Development of Zeolite Y from Arobieye Mined Kaolin

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***Abstract*- Zeolite Y was synthesized from Arobieye mined kaolin in Ota, Ogun state Nigeria through metakaolinization and zeolitization. The thermal activation of kaolin was achieved through the process of metakaolinization while zeolitization involved alkaline attack of thermally activated amorphous kaolin (metakaolin) and its transformation into Zeolite Y crystal. Silica/Alumina molar ratio of 5.84 of dealuminated metakaolin was synthesized under hydrothermal treatment with aqeous NaOH at atmospheric pressure after 7 days aging at room temperature, and hydrothermally crystallized at 100^{o}C for 24 hours. Zeolite NaY with Si/Al molar ratio of 3.46 was achieved and then modified to its hydrogen form by ion exchange with NH_4Cl. The molar ratio of Zeolite Y in hydrogen form is 3.22. The sample was characterized by Scanning Electron Microscope (SEM) which gives Zeolite Y Structure.**

Keyword- Arobieye mined kaolin, Zeolite Y, Crystallization, Hydrothermal Reaction

I. INTRODUCTION

Zeolites are crystalline aluminosilicates with fully cross-linked open framework structures made up of corner-sharing SiO_4 and AlO_4 tetrahedra. Its crystalline minerals composed primarily of silica and alumina with a microporous (having pore sizes below 2nm) structure, have been used in many applications in research and industry. It costs over 5 Billion Naira annually to import zeolite used in our refinery [1]. The production of zeolite from clay as a source of silica and alumina has been investigated with positive achievement [2-3]. The benefits of using kaolin as an aluminosilicate source in zeolite production are widely known [4]. The minerals have huge industrial, scientific and academic interest in the areas of ion exchange, petroleum refining and separation.

II. METHODOLOGY

Arobieye clay was thoroughly purified by a clay-split method. The purified kaolin was calcined to metakaolin at 850^{o}c for 6 hours [5]. The metakaolin was dealuminated by using 98% sulphric acid. Novel method of dealumination was used in this research work. Sodium hydroxide pellets (Sigma-Aldrich, Lobal Chemie, ≥98%) was reacted with dealuminated metakaolin in a ratio of 2.5: 1 by weight and molar composition of $6SiO_2$: Al_2O_3: $9Na_2O$: $24H_2O$ [5]. The gel obtained was aged for 7 days at room temperature and then hydrothermally crystallized at 100^{o}C for 24 hours. Figure 1.0 shows the flow diagram of the processes involved in the synthesis of zeolite Y from kaolin.

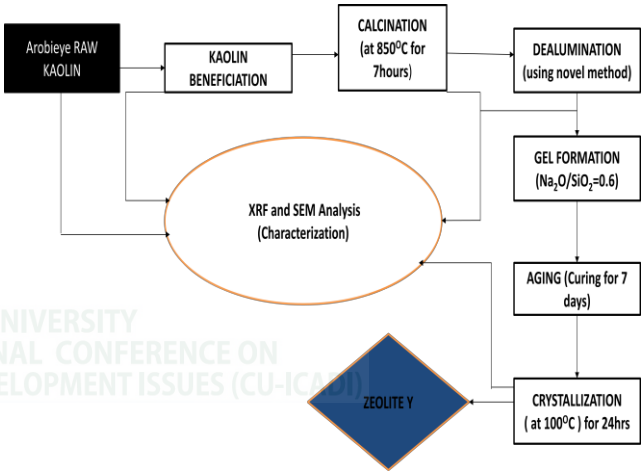


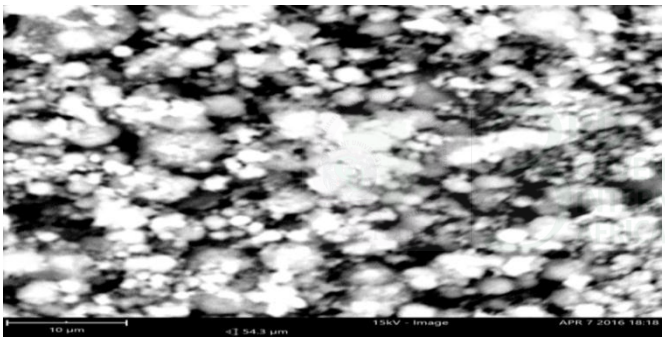
Fig. 1: Flow diagram of zeolite Y synthesis from Arobieye Kaolin

III. RESULTS AND DISCUSSION

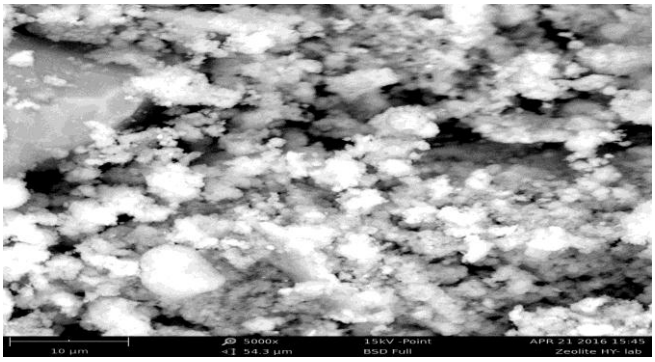
Table 1.0 shows that Arobieye kaolin deposit is rich in oxides of iron, calcium and titanium. It also indicates that there are large quantities of quartz in the sample. Usually, raw kaolinite clay has a silica/Alumina ratio of 2 [2, 6]. Table 1.0 however shows that Arobieye Kaolin is richer in Aluminium at a SiO_2/Al_2O_3 ratio of 1.46. Table 1.0 shows the XRF analysis of the Arobieye Kaolin, Synthesized Zeolite NaY and Zeolite HY. The results show that the
silica/alumina molar ratio is 3.46 and 3.22 which correspond to Zeolite Y (minimum ratio of 3).

Table 1.0: XRF analysis of the synthesized zeolite NaY and zeolite HY

	Chemical composition		**Chemical composition**	
Oxide	Arobieye kaolin	Synthesized zeolite NaY Con wt%	Synthesized zeolite NH4Y Con wt%	Synthesized zeolite HY Con wt%
SiO_2	48.79	37.57	38.58	39.71
Al_2O_3	33.58	18.44	18.68	20.94
Fe_2O_3	2.65	2.03	2.00	2.26
CaO	2.98	3.14	3.08	3.15
MgO	0.58	0.23	0.24	0.28
SO_3	0.04	7.30	6.46	6.76
Na_2O	0.07	33.27	30.07	28.47
K_2O	0.01	0.07	0.07	0.06
TiO_2	1.48	1.39	1.42	1.67
P_2O_5	0.10	0.07	0.07	0.07
Mn_2O_3	0.01	0.02	0.01	0.02
Si/Al	1.45	3.46	3.51	3.22



(a)



(b)

Figures 2a- b shows the structural morphology of the synthesis zeolite NaY and zeolite HY at magnifications, 5000. The clear boundary shapes of the crystals are very obvious.

IV. CONCLUSION

They show clearly the formation of Zeolite Y crystals. However, the crystal size is not uniform indicating a level of impurity. This impurity could be excess sodium compound introduced during the gelation step. This was shown on the XRF result to be as high as 33%. With the application of Novel dealumination process, Zeolite NaY with the SiO_2/Al_2O_3 molar ratio 3.46 was obtained. The transformation of Zeolite NaY to Zeolite HY has SiO_2/Al_2O_3 molar ratio of 3.22. The crystal formation of both Zeolite NaY and Zeolite HY are clearly seen on the SEM analysis.

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