



Waste To Wealth: A Case Study Of Chemical Conversion Of Carbide Waste To Laboratory Chemicals

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Abstract - Carbide waste (calcium hydroxide) is the main waste from the panel beaters and one of the sources of environmental pollution. The carbide waste was collected from the panel beater work shop within Ede, Osun state, and subjected to chemical analysis. The quality and quantity of the Calcium composition of this waste was investigated in comparison with the laboratory grade of calcium hydroxide using complexometry titration. The result shows that carbide waste yielded 5.61mg of Calcium while the laboratory grade yielded 6.87mg of Calcium. The waste product was recycle into useful laboratory salts such as Calcium Chloride (CaCl₂), Calcium Tetraoxosulphate(vi) (CaSO₄) and Calcium Trioxonitrate(v) (Ca(NO₃)₂), with 72.27% CaCl₂, 66.18% CaSO₄ and 54.87% Ca(NO₃)₂, percentage yield of the salts. This was favourably compared with the laboratory grades of those salts, which yielded 84.08% CaCl₂, 73.53% CaSO₄ and 57.14% Ca(NO₃)₂ salts. From the study it could be summarized that apart from recylation of the carbide waste it is an excellent pollution control measure.

Keywords: Carbide, Complexometry, Pollution, Recylation, Titration, Waste, Wealth.

1. Introduction

Artisans are the skilled craft workers who makes or creates things by hand that may be functional or strictly decorative, for example furniture, decorative arts, sculptures, clothing, food items, tools etc (History of Western Civilization, 2009). There are many artisans such as panel beaters, electricians, plumbers, carpenters, blacksmiths, goldsmiths etc. Panel beater is an artisan who specializes in vehicle body repair, usually after the event of either a major or minor accident. A panel beater's job is to perform the necessary repairs to the main panels and sub panels of any vehicle, which may also include making and forming new panels using either machines or hand tools (Yoder, et al 2017 and Jobguide, 2009). This operation may involve the use of heat or flame. In the local setting, one of the major materials needed by panel beaters to generate heat or flame is calcium carbide (CaC₂). Calcium carbide is produced industrially in an electric arc furnace from a mixture of lime and coke at approximately 2000°C. This method has not changed since its invention in 1888 (Aliyu, 2010 and Morehead, 1896).

Calcium hydroxide with impurities or calcium carbide sludge (carbide waste) is the by-product of reaction between calcium carbide and water in the production of acetylene for welding purposes. The reaction of calcium carbide with water was discovered by Fredrich Wohler in 1962. This reaction is the basis for industrial manufacture of acetylene gas. The acetylene gas in combination with oxygen produces oxyacetylene flame used by panel beaters and welders for welding and fabrication work. The sludge is whitish or grayish in colour, has a pH of 12.2 and contains Cu, Pb, Fe, Mn, Ni and Zn ions as impurities (Bogner et al. 2002).

After the welding work, these wastes (carbide waste) are usually dumped carelessly without control in the environment which sooner or later gets incorporated into the soil. Environmental sustainability depends largely on a sustainable soil ecosystem, because soil is the key component of natural ecosystem (Adedokun and Ataga, 2007; Adenipekun, 2008; Onuh *et al.*, 2008). The biological activities in the soil are largely in the topsoil, and the topsoil receives the greatest impact from pollutants. Calcium Carbide wastes have toxic effect on microorganisms, which could ultimately affect the higher organisms which depend on microbes and their by-products for growth and development (Lavoie, 1980). This study thereby aimed at recycle the waste carbide to other useful laboratory chemicals.

2. Materials and Methods

2.1 Materials

2.1.1 Sample collection

The experimental sample was collected freshly from the workshop of panel beaters at different locations in Ede. The collected sample was soaked in distilled water and stirred continuously for 5-6 hours. The solution was filtered using filter cloth, the residue was allowed to dry in a dust free environment inside the laboratory for about 3 days. The dried solid material was grinded to fine powder, and kept in a closed container, while the liquid mixture (filtrate of the sample) was kept in a corked reagent bottle.

2.1.2 Preparation of bench reagents

The following laboratory reagents were prepared using standardized classical methods

- 2, 0.3, and 0.5 moles of hydrochloric acid solutions (HCl)
- 5 moles of ammonium chloride solution (NH₄Cl)
- 1 mole of hydrogen sulphide gas (H₂S)
- 0.5 mole of sodium hydroxide (NaOH)
- 1:1 hydrochloric acid (HCl)
- Phenolphthalein indicators
- Various concentrations of acids solution were prepared; this was done to determine which concentration will give highest calcium percentage yield of the salts.
 - Hydrochloric acid (HCl) - Ratio of acid to water 1:1, 1:2, 1:3, 1:4 and 1:5,
 - Sulphuric acid (H₂SO₄) -Ratio of the acid to water 1:1, 1:2, 1:3, 1:4 and 1:5.
 - Nitric acid (HNO₃) -Ratio of the acid to water 1:1, 1:2, 1:3, 1:4 and 1:5.
- Preparation of reagents for complexometric titration
 - 0.5M Ethylene Diamine Tetra Acetic acid (EDTA) solution (A)
 - Standardization of EDTA solution (B)
 - Ammonia - ammonium chloride buffer (Buffer solution) (C)
 - Preparation of solution of the sample (D)

2.2 Methodology

2.2.1 Study design

The research was an observational descriptive experimental study

2.2.2 Qualitative analysis

Below are the qualitative analysis performed using standard classical methods.

- *insoluble chlorides*
- *insoluble hydroxides*
- *insoluble sulphides*
- *insoluble carbonate*

2.2.3 Quantitative analysis

2.2.3.1 Complexometric titration analysis

50cm³ of the already prepared sample solution D was added to 2cm³ of standardized EDTA solution B in a clean conical flask. After which 3 drop of Erichrome black- T indicator was added. The mixture was titrated against 0.5M EDTA solution until the colour changed from red to Skye blue. This procedure was repeated to find the titre value. The procedure was repeated using the laboratory grade of Ca(OH)₂.

2.2.3.2 Gravimetric analysis

The principle behind this type of analysis is that once an ion's mass has been determined as a unique compound, that known measurement can then be used to determine the same analyte's mass in a mixture, as long as the relative quantities of the other constituents are known (Yoder Claude, 2017).

2.2.3.3 Percentage yield

This was determined using the Precipitated Calcium Trioxocarbonate (CaCO₃)

- For the samples, the following was experimented

- Chlorides (Cl^-) salt using 1:1, 1:2, 1:3, 1:4, 1:5, HCl acid to water concentration to dissolve $CaCO_3$
 - Trioxonitrate (v) salt ditto the above
 - Tetraoxosulphate (vi) Salt ditto the above
- For the laboratory grade, the above experiments were repeated.

2.2.4 Test statistics

Correlation statistical test was used. But Pearson r correlation which is the most widely used correlation statistic to measure the degree of the relationship between linearly related variables was applied, since there four types of correlation test statistics.

3.0 Results and Discussions

3.1 Results

Correlation statistical test was used to investigate the linear relationship between the carbide waste and the laboratory grade samples.

3.1.1 Complexometric Titration

Table 1 : Complexometric titration

| Solution | Carbide waste sample | | Laboratory grade of $Ca(OH)_2$ | |
|----------|------------------------|-----------------|--------------------------------|-----------------|
| | Titre value (cm^3) | Mass of Ca (mg) | Titre value (cm^3) | Mass of Ca (mg) |
| 200mg | 1.43 | 2.87 | 0.87 | 1.74 |
| 400mg | 2.83 | 5.68 | 2.40 | 4.81 |
| 600mg | 2.80 | 5.61 | 3.43 | 6.87 |

Correlation Coefficient = 0.9134

3.1.2 Percentage Yield of the Precipitated Salts

Table 2: Percentage yield of $CaCl_2$ precipitated salts

| Ratio of HCl acid to distilled water | % of Calcium yield (Sample) | % of Calcium yield (lab. Grade) | Difference in % yield |
|--------------------------------------|-----------------------------|---------------------------------|-----------------------|
| 1:1 | 59.10 | 69.07 | 9.97 |
| 1:2 | 63.64 | 69.07 | 5.43 |
| 1:3 | 64.64 | 75.08 | 11.44 |
| 1:4 | 68.18 | 78.08 | 6.90 |
| 1:5 | 72.27 | 84.08 | 11.81 |

Correlation Coefficient = 0.1377

Table 3: Percentage yield of $Ca(NO_3)_2$ precipitated salts

| Ratio of HNO_3 acid to distilled water | % of Calcium yield (Sample) | % of Calcium yield (lab. grade) | Difference in % yield |
|--|-----------------------------|---------------------------------|-----------------------|
| 1:1 | 32.58 | 36.73 | 4.15 |
| 1:2 | 42.68 | 42.85 | 0.17 |
| 1:3 | 45.73 | 46.94 | 1.21 |
| 1:4 | 51.53 | 52.85 | 1.02 |
| 1:5 | 54.87 | 57.14 | 2.27 |

Correlation Coefficient = 0.9863

Table 4: Percentage yield of CaSO₄ precipitated salts

| Ratio of H ₂ SO ₄ acid to distilled water | % of Calcium yield (Sample) | % of Calcium yield (lab. grade) | Difference in % yield |
|---|-----------------------------|---------------------------------|-----------------------|
| 1:1 | 36.76 | 49.02 | 12.26 |
| 1:2 | 40.44 | 53.92 | 13.48 |
| 1:3 | 58.52 | 58.92 | 0.30 |
| 1:4 | 62.50 | 66.18 | 3.68 |
| 1:5 | 66.18 | 73.53 | 7.35 |

Correlation Coefficient =0.9280

3.2 Discussions

3.2.1 Complexometric Titration

The complexometric titration, showed similar trend in the calcium composition with concentration, of both the carbide waste (2.87 – 5.61) and the laboratory grade (1.74 – 6.87) samples as observed from table 1, similar to the works of Yoder 2017, Bogner et al 2002, and Lavoie 1980. Similarly, the correlation coefficient (0.9134) between the two samples (carbide waste and laboratory grade) was positive; therefore the samples are highly correlated.

3.2.2 Percentage Yield of the Precipitated Salts

Table 2 showed the trend in percentage yield of calcium from calcium chloride obtained from carbide waste (59.10 -72.27) and laboratory grade (69.07 – 84.08) with various proportional ratio, this is in concordance with the works of Adedokun et al 2007, Adenipekun 2008, and Onuh et al 2008. Similarly, the positive correlation coefficient of 0.1377 showed that the two samples are highly correlated. Table 3, showed similar observable trends for calcium percentage yield obtained from calcium nitrate of carbide waste (32.58 – 54.87) and laboratory grade (36.73 – 57.14), which is in concordance with the work of Aliyu, 2010. The significant correlation among the two samples was inferred with the positive correlation coefficient of 0.9863. The percentage yield of calcium from the calcium sulphate prepared from the two samples, waste carbide (36.76 – 66.18) and laboratory grade (49.09 – 73.53) share similar trends, shown in table 4, which is similar to the works of Bernhard 2000, Carlisle et al 2004 and Dun Ya 2006. The correlation between the samples was inferred with the positive correlation coefficient of 0.9280.

4. Conclusion and Recommendations

4.1 Conclusion

In conclusion, it could be observed that the main waste product from Panel beaters is carbide waste (calcium hydroxide). From the complexometric titration and percentage calcium yield obtained from various salts prepared from the carbide waste in comparison with laboratory grade, carbide waste is a very rich source of Calcium which can be used to prepare other Calcium salts for use in the laboratory. Therefore, apart from being recyclable laboratory chemicals, it serves as a measure of environmental pollution control, which the carbide waste might generate in the ecosystem.

4.2 Recommendation

Conversion of waste to wealth is a phenomenon that needs to be given wider publicity among the researchers, especially in this era of technological advancement. Hence the following are recommended:

- Investigate the environmental hazards associated with the occupation
- Assessed the associated risks
- If possible research into control or mitigation measure against occupational hazards
- Set up monitoring and evaluation to control the dose rate of habitants
- Further research work is also suggested

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Waste to wealth, Response Surface Methodology (RSM), Artificial Neural Network (ann). *Jatropha Curcas* Leaves Extract as Corrosion Inhibitor for Mild Steel in 1M Hydrochloric Acid. IUCERI has identified agricultural and industrial wastes from India that can be converted into value-added products such as construction materials by using carbon dioxide and commercial low-carbon technology (P. J. Gunning et al.). Chemical composition of *Hyptis suaveolens* grown in saki, south western nigerian, for its resource recovery. This study determined oil recovery potential of *Hyptis suaveolens* for its beneficial use. Pulverized leaves (500 g) of *Hyptis suaveolens* was hydro-distilled for 3 hours using Clevenger apparatus set up. Chemical waste is a waste that is made from harmful chemicals (mostly produced by large factories). Chemical waste may fall under regulations such as COSHH in the United Kingdom, or the Clean Water Act and Resource Conservation and Recovery Act in the United States. In the U.S., the Environmental Protection Agency (EPA) and the Occupational Safety and Health Administration (OSHA), as well as state and local regulations also regulate chemical use and disposal. Chemical waste may or may not be classed CASE 3. Waste paper recycling for youth employment, Bhutan. 16. CASE 4. Waste to resources: community campaigns for a better environment, China. 18. CASE 5. Communities pilot chemical free agriculture, Ghana. Recognizing the global challenges in chemicals and waste management, the world leaders adopted multilateral environmental agreements, including the Stockholm Convention on Persistent Organic Pollutants and the Minamata Convention on Mercury, both of which designated the Global Environment Facility (GEF) as the financial mechanism for their implementation.