observed with minor quartz from the XRD result presented in Fig. 3. The diffraction pattern of the two evaluated samples perfectly matched with KAOLINITE JCPDS no. 01-089-6538 database. Accordingly, both the crude kaolins have adequate representation of kaolinite mineral at 12.5° and 26.2° of 2θ position and a visible phase of quartz, which appeared at 21.11° and 27.03°. Although the intensity of kaolinite is found to be higher for M-kaolin, it suggests indicating the presence of high aluminosilicate content in the Malaysian kaolin deposit. Also, the patterns are consistent with earlier literature (Zhu, Jiang, & Xiao, 2010). However, there is a visible trace of illite at 22.12° 2θ position on the N-kaolin diffraction pattern, highlighting the cause for the high crystallinity and the short range of particle size distribution of N-Kaolin as shown in Fig 2.

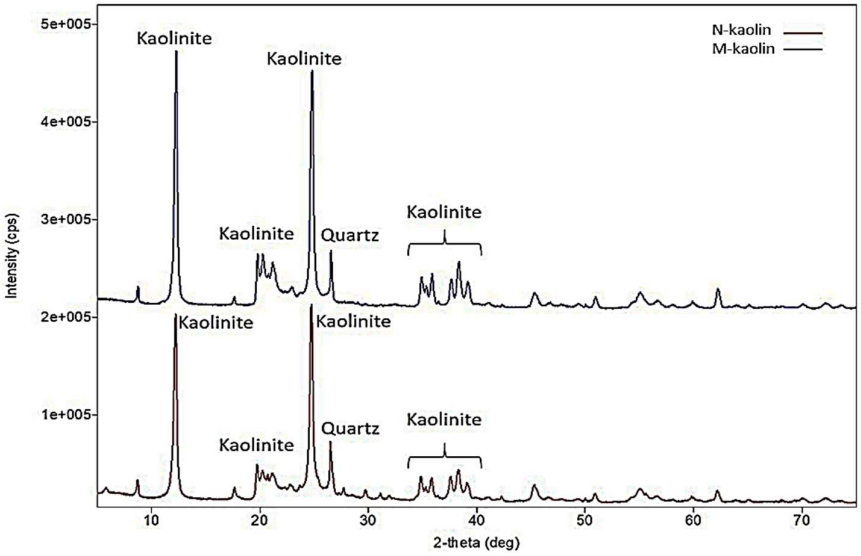

Figure 3: X-ray Diffractograms of the crude kaolin samples.

In order to certify the suitability of the kaolin samples for refractory and high temperature application, the Thermogravimetric analysis was performed on the two kaolin samples toward recognizing their thermal stability. Fig. 4 illustrate the results obtained.

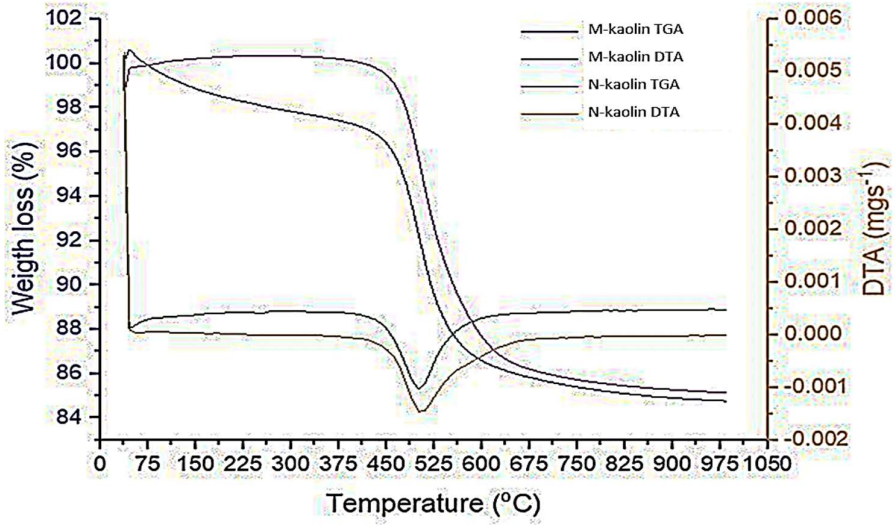

Figure 4: TGA and DTA of the two kaolin samples

As shown in the thermograph, M-kaolin exhibits a higher weight loss for about 16% more than N-kaolin, due to the presence of other impurities associated with the naturally sourced kaolin deposit. At 450 °C, there is visible decomposition and loss of the water of crystallization for both two samples. However, the TGA of M-kaolin indicated a rapid stage of dihydroxylation of the kaolinite as a result of the structural loss of the hydroxyl group present in the kaolinite layers, in accordance with Abiodun et al. (2019). This result also coincides with DTA endothermic peak at

510 °C for both samples, an indication that the kaolinite mineral begins to decompose thereby forming free alumina, silica, and water. A further event that might lead to exothermic reaction is bound to happen as the heating temperature increases, but this work is delimited to 1000 °C. thus, suggesting the ability of N-kaolin to withstand more temperature change than M-kaolin.

CONCLUSION

This paper reported a successful comparative study of a crude kaolin from Malaysia and Nigeria, both crude kaolins have adequate representation of kaolinite mineral and quartz, with a visible phase of Illite in N-kaolin. Overall, the two crude kaolin samples have a similar crystalline structure with different pore size distribution properties. It can be observed from the results that the thermal properties of the two-country kaolin are alike at the studied temperatures. Nonetheless, M-kaolin showed a rapid stage of dehydroxylation of the kaolinite as a result of the structural loss of the hydroxyl group present in the kaolinite layers due to the wider distribution of particle size, which allows the formation of ordered pores. It indicates that the N-kaolin has good potential for refractory application, which can be improved with further studies.

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