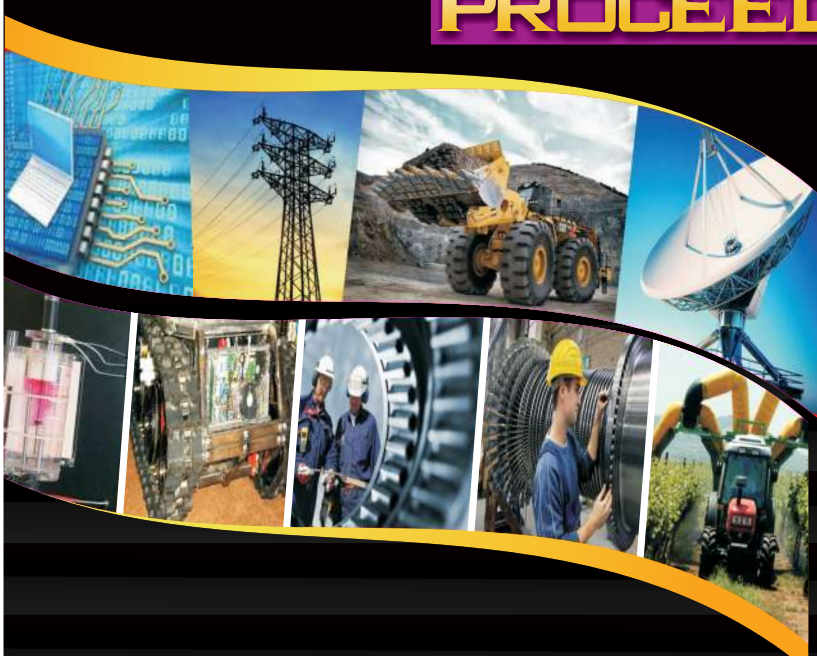
FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA

SCHOOL OF ELECTRICAL ENGINEERING AND TECHNOLOGY &
SCHOOL OF INFRASTRUCTURE, PROCESS ENGINEERING AND TECHNOLOGY

3rd INTERNATIONAL ENGINEERING CONFERENCE IEC 2019

THEME THE ROLE OF ENGINEERING AND TECHNOLOGY IN SUSTAINABLE DEVELOPMENT

BOOK of PROCEEDINGS



DATE:
24TH - 26TH SEPTEMBER 2019

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EDITED BY

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FORWARD

The School of Engineering and Engineering Technology, Federal University of Technology, Minna, organized the 1st and 2nd International Engineering Conference in 2015 and 2017 respectively. With the emergence of the new School of Electrical Engineering and Technology and the School of Infrastructure, Process Engineering and Technology, the two schools came together to organize this 3rd International Engineering Conference (IEC 2019) with the theme: "The Role of Engineering and Technology in Sustainable Development" considering the remarkable attendance and successes recorded at the previous conferences. The conference is aimed at offering opportunities for researchers, engineers, captains of industries, scientists, academics, security personnel and others who are interested in sustainable solutions to socio-economic challenges in developing countries; to participate and brainstorm on ideas and come out with a communiqué, that will give the way forward. In this regard, the following sub-themes were carefully selected to guide the authors' submissions to come up with this communiqué.

1. Engineering Entrepreneurship for Rapid Economic Growth.
2. Regulation, Standardization and Quality Assurance in Engineering Education and Practice for Sustainable Development.
3. Solutions to the Challenges in Emerging Renewable Energy Technologies for Sustainable Development.
4. Electrical Power System and Electronic as a Panacea for Rapid Sustainable Development
5. Promoting Green Engineering in Information and Communication Technology
6. Reducing Carbon Emission with Green and Sustainable Built Environment
7. Artificial Intelligence and Robotics as a Panacea for Rapid Sustainable Development in Biomedical Engineering
8. Petrochemicals, Petroleum Refining and Biochemical Technology for Sustainable Economic Development.
9. Advances and Emerging Applications in Embedded Computing.
10. Traditional and Additive Manufacturing for Sustainable Industrial Development.
11. Emerging and Smart Materials for Sustainable Development.
12. Big Data Analytics and Opportunity for Development.
13. Building Information Modeling (BIM) for Sustainable Development in Engineering Infrastructure and Highway Engineering.
14. Autonomous Systems for Agricultural and Bioresources Technology.

The conference editorial and Technical Board have members from the United Kingdom, Saudi Arabia, South Africa, Malaysia, Australia and Nigeria. The conference received submissions from 4 countries namely: Malaysia, South Africa, the Gambia and Nigeria. It is with great joy to mention that 123 papers were received in total, with 0.9 acceptable rate as a result of the high quality of articles received. Each of the paper was reviewed by two personalities who have in-depth knowledge of the subject discussed on the paper. At the end of the review process, the accepted papers were recommended for presentation and publication in the conference proceedings. The conference proceedings will be indexed in Scopus.

On behalf of the conference organizing committee, we would like to seize this opportunity to thank you all for participating in the conference. To our dedicated reviewers, we sincerely appreciate you for finding time to do a thorough review. Thank you all and we hope to see you in the 4th International Engineering Conference (IEC 2021).

Engr. Dr. S. M. Dauda
Chairman, Conference Organizing Committee

ACKNOWLEGEMENT

The Chairman and members of the Conference Organizing Committee (COC) of the 3rd International Engineering Conference (IEC 2019) wish to express our gratitude to the Vice Chancellor and the management of the Federal University of Technology, Minna, the Deans and all staff of the School of Electrical Engineering and Technology (SEET) and the School of Infrastructure, Process Engineering and Technology (SIPET) for the support towards the successful hosting of this conference. We also thank the entire staff of the university who contributed in one way or the other. We are sincerely grateful to you all.

Optimization of Synthesis parameters of silica from Bentonite Clay using acid leaching

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ABSTRACT

The synthesis of silica adsorbent from natural clay obtained from Obajana, Kogi state, Nigeria was carried out using thermal and acid treatment processes. The calcined clay particles was added in 50ml of 5.00M H_2SO_4 solution and left for stirring at 100ºC for 1.00hour decanted to obtain the silica reach clay. The leached clay particles were washed thoroughly with distilled water until a neutral pH was obtained. The raw clay was characterized to determine its properties using X-ray fluorescence (XRF) analysis and the effect of the thermal treatment was determined using X-ray diffraction principle. The leached clay sample using experimental design was analyzed using atomic absorption spectroscopy. The results indicated that the clay sample was rich in silica which emanated from 62.67% efficiency of leaching of alumina content present.

Keywords: Silica, Bentonite clay, Calcinations, Leaching, Acid treatment, Optimization.

1. INTRODUCTION

Silica is extensively found in nature either as a major mineral in most igneous (e.g. granite) or sedimentary (e.g. sand and sand stone) or metamorphic rocks (quartzite, gneiss) (Usama *et al*., 2015). Silica is most commonly found in nature as quartz, as well as in various living organism. Silica particles have found applications in a variety of fields including drug delivery systems, catalysis, biomedical, biological imaging, chromatography, sensors, and liquid armors and as filler incomposite materials (Usama *et al*., 2015). Clay is a potential source of silica, which contains smectite as a main clay mineral. As alumina component is present in clays along with silica, a range of acid and alkali hydrometallurgical methods are employed to isolate them from each other (Essien et al., 2011). Usually acids are used for the processing of clay rather than alkalis (Ajemba and Onukwuli, 2012) and H_2SO_4 is preferred over other acids due to the easy separation of filtrate from the residue (Usama *et al*., 2015). For effective removal of alumina from clays, calcination is a critical step; solubility of alumina increases after thermal treatment in the temperature ranges of 500–900◦C (Aghbasho *et al*., 2012). Previously, kaoline clay was studied for the production of aluminum sulfate and it was found that heating the clay to 700◦C for 1 h followed by acid leaching with sulfuric acid (H_2SO_4) were the optimum conditions to extract alumina (Essien *et al*., 2011). In the present study, silica particles were synthesized from bentonite clay in nanometer and micrometer size range. Alumina content in bentonite clay was lowered by a series of thermal and acid treatments.

Clays are very abundant on the earth's surface; they form rocks known as shale and are major component in nearly all sedimentary rocks. The small size of the particles and their unique crystal structures give clay materials special properties, including cation exchange capabilities,

Plastic behavior when wet, catalytic abilities, swelling behavior, and low permeabilities, (Al-Zahrani and Abdul-Majid., 2009).

This research is aimed at extracting out alumina component of the bentonite clay sample. It will involve calcination of the raw clay sample, acid leaching of the calcined clay and analysis of the leached sample.

2. METHODOLOGY

2.1 Materials

The clay sample used in this research was mined from Obajana in Kogi state north central of Nigeria. The clay was analyzed to determine its chemical composition using x-ray fluorescence spectrometer (XRF). Tetraoxosulphate VI acid (H2SO4) was purchased from panlac and used without further purification.

2.2 Pretreatment of the clay sample

The clay sample was oven dried at 105°C for 12 hours, crushed and sieved to 75 mm particle sizes. The sieved samples were then calcined in a muffle furnace at temperature of 700° C for 2 hours

2.3 Leaching of silica from Obajana clay

About 10 g of the calcined Obajana clay was added to 250 mL conical flash containing 50 mL of predetermined concentration of H_2SO_4 solution which was stirred at a temperature of 100°C for 1.00 hour as specified by the experimental design (design experiment software) using response surface methodology application. The experimental design for the experiment is presented in Table 2. At the end of each reaction time, the undissolved materials in the suspension was allowed to settle and separated by decantation. The resulting solutions were diluted and analyzed for alumina content determination using atomic absorption spectrophotometer (AAS). The residue was also collected, washed to neutrality with distilled water, and oven dried at 105° C.

3. RESULTS AND DISCUSSION

3.1 Characterization of raw Obajana clay sample

The XRF analysis of the Obajana clay used revealed that the clay was more of a bentonite material as it had higher silica to alumina ratio (> 1:1) than the usual kaolinite. The silica content of the clay was 62.67%. The XRF characterization result of the lay is presented in Table1.

TABLE 1: XRF ANALYSIS OF OBAJANA CLAY SAMPLE

Composition	Raw clay (%)	Calcined at 700°C
SiO_2	62.67	65.85
Al_2O_3	14.91	15.99
Fe_2O_3	4.90	1.47
CaO	0.13	0.07
MgO	1.77	2.10
K_2O	1.98	2.27
Na_2O	2.07	1.73
LOI	10.50	3.70

3.2 Calcination of Obajana clay sample

The calcinations process was done in order to reduce the volatile matter content of the raw clay sample and to improve its susceptibility to acid leaching. The XRD analysis of the raw and calcined clay sample to determine the effect of the thermal treatment on it and the result is presented in Figure 1. The XRD patterns revealed presence of crystalline peaks of quartz on the both uncalcined and calcined clay samples. However, peaks of both kaoline and montrimorillonite were visible in the spectrum of the calcined Obajana clay (Usama et al., 2016). The XRD pattern revealed an amorphous phase between 11-14° θ. In pure bentonite, peaks of Kaoline exist in this region which disappears after thermal treatment and substituted with an amorphous band. This indicates the transformation of the kaoline content of the clay to amorphous metakaoline (Ajemba and Onukwuli, 2012). Calcination of bentonite clay causes it to dehydrate and further heating beyond 680 °C leads to dehydroxylation reaction (zymankowska et al., 2012).

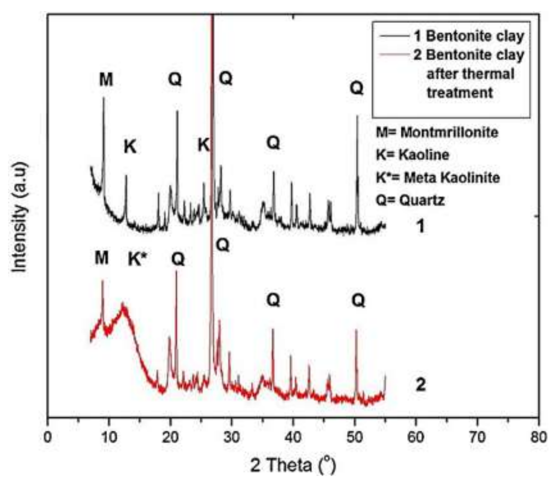

Figure 1: XRD patterns of Obajana clay before and after thermal treatment at 700◦Cfor 1 h.

3.3 The AAS analysis of the acid leached clay solution

The various acid leached samples using the concentration of H_2SO_4, reaction time and temperature obtained from the experimental design using RSM were analyzed using AAS to determine the alumina content. The stirring speed and dosage were kept constant in the 20 experimental runs obtained from the software (Sudamalla et al., 2012). The results of the analysis at various conditions are presented in Table II. It was observed that a non-dominated optimal response of 79.51% yield of alumina removal at 5.00 M sulphuric acid concentration, 60 min leaching time, 0.085 g/ml dosage and 214 rpm stirring speed was established as a viable route for reduced material and operating cost.

TABLE II: THE AAS ANALYSIS OF ALUMINA IN THE ACID LEACHED CLAY SOLUTION

Run/Order	Temp (^{0}C)	Time(min)	Conc(M)	Alumina yield(%)
1	80.00	180.00	3.50	28.60
2	80.00	21.82	3.50	26.98
3	80.00	180.00	3.50	28.60
4	100.00	60.00	2.00	30.43
5	46.36	180.00	3.50	44.22
6	100.00	60.00	5.00	79.51
7	80.00	180.00	3.50	28.60
8	80.00	180.00	0.98	29.21
9	80.00	381.82	3.50	54.36
10	80.00	180.00	6.02	22.72
11	113.64	180.00	3.50	56.795
12	60.00	300.00	5.00	33.874
13	60.00	300.00	2.00	87.63
14	80.00	180.00	3.50	28.60
15	100.00	300.00	5.00	69.37
16	80.00	180.00	3.50	28.60
17	100.00	300.00	2.00	55.98
18	80.00	180.00	3.50	55.984
19	60.00	60.00	5.00	50.719
20	60.00	60.00	2.00	26.77

3.4 Analysis of the RSM experimental result yielded 3D surface plots presented in Figure 2.

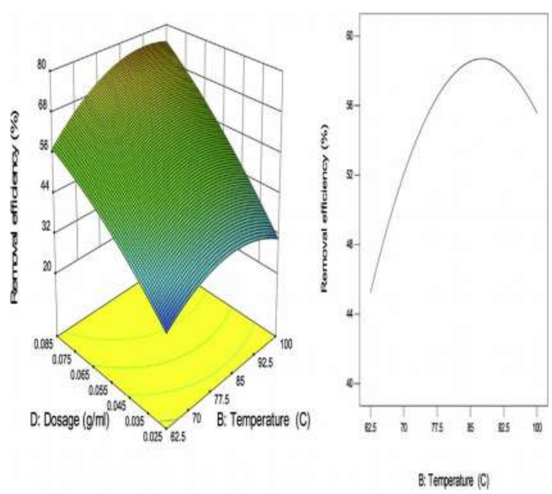

Figure "a" Figure "b"

Figure 2: 3D Surface (a), and single effect (b) plot for effects of dosage ratio and reaction temperature on alumina removal from Obajana clay.

The combined effects of adjusting the process variables within the design space were monitored using 3D surface plots. Every significant interaction effects on the system response between two independent variables were analysed in phases. The observed trends suggest that by proper adjustment of the system variables within the sampled space, a valid optimal could be attained. The results conform largely to what is already known for alumina removal processes (Ajemba and Onukwuli, 2012). Nevertheless, one noticeable unusual result may be the apparent linear (one-directional) response observed in the system response with respect to dosage ratio axis. This does not reflect a typical behavior of batch dissolution processes. Clay particle congestion which occurs at high dosage ratio in the reactor and increased turbulence associated with high stirring rate is formally expected to introduce significant nonlinearities or at least a quadratic behavior in the system response. The consistent linear behavior (in which increasing the input value leads to a corresponding increase in output with respect to dosage ratio) implies that no definite optimal solution could be obtained for the two variables. If such optimal condition exists for the present case, then it definitely lies in a range outside the sampled space. The selection of a useful optimal condition for the two variables would thus be guided strictly by a balance of compromise between their effects on system response and economic implication. The maximum removal of alumina is predicted on the optimum condition from the RSM result by the AAS analysis.

4. Conclusions

Silica was synthesized from bentonite clay after sequence of acid and thermal processes. The experiment investigated the optimum condition for the extraction of alumina from obajana clay using RSM method from design expert software. The results revealed that H_2SO_4 can successfully leach alumina from clay to about 79 %.

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