

OVERVIEW OF THE AVAILABILITY AND UTILIZATION OF KAOLIN AS A POTENTIAL RAW MATERIAL IN CHEMICALS & DRUGS FORMULATION IN NIGERIA

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ABSTRACT

This paper reviews the potentials of Kaolin as an essential natural occurring mineral raw material employed in the formulation of chemicals, drugs and other medicinal applications. The Occurrence and distributions of the Kaolin in the various places within the country are clearly enumerated. The quality specifications of kaolin for various industrial applications in Nigeria are also outlined with emphasis on the quality specification for some chemicals and pharmaceuticals use. The paper also presents the major kaolin processing methods employed in Nigeria. The methodology employed involves consulting well research materials by relevant government agencies, stakeholders in the country and other related materials from other sources. The roles of stakeholders in promoting the utilization of kaolin in chemical and pharmaceutical applications are also clearly outlined. The work intends to expose researchers, chemists, pharmacists and pharmaceutical industries to the availability of kaolin and benefits that could be derived from optimally utilizing same in chemicals and drugs formulation as against the practice of importing the processed kaolin for such purposes.

KEYWORDS: Availability, Utilization, kaolin, Drugs, Chemicals, Raw Materials.

INTRODUCTION

The chemically inert nature of Kaolin (Anderson, 1997) has made it to be a versatile industrial mineral with wide application in the formulation of many products in the cosmetic, pulp & paper, agro allied, chalk, paints and pharmaceutical industries. In recent time, the cosmetic and pharmaceutical industries have shown a high apathy for the utilization of kaolin in their products formulations. The inability of the locally sourced kaolin to meet the quality specification of cosmetics and pharmaceutical industries has resulted in the importation of a large quantity of processed kaolin on a continuous basis (RMRDC, 2003). This development however, is not good for Nigeria with a proven reserve of 7million tonnes of various grades of kaolin needed for any industrial purpose.

Medically, kaolin is used as adsorbent and has also being found to have tremendous use in anti-diarrhoea formulations. It is sometimes used in combination with pectin: a polygalactonic acid extracted from the pulp residues of citrus fruits. Conservatively about 500MT of kaolin is required for the formulation of anti-diarrhoea mixture alone in Nigeria (RMRDC, 2003). That is aside the quantity requirement for the formulation of other drugs.

This work intended to bring to the notice of researchers, pharmacists, chemicals and pharmaceutical industries the availability of kaolin and benefits that could be derived from optimally utilizing the locally sourced kaolin in drug formulation as against the practice of importing it.

SOURCE, CHEMISTRY & PHYSICAL PROPERTIES

Kaolin is a weathering product of silicate rock naturally occurring hydrated aluminium silicate which is white, yellowish-white, earthy, nonporous and odourless to dull material having a plastic touch and slightly oily feel. It is also almost tasteless and practically insoluble in water (RMRDC MTF Survey, 2003; Mikota, 2006). The approximate chemical formula of kaolin is $Al_4Si_4O_{10}(OH)_8$. It has the median particle size range of commercial products varying between 0.1-10microns. The hydrophilic surface of kaolin allows it to be easily dispersed in water at neutral pH of 6-8. The other common physical properties of kaolin are; platy shape, high brightness (80-95). specific gravity (2.58-2.63), refractive index (1.56-1.62) and mohs hardness of 2-3 (Anderson, 1997).

The most preferred kaolin for pharmaceutical formulations is the finely divided particles because they yield a very large surface area that adsorbs a wide variety of compounds. The bulk of kaolin in the country is either of sedimentary or residual origin. The characteristics chemical composition of kaolin deposit often determines its industrial utilization.

The ability of kaolin to enhance citric acid production by *Aspergillus niger*, a thermophilic fungus, has been studied in which the aqueous suspensions of kaolin were added to the fungus medium in concentration of 5-25 ppm. A maximum yield of citric acid (74.62g/l) occurred within 96 hours after the production phase when using the 15ppm aqueous suspension. Kaolin is effective in improving citric acid concentration because of its ability to adsorb metal cations in the medium. These results in increase activity of citrate synthase; an enzyme essential for the production of citric acid (Ali, 2006). Kaolin/Pectin is reported to be incomparable with alkalis, heavy metals, salicylic acid, tannic acid or strong alkali (Mikota, 2006). In a study on the multifunctional micro-sized modified kaolin and its application in wastewater treatment, it was discovered and further suggested that the addition of kaolin to oil field wastewater can result in the removal of chemical oxygen demand (COD), removal of scaling iron such as; iron, calcium and magnesium, improvement in membrane filter index, bacteriocidal and inhibition of corrosion (Ma *et al*, 2006).

Due to the fact that kaolin is highly insoluble and not absorbed systematically, it is generally believed to be associated with severe toxicity. Hence, inhalation of nonferrous silicate compounds like kaolin expose miners to risk of pulmonary diseases (Samaik *et al*, 1993).

HISTORY OF KAOLIN AS DRUG INGREDIENT

Kaolin has been employed to adsorb toxic substances from the alimentary canal and in the treatment of diarrhoea associated with food poisoning (Raynold, 1992). It is used in pharmaceutical preparations as a filtering agent; it also serves as an emollient and drying agent when ingested. It is found to act as adsorbent. Kaolin has been added to dusting powder and is used as a tablet excipient and utilized variety of automated laboratory chemistry test, including the determination of activated clothing time-act (Huyzen, 1994) and in the serodiagnosis of tuberculosis using the kaolin agglutination (Samaik *et al*, 1993). In the animal medicine kaolin/peptin has been reported to be used primarily in veterinary medicine as an oral anti-diarrheal agent. It is also used as an adsorbent agent following the ingestion of toxins (Mikato *et al*, 2006).

THE RESOURCE POTENTIAL OF KAOLIN IN NIGERIA

Table1: Kaolinitic Clay Deposits in Nigeria

Region	State (Location)	Reserve (Million Tonnes)
North	Kaduna (Mararaban-Rido)	5.5
	Katsina (Kankara, Safana, Malumfashi, Musawa, Faskari, Ingawa, Dushin-Ma, Bakori)	Very large
	Kebbi (Illo, Kaoje)	Very large
	Plateau (Major Portar, Nahuta)	8.0
	Borno (Maiduguri)	Large
	Kwara (Lafiagi)	Large
	Bauchi (Darazo, Jagalwa)	18.0
	Benue (Apa, Iga Okpava, Okpaga)	10.0
	Niger (Gubaji, Gbako)	Very large
South	Anambra (Ogubulu)	4.2
	Enugu (Enugu)	50
	Oyo (Tede)	1.5
	Ogun (Onibode, Ibamaje, Miroko)	Large

Source: RMRDC MCTS Survey Report, (2003); NMC (2003)

Nigerian Kaolin is known to have purity as high as 90% and an estimated reserve of three (3) billion metric tonnes distributed in various parts of the country where it is found (MSMD, undated). It is known to be located in large quantity (Table 1) at Katsina, Plateau, Bauchi, Ogun, Ondo, Niger, Oyo, Kwara, Benue, Enugu and Ekiti States of the country (RMRDC-TB, 2004). The Katsina kaolin deposit is adjudged the best for pharmaceutical and drug applications because it has a characteristic chemical composition that fits that purpose. For a wide range of industrial application, it is estimated that the annual national demand for kaolin is over 350,000 tones. However, local

production is estimated at about 25,000tonnes only, indicating just about 7.1% of the annual national demand. The pharmaceutical subsector alone has a national demand of 128.8MT of kaolin but the average capacity utilisation of the subsector alone is put at 33.3 metric tonne/annum between 2000-2003 (RMRDC MCTS Survey, 2003). This goes a long way to give the indication that there is a gross under utilization of the viable product in the chemical and pharmaceutical subsector, bulk of which is imported.

QUALITY SPECIFICATIONS OF KAOLIN

Every industry that uses kaolin as an ingredient for the formulation of any of its products, has a set standard and specification to meet the quality standard of such products. Table 2 is products quality specifications for Pharmaceutical, Steel, Coating agent and as filling agent.

Table 2: Product Specification for Kaolin Selected Industries in Nigeria

Chemical	Pharmaceuticals (%)	Ceramics (%)	Filling Agent (%)	Coating Agent (%)	Steel (%)
SiO ₂	48.00	48.00	48.70	47.80	5.00
Al ₂ O ₃	36.00	37.00	36.00	37.00	0.002
Fe ₂ O ₃	0.10	0.60	0.82	0.58	0.002
TiO ₂	0.02	0.30	0.05	0.03	-
CaO	0.01	0.10	0.60	0.40	54.28
MgO	0.20	0.30	0.25	0.16	3.00
K ₂ O	1.10	1.60	2.10	0.10	-
Na ₂ O	0.10	0.10	0.10	0.10	-
LOI	11.90	12.40	11.90	13.10	-

Source: RMRDC MCTS Survey Report, 2003.

The slightly low percentage of 0.10 and 0.02 for Fe₂O₃ and TiO₂ respectively for pharmaceutical industries when compare with the percentage for ceramics coating and filling agent gives the uniqueness in the quality specification of kaolin required in the pharmaceutical industries. Other unique specifications of pharmaceutical is the low percentage of CaO (0.01), MgO (0.20) when compared with the percentage composition of similar oxides in other products (Ceramics, Filling agents, Coating agents and Steel).

PROCESSING TECHNIQUES

Two major processing techniques are employed in kaolin which are; Wet and dry method. The processing techniques employed plays a very significant role in what the kaolin product will be used for. In pharmaceutical uses high degree of purity is required in the processing, that informs why the processing units for pharmaceutical grade kaolin is made from Stainless still in a very clean and hygienic environment free from any microbial interference and the Wet processing method is often employed for such purposes.

Wet Processing

In this method the raw kaolin lumps are crushed and mixed with water to form slurry. Some chemicals like diatomite could then be added to decolorize the clay. The slurry is pumped into a vibrator screen to remove all forms of impurities. The water separated by pumping the slurry into a filter press. The product is dried, pulverized, milled and classified. The resulting product may be processed further to improve properties such as brightness, dispensability, electrical and water resistance properties etc. The final product is then packaged appropriately based on the industrial specification for the kaolin output (Fig 1).

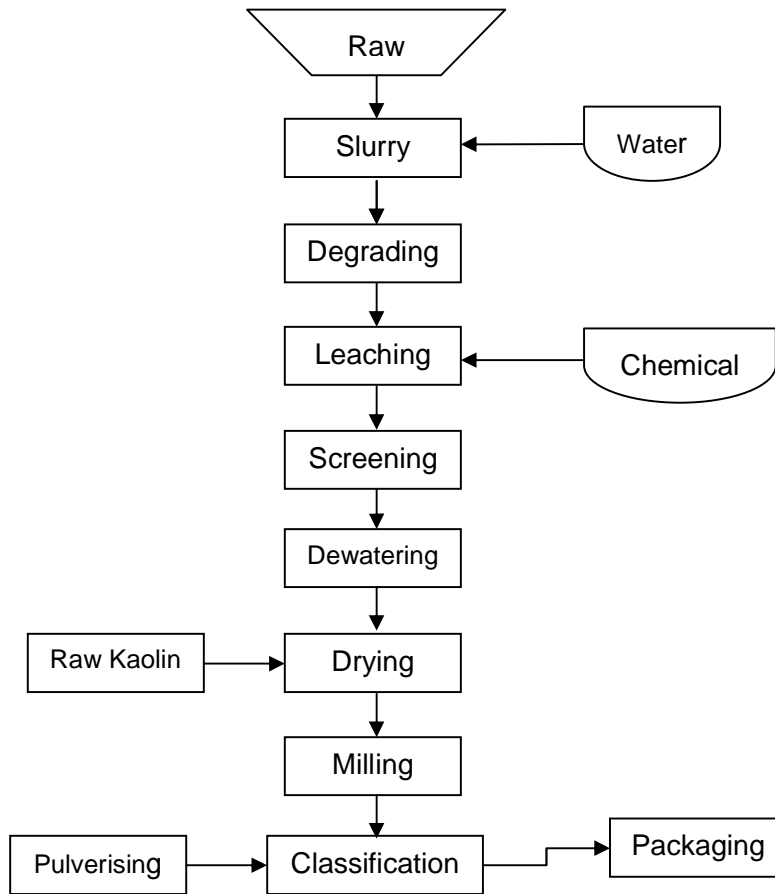


Fig 1: Flow Chart for the Wet Processing of Kaolin

Dry Processing

This is the easiest and simplest processing method in which the raw kaolin is directly fed into the crusher. The crushed kaolin is then milled and passed through classifier and blower before finally passing through cyclone for grain size classification and storage (Fig 2). In Nigeria, over 90% of the kaolin industries use this method owing to the less cumbersome processing method.

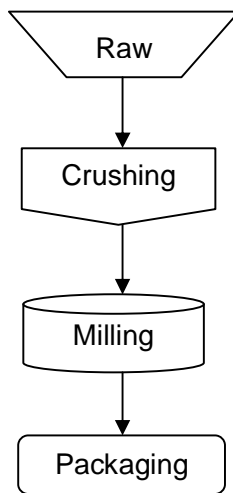


Fig 2: Flow Chart of Dry Processing of Kaolin

MEDICINAL APPLICATIONS OF KAOLIN

As an Adsorbent

Kaolin has long been employed to adsorb toxic substances from the alimentary canal and in the treatment of diarrhoea in which it binds GI toxins and controls diarrhoea associated with food poisoning (Reynolds, 1989). It is widely known as adsorbent and has lubricant property in powders and therefore used as a lubricant in tablet formulations (Onyekweli *et al*, 2003).

As an Excipient

Kaolin is used as an excipient in personal care products, for example, Thalasso therapy (bath skin treatments) and cosmetics (EKA, 2009).

As a Filtering Agent

It is used in pharmaceutical preparations as a filtering agent to clarify liquids used for drug formulations.

As an Emollient

When applied topically, kaolin is found to serve as a good emollient and drying agent.

As a Filler

Kaolin is found to be used in many pharmaceutical tablets as an inert filler or carrier for active ingredients. In recent times kaolin is used for casting the body bony parts (teeth, bones).

ROLE OF STAKEHOLDERS

The stakeholders identified in kaolin project for chemicals, pharmaceuticals and other medicinal applications are; government agencies like RMRDC, MSMD, relevant professional bodies like NMGS, CSN, NAPA, Kaolin

Processing and Pharmaceutical Industries: The following are enumerated as the roles these bodies will play.

- The effort of the government through the RMRDC in identifying and setting a catalytic model plant for processing of pharmaceutical grade kaolin in Kankara, Katsina State is commended and should not just end at the policy level.
- The professional bodies should work as a team toward harnessing, researching and developing the pharmaceutical grade kaolin not only for use in the country but export as well.
- Chemicals and Pharmaceutical industries should encourage the processing industries by utilizing their processed product for their formulations.
- From the literature there are varying opinions on the toxicity of kaolin, this calls for more thorough research on this toxicity of kaolin from various deposits in Nigeria with a view to ascertaining the authenticity of either of the schools of thought.

REFERENCES

- Ali, S. (2006). Application of Kaolin to Improve Citric Acid Production by a Thermophilic *Aspergillus Niger*. *Appl. Microbiol. Biotechnol.* 73 (4): 755-762.
- Anderson, J. L. (1997). Pesticide Tolerance Petition Filing. Environmental Protection Agency (EPA) (www://pmep.cce.cornell.edu/profiles/misc_E_N/kaolin/kaolin_pet_0197.html)
- Harben, P. W. (1995). The Industrial Minerals Handbook. Second Edition. Pp 22-50
- Huyzen, R. J., Harder, M. P., Huet, R. C., Boonstra, P. W., Brenken, U., Van-Deveren, W. (1994). Alternative Perioperative Anticoagulation monitored during Cardiopulmonary bypass in Aprotinin-Treated Patients. *J. Cardiothorac Vasc. Anesth.* 8(2): 153-156.
- Ma, H. Z. And Wang, B. (2006). Multifunctional Microsize Modified Kaolin and its Application in Waste Water Treatment. *J. Hazard. Mater.* 136 (2): 365-370.

Mikota, S. K. and Plum, D. C. (2006). The elephant Formulary. Elephants Care International (www.elephantcare.org/Drugs/Kaolin.htm)

Ministry of Solid Minerals Development (undated). *In*: Okpanachi, U. M. (2004). The Economics of Solid Minerals Development. A paper presented at a seminar on Solid Minerals Exploration and Exportation at The Hill Station Hotel Jos, Organised by The Nigerian Shippers' Council on 22nd July, 2004.

Nigeria Mining Corporation (NMC) Jos (2004). An Awareness Leaflet.

Onyekweli, A. O., Usifoh, C. O., Okunrobo, L. O. and Zuofa, J. D. (2003). Adsorptive Property of Kaolin in Some Drug Formulation. *Trop. J. Pharm. Res.* 2 (1): 156-158.

Ogezi, A. E. (1985). Mineral Raw Materials and Nigerian Industry. *Postgraduate Open Lecture Series*, 7(2):18-21.
RMRDC Opportunity Magazine (2004). Kaolin: A Versatile Industrial Mineral. Pp6-7

Raw Materials Research and Development Council (RMRDC) Multidisciplinary Committee Techno-Economic Survey (MCTS) Report (2004). Non Metallic Mineral Sector. 4th Update. Pp. 68-69.

Raw Materials Research and Development Council (RMRDC) Multidisciplinary Committee Techno-Economic Survey (MCTS) Report (2003). Chemicals and Pharmaceutical Sector. 4th Update. Pp. 16-69, 102.

RMRDC (2003). Investment Profiles for Nigeria. Volume 2. (Revised Edition). Pp 73-74.

Raw Materials Update Magazine (2000). Kaolin: A versatile Non-Metallic Mineral. September Edition. Pp. 25-26.

RMRDC Technical Brief (TB) on Minerals in Nigeria (2004):. Kaolin. No1 pp. 6, 7, 8, 21.

Reynolds, J. E. F. (1989). Martindale. The Extra Pharmacopoeia, London Pharmaceutical Press. Pp 1092.

Samaik, R.M., Sharma, M., Kate, S. K. (1993). Serodiagnosis. Assessment of Kaolin Agglutination Test. *Tuber Lung Dis.* 74 (6): 405-406.

The European Kaolin Association-EKA (2009). Kaolin. (www.ima-eu.org/eka.html).

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