Extraction of Aluminum Oxide from Kaolinite

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Introduction

The focus of this research is to use the Lime-Sinter process to extract aluminum oxide from food-grade kaolinite. The Lime-Sinter process is superior to the Bayer process because it can isolate the silica from the aluminum oxide present in the sample. In the Bayer process, the presence of silica in the ore severely reduces the amount of aluminum oxide that can be obtained. This eliminates most aluminum containing ores leaving only low silica bauxites available for extraction with the Bayer process. The Lime-Sinter process has no such difficulty because adding lime allows for the formation of calcium-silicates and calcium aluminates. The aluminates can then be separated from everything else via the introduction of sodium ions in the form of soda ash. However, the introduction of sodium ions creates a sodium contamination problem that can only be eliminated by washing the product with acid. The Lime-Sinter process and its XRD results after 1200 C calcination for samples with and without the acid wash step are laid out here.

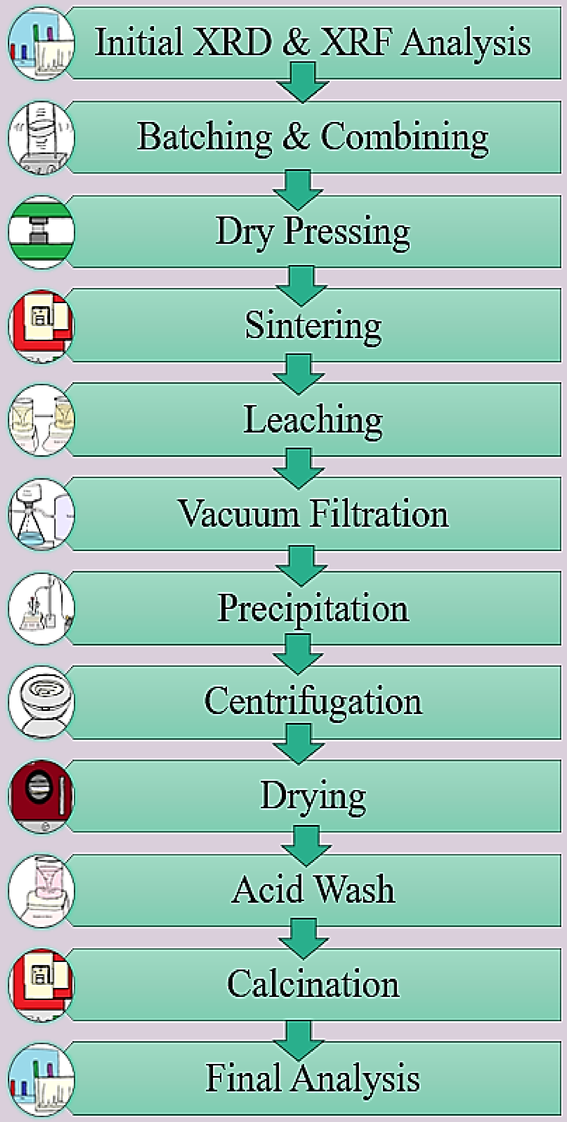
Important Chemical Equations for the Lime-Sinter Process:

$$12CaCO_3(s)+7Al_2O_3(s) \rightarrow 12CaO\cdot 7Al_2O_3(s)+CO_2(g)$$

$$12CaO\cdot 7Al_2O_3(s)+12\,Na_2CO_3(aq)+5\,H_2O(l) \rightarrow 14NaAlO_2(aq)+12CaCO_3(s)+10\,NaOH(aq)$$

Methodology

The Lime-Sinter process combines kaolinite and lime, then heats it at 1360O C, leaches it with Na_2CO_3, and filters out the resulting Calcium-Silicate slurry from the solution. This leaves behind a $NaAlO_2$ solution that when mixed with CO_2 gas reduces the $NaAlO_2$ while simultaneously lowering the pH and leaving behind a gibbsite precipitate. Filtering and washing the precipitate in glacial acetic acid ensures that the precipitate is gibbsite, which can then be analyzed using XRD and XRF in order to verify identification of the substance and determine purity. The following flowchart illustrates this process:



Results

XRD of the calcined products were taken using a Panalytical X'Pert Pro. The results revealed that certain alterations can be made to the process in order to ensure different products. Washing the precipitate in glacial acetic acid and then calcining at 1200°C results in corundum (Aluminum Oxide). Not washing with glacial acetic acid results in a mixture of beta-alumina and diaoyudaoite.. How well the data fits the references patterns used for the determination of the products is signified by the carats above each peak.

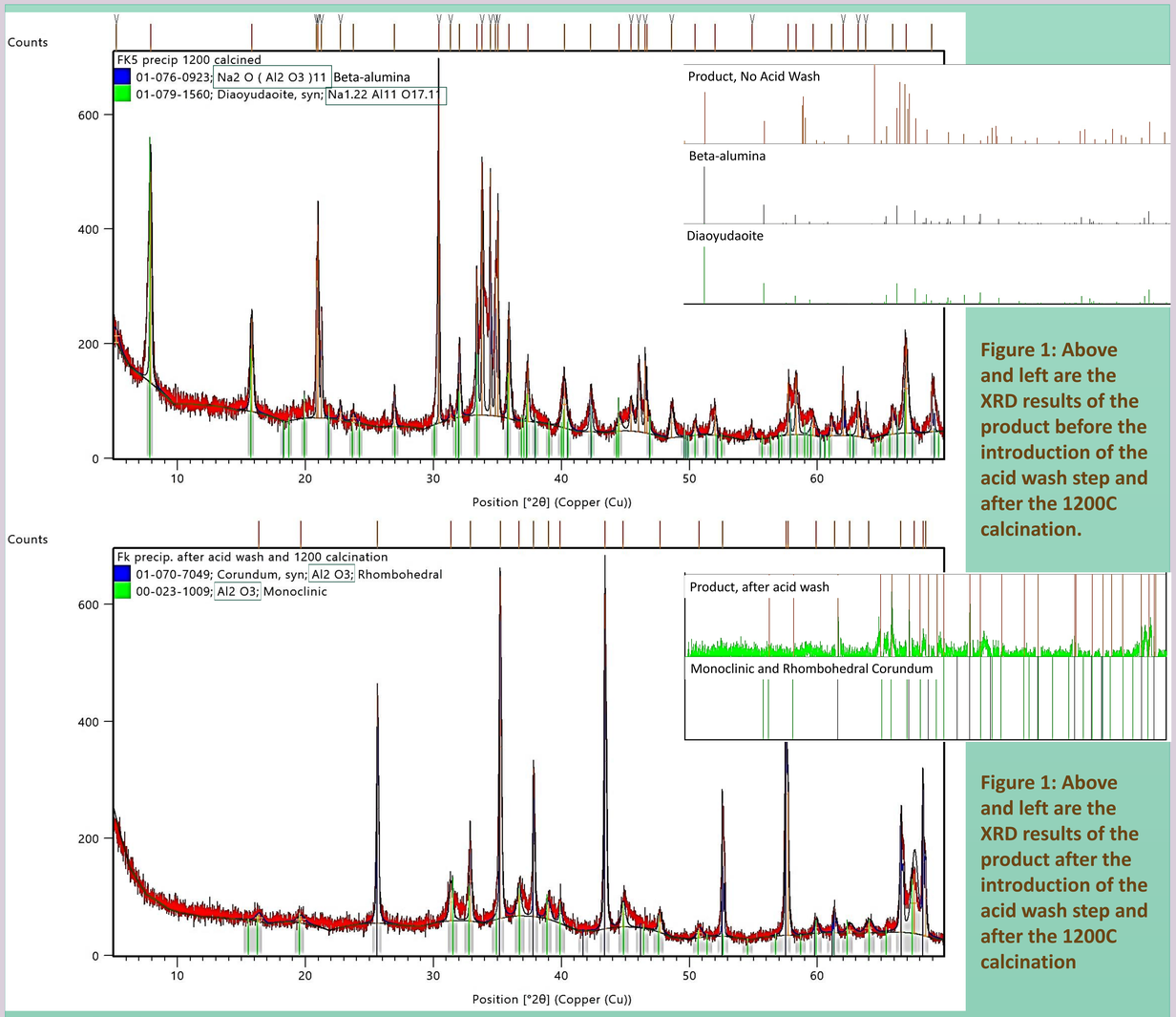


Figure 1: Above and left are the XRD results of the product before the introduction of the acid wash step and after the 1200C calcination.

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Conclusion

The Lime-Sinter process has proven highly effective at extracting aluminum oxide from aluminum ores high in silica (including kaolinite), and the acid wash step has proven effective at purifying the product so that it is aluminum oxide.

Future Work

The next stage of the research is to run the extraction process on samples gathered from around New Mexico. These samples were all gathered from sites that have been mined or are of interest for mining, as such they are all road accessible.

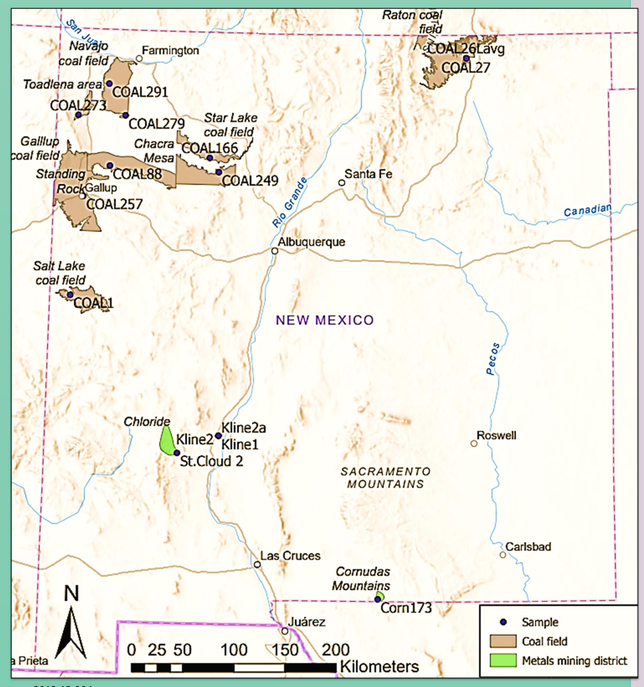

Figure 3: Map of Sample and mine locations.

Acknowledgments

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Park, N.-K., Choi, H.-Y., Kim, D.-H., Lee, T. J., Kang, M., Lee, W. G., ... Park, J. W. (2013). Purification of Al(OH)3 synthesized by Bayer process for preparation of high purity alumina as sapphire raw material. Journal of Crystal Growth, 373, 88–91. doi:10.1016/j.jcrysgro.2012.12.004 0.1016/j.jcrysgro.2012.12.004

ElDeeb, A.B., et al. "Extraction of Alumina from Kaolin by a Combination of Pyro- and Hydro-Metallurgical Processes." Applied Clay Science, vol. 172, 2019, pp. 146–154., https://doi.org/10.1016/j.clay.2019.03.008.

Séailles, J. C., & Dyckerhoff, W. R. G. (1941, July 8). RECOVERY OF ALUMINA .

Initial XRD & XRF Analysis

Batching & Combining

Dry Pressing

Sintering

Leaching

Vacuum Filtration

Precipitation

Centrifugation

Drying

Acid Wash

Calcination

Final Analysis