FUPRE Journal

of

Scientific and Industrial Research

ISSN: 2579-1184(Print) ISSN: 2578-1129 (Online)

http://fupre.edu.ng/journal

Synthesis of Potash Alum from Waste Aluminum Foil Papers used for Fish Barbeque

OVIE, B. E.[1]* *ODIRI, U.*[2]

[1,2]*Department of Chemistry, Faculty of Science, Delta State University Abraka, Delta State, Nigeria*

ARTICLE INFO

Received: 23/05/2024

Accepted: 23/10/2024

Keywords

Alum, Aluminium, Coagulation, Potash, Purification, Turbidity

ABSTRACT

Aluminium is an important metal that find application in various areas ranging from simple kitchen utensils to construction and packaging materials. Due to its versatile uses, aluminium wastes are frequently generated. The aim of this research was to recycle waste aluminium foil papers used for barbequed fish packaging into useful potash alum. The method used explored the amphoteric nature of aluminium to react with both acid and alkali to form a double salt. 1.20g of the waste aluminium foil pieces was first reacted with 25ml of 3 M KOH to form a colourless solution. Further addition of 3M H_2SO_4 to the solution led to the precipitation of a double salt of potash alum. The percentage yield of the synthesized potash alum obtained from 1.20g waste aluminum foil was 76%. The alum also recorded 45% water of crystallization. The efficiency of the synthesized alum in water purification was also tested. Results gave 90.81% reduction in turbidity of muddy water sample from initial turbidity of 1639 NTU to 169 NTU. Thus, the potash alum synthesized from waste aluminium foils was able to coagulate fine suspension of mud from the water, therefore effective in water purification.

1. INTRODUCTION

Aluminium is the most available metal in the earth's crust and ranks third in terms of abundance among all elements in the globe, as had long been established (Greenwood et al, 2019). Owing to its abundant qualities, aluminium is used in many different fields, such as building, transportation, healthcare, water purification, agriculture, packaging, and many more. These versatility of its uses and applications is associated with its waste generation and disposal (Omang et el, 2021)

In food packaging alone, aluminium foil paper plays a major role. Of most significant is in fresh fish barbequing. With many farmers and young entrepreneurs venturing into in-land fish farming in the country today, especially the catfish breeds, the fish market is growing wider and faster (Adewumi et al, 2017). Commercial barbeque spots are springing up almost at every relaxing spot and more recently at street junctions and even along the road sides of most major cities and urban areas. The primary packaging material for these barbeque fishes is the aluminium foil (Bcn-Chendo et al, 2017).

This has led to the generation of aluminium foil paper wastes in these environments. Aluminium wastes persist in the

*Corresponding author, e-mail:author@fupre.edu.ng
DIO

environment. Unlike most degradable wastes, aluminium wastes can persist in the environment for a far longer time (Wade et al, 2016). This is because, it hardly undergoes corrosion. The inability of the aluminium metal to undergo corrosion easily is as a result of the formation of a thin protective film of aluminium oxide once it is exposed to air. The thin film of aluminium (iii) oxide, Al_2O_3 covers the surface of the solid thereby preventing the bulk of the aluminium from further undergoing oxidation (Wade et al, 2016).

Although it is common to get in contact with aluminium most of the time through dietary intake, drugs and other form of exposure, it may not be harmful to health as long as it is in low quantity. However, exposure to high quantities of aluminum compounds leads to aluminum poisoning. Aluminum poisoning is of complex and diverse effects that may include the inhibition of enzymes activities, interfering with protein synthesis as well as nucleic acid function, hindering cell membrane permeability, altering the stability of DNA organization and preventing DNA repairs (Rahimzadeh et al, 2022; ATSDR, 2008)

The recycling of aluminum waste can provide a sustainable and cost-effective way of ridding the environment of its pollution. Previous studies had shown the conversion of aluminium wastes into Potash alum, an important salt that has various applications including water purification (Greenwood et al, 2019, Birnin-Yauri et al, 2014; Shoag,2021].

Potash alum, commonly called 'alum' is actually Potassium aluminium sulfate dodecahydrate, $KAl(SO_4)_2 \cdot 12H_2O$ [9]. It is a double salt of potassium and aluminium. Alum is used as a flocculating agent. As a flocculant, aluminum reacts with water by forming an insoluble aluminum hydroxide which removes all fine suspended colloidal impurities which settle at the bottom of the container (Sanga et al, 2018).

The objective of this study was to synthesize potash alum from waste aluminum foil papers used in barbequed fish packaging and to determine its efficiency in water purification.

2.MATERIALS AND METHODS

Chemicals used for the synthesis and analysis were of analytical grade as purchased. They include, 3M Potassium Hydroxide solution (Sigma Aldrich), 3M Tetraoxosulphate (vi) acid (Sigma Aldrich) and ethanol (Sigma Aldrich).

2.1. Sample Collection Site

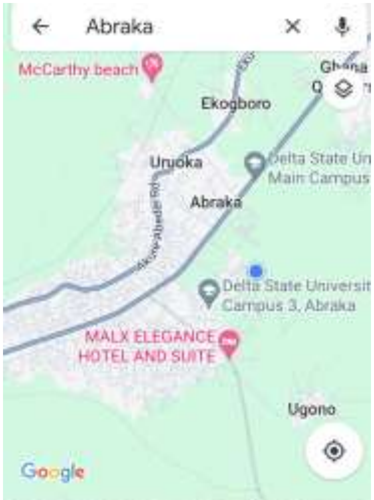

Figure 1: Google map of Abraka

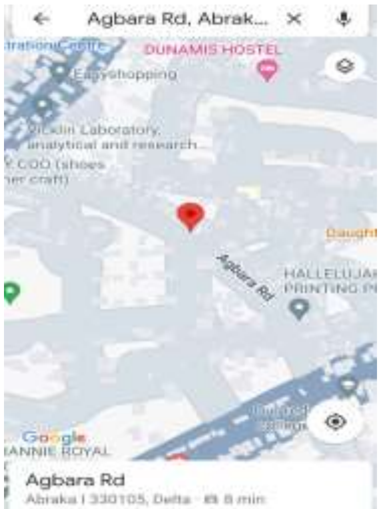

Figure 2; Google map showing Agbara Rd. Abraka.

Source: (Google maps, 2024)

The aluminium foil paper wastes were collected from a barbeque stand along Agbara road in Abraka, Delta State of Nigeria. Abraka lies along latitude 5.7894^0 N and longitude of 6.1023^0 E (Latitude, 2024).

2.2. Sample Collection and Preparation

After gathering the waste aluminium foil papers, they were washed carefully with detergent to remove any leftover fish and oily residues, they were further rinsed with distilled water, and air dried. Thereafter, the aluminium foils were cut into very tiny pieces and weighed with a weighing balance (Mettler Toledo).

2.3. Synthesis of Potash Alum

1.20 g of the aluminium pieces weighed, was placed into a beaker. 250 mL of 3M KOH solution was then carefully added to it and heated slowly on a Bunsen burner. The temperature was kept at 600C. The heating went on until all the hydrogen gas ceased to bubble out and all the aluminium pieces had reacted leaving a clear solution of potassium aluminate. The solution was filtered out with a Hawach Scientific vacuum filtration apparatus into a 500 mL volumetric flask and was further placed in a cooling bath to cool.

$$2\ Al(s) + 2\ KOH\ (aq) + 6\ H_2O(l) \rightarrow 2KAl\ (OH)_4(aq) + 3H_2(g)$$

The next step was to slowly add 250 mL of H_2SO_4 into the flask containing the

potassium aluminate solution. The solution was warmed gently at 60^{0}C and stirred. On initial addition of the acid, precipitates of aluminium hydroxide started forming;

$$2\ KAl\ (OH)_4(aq) + H_2SO_4(aq) \rightarrow 2\ Al\ (OH)_3(s) + K_2SO_4(aq) + 2\ H_2O(l)$$

On further addition of the acid, the precipitates of the aluminium hydroxide dissolve back into the acid solution to form the sulphate;

$$2\ Al\ (OH)_3(s) + 3H_2SO_4(aq) \rightarrow Al_2(SO_4)_3(aq) + 6\ H_2O(l)$$

The solution was stirred until all precipitates of aluminium hydroxide were completely dissolved. Thereafter, the flask was removed from the burner and put in an ice bath for about 25 minutes to enable the alum crystallize out. When the alum crystals were formed, they were filtered out and then recrystallized with a cool mixture of 50 mL of 50 % ethanol/water mixture in an ice bath. The alum crystals were finally filtered, dried and then weighed.

The overall equation of the reaction is given as;

$$2\ Al(s) + 2\ KOH\ (aq) + 4\ H_2SO4(aq) + 22\ H_2O(l) \rightarrow 2\ KA1(SO4)_2{\bullet}12H_2O(s) + 3H_2(g)$$

2.4. Determination of Percentage Yield

Percent yield = Mass of alum obtained/Theoretical yield of alum **x** 100%

The theoretical yield is determined using the overall reaction equation;

$$2\ Al(s) + 2\ KOH(aq) + 4\ H_2SO4(aq) + 22\ H_2O(l) \rightarrow 2\ KA1(SO4)_2{\bullet}12H_2O(s) + 3H_2(g)$$

2.5. Determination of Water of Crystallization of Synthesized Alum

3.0 g of the alum was weighed in a dish and then dried to a constant weight in an oven at 240^{O}C and the weight difference was recorded.

$$KA1(SO4)_2{\bullet}12H_2O(s) \ - \Delta\rightarrow \ KAl\ (SO_4)_2(s) + 12\ H_2O(g)$$

2.6. Efficiency in Water Purification

Muddy water with fine clay suspension was used to check the efficiency of the synthesized alum. Distilled water was used in control experiment. 20 mL of the muddy water sample was measured in two separate test tubes labeled A and B. The third test tube contain 20 ml distilled water and was labeled C to serve as control. The initial turbidity level of each water sample was recorded using digital turbidity meter. 0.50 g of the synthesized alum was added only to test tube A and C. None was added to test tube B. All test tubes were left to stay overnight. The turbidity of the water in test tubes A, B and C were measured after twenty-four hours of standing using a turbidity meter (Hach 2100Q) and the readings were noted.

3. RESULTS AND DISCUSSION

3.1. *Yield of Potash Alum from Aluminum Foil Wastes*

Table 1 Yield of Potash Alum from Aluminum Foil Wastes

Mass of Aluminum Used (g)	1.20
Theoretical yield of alum (g)	20.19
Mass of alum obtained (g)	15.35
Yield of alum (%)	76.00

3.2. *Determination of Water of Crystallization of the Alum*

Table 2 Determination of Water of Crystallization of the Alum

Initial mass of alum (g)	3.00
Final mass of alum (g)	1.65
Water of crystallization (%)	45.0

3.3 Determination of the Turbidity of Water samples Before and After Addition of Alum

Water Samples	Initial turbidity level *(NTU)	Final turbidity level (NTU)	% Reduction
A	1839	169	90.81
B	1839	1831	0.44
C	0.00	1.53	None

*NTU = Nephelometric turbidity unit

Table 3 Determination of the Turbidity of Water samples Before and After Addition of Alum

Table 1 showed the yield of the synthesized Alum. It indicated that the mass of alum obtained from 1.20g of aluminum foil used was 15.35 g. Therefore, the percentage yield of the synthesized alum was calculated as 76%. The difference in the theoretical yield of alum and the actual yield of Alum obtained could be attributed to impurities that may be present in the Aluminium foil used. A similar difference between theoretical yield and actual yield was also noticed in the works of Adejumo in the synthesis of alum from waste aluminium cans (Adejumo, 2016).

Table 2 showed the value of Water of Crystallization of the Alum synthesized. The presence of water of crystallization was indicated by the difference in mass of the alum before and after dryness to a constant weight. The initial mass of the alum measured was 3.00g and after dryness to a constant weight, the mass was measured to be 1.65g. The difference in weight, 1.35g gave the water of crystallization which was expressed as 45%. Potassium alum is hydrated potassium aluminium sulphate; $KAl(SO_4)_2*12H_2O$. The salt crystallizes in a face-centred cubic arrangement of hydrated K and Al atoms alternating with SO_4 radicals. There are ionic bonds between

K^+ and SO_4^{2-} and Al^{3+} and SO_4^{2-}, and there are also covalent bonds within SO_4. This allows an electrostatic attraction between the polar water molecules and the ions (Chou et al, 2013)

The efficiency of the alum in water purification was tested. Table 3 showed values of the Turbidity of water samples taken before and after addition of synthesized Alum. The values showed 90.81% reduction in turbidity of muddy water sample from initial turbidity of 1639 NTU to 169 NTU. This indicated that the alum was able to coagulate the fine suspension of mud from the water. Similar findings were also reported in the works of Birnin-Yauri and Aliyu, where it was also shown that potash alum synthesized from waste aluminium beverage cans was able to coagulate mud suspensions from a muddy water sample (Birnin-Yauri et al, 2014).

Being a double salt, alum ionizes to form three distinct ions in solution: (two positively charged ions (K^+ and Al^{3+}) and a negatively charge ion; SO_4^{2-}) . The alum produced has a large coagulating property due to the large positively charged ions present in it when it dissolves in solution. These positively charged ions help to attract all the neighbouring negatively charged particles present in the water forming flocs in the process, which then coagulates and settle at the bottom of the water container (Choe et al, 2013).

4. CONCLUSION

This study was able to show the synthesis of potash alum from waste aluminium foils obtained from a barbeque fish stand in Abraka metropolis. The potash alum obtained also demonstrated effectiveness as a coagulant in water purification. The yield of the potash alum obtained in the study is an indicator that waste aluminium foils used in fish barbeque can be potential raw materials for the production of potash alum. Instead of posing risk of environmental pollution, waste aluminium foils can be recycled into useful potash alum.

References

Adejumo A.I, Owolabi R.U, Adebisi S.A, Agbaje W.A, Usman M.A. (2016) Synthesis, Characterization and Efficiency of Alum Produced from Waste Aluminium Cans for Wastewater Treatment Journal of Engineering and Applied Sciences, 3,

Adewumi A.I. and Olaleye V.F. (2017) Catfish culture in Nigeria: Progress, prospects and problems. Advanced Journal of Environmental Science and Technology ISSN 7675-1686, 8 (2), 001-005.

Agency for Toxic Substances and Disease Registry (ATSDR). (2008) Toxicological Profile for Aluminum. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

Bcn-Chendo G.N., Obasi P.C., Osuji M.N, Nwosu F.O, Emenyonu C.A., B.O. lbcagwa B.O, Uhuegbulem I.J. (2017) "Marketing Analysis of Fresh and Processed (Barbecue) Along Catfish Value Chain, Implication for Youth Livelihood in Southeast, Nigeria," 2017 Annual NAAE Conference, October 16-19, Abeokuta, Nigeria 288363, Nigerian Association of Agricultural Economists.

Birnin-Yauri A.U and Aliyu M. (2014) Synthesis and Analysis of Potassium Aluminium Sulphate (Alum) from Waste Aluminium Can. *International Journal of Advanced Research in Chemical Science*. **1**(8), 1-6.

Chou I.M, Seal R.R, Wang A. (2013). The stability of sulfate and hydrated sulfate minerals near ambient conditions and their significance in environmental and planetary sciences. Journal of Asian Earth Sciences. 62, 734–758.

Duan J., Wang J., Guo T., Gregory J. (2014). Zeta potentials and sizes of aluminum salt precipitates – Effect of anions and organics and implications for coagulation mechanisms. Journal of Water Process Engineering, 4, 224-232. ISSN 2214-7144.Google maps. (2024) https://maps.google.com/

Greenwood N.N. and Earnshaw A. (2019) Chemistry of the Elements (2nd ed.). Butterworth-Heinemann. ISBN 978-0-08-037941-8.

Latitude.(2024) https://database.earth/countries/nigeria/regions/delta/cities/abraka

Omang D.I., John G.E, Inah S.A., Bisong I.O. (2021) Public health implication of solid waste generated by households in Bekwarra Local Government area. African Health Sciences. 21(3),1467-1473.

Rahimzadeh M.R. Kazemi S., Amiri R.J., Pirzadeh M, & Moghadamni A.A. (2022). Aluminum Poisoning with Emphasis on Its Mechanism and Treatment of Intoxication. Emerg Med Int. 2022 Jan 11; 2022:1480553. doi: 10.1155/2022/1480553. PMID: 35070453; PMCID: PMC8767391.

Sanga, P. Iradukunda Y and Munyemana J.C. (2018) Recycling of Alum from Water Treatment Residue and Reuse It as a Flocculating Agent for Raw Water Treatment. *Journal of Geoscience and Environment Protection*. **6**, 216-226.

Shoag M. and (2021) Rahman M.F. Using Recycling Aluminum Cans as Composite Materials Aluminum Fiber. IOP Conf. Series: Earth and Environmental Science. 943, 1-7.

Wade K. and Banister A.J. (2016) The Chemistry of Aluminium, Gallium, Indium and Thallium: Comprehensive Inorganic Chemistry. Elsevier. p. 1049. ISBN 978-1-4831-53223.