Determination of Optimal Sample and Mixing Ratio for Activated Carbon Composite for Best Quality Conductivity

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Abstract*- The study, determination of optimal sample and mixing ratio for activated carbon composite for best quality conductivity was successfully investigated. Coconut shells were gathered from deposited areas as waste, cleaned, washed, sun dried and broken into smaller sizes for combustion inside muffle furnace to achieve carbonization. Researchers adopted different samples masses; sample A (600g), sample B (450g) and sample C (800g) of coconut shells, in addition with variable masses of potassium carbonate 123g, 100g and 200g were also added to the various samples respectively. Furthermore, variable masses of purified water 1.32g, 1.5g and 2.5g were added to achieve activation at carbonization temperature of 800°C, 900°C and 1000°C respectively. The conductivity for the three samples was measured and recorded using conductivity meter. Results suggested that the optimal standard conductivity was 12.0129ms/cm from the optimization model. Also, optimal values of material mixing ratio was 43.25g of coconut shell, 43.25g of potassium carbonate and 0.144g of water respectively. This data suggested that balancing the amount of coconut shell with that of potassium carbonate, in an activated carbon composite might give best quality conductivity. Hence, optimal sample as per the study was sample C, containing 800g of coconut shell, 200g of potassium carbonate and 2.5g of water activated at temperature of 1000°C.

***Indexed Terms*- Coconut shell, Potassium carbonate, Water, Mixing ratio, Activated carbon composite**

I. INTRODUCTION

It has been the interest of battery production industries to have a renewable way of producing best conducting quality batteries without the use of conventional materials. Activated carbon simply referred to as activated charcoal is very porous form of carbon achieved by thermal destruction of carbon rich materials; such as coal, wood, coconut shells at a very high temperature. The use of activated carbon composite in the production of battery electrodes has shown reliability, flexibility and light weight due to the nature of organic materials as compared to inorganic materials. Activated carbon electrodes has the advantages of be printed, cast, and vapor deposited, which broadens applications in miniature and rapidly changing devices. In addition, many activated carbon electrodes can be synthesized at low cost or extracted from biomass and even recycled (Liang et al., 2018).

Obidiegwu et al (2024) maintained that conductive activated carbon composite are known as class of organic materials with unique electrical and optical properties similar to those of inorganic semiconductors and metals. Conductive activated carbon composite could be synthesized using reliable, simple and cost-effective approaches and presently have wider applications in batteries. It is on this note, researchers aimed to study the determination of optimal sample and mixing ratio for activated carbon composite for best quality conductivity.

The activated carbon composite adopted by the paper would be produced using coconut shell, potassium carbonate and water. The coconut shell would be carbonized at varying temperature of 800℃, 900℃ and 1000℃ and activated using $KHCO_3$ and water.

II. METHODOLOGY

Coconut shells were gathered from deposited areas as waste, cleaned, washed, sun dried and broken into smaller sizes for combustion inside muffle furnace for carbonization. Different samples masses were adopted to achieve sample A (600g), sample B (450g) and sample C (800g). Also, variable masses of potassium carbonate 123g, 100g and 200g were added to the various samples respectively. In addition, variable masses of purified water 1.32g, 1.5g and 2.5g were also added for activation. The conductivity for the three samples was measured and recorded using conductivity meter as shown in the table below.

Optimal mixing ratio of the materials was determined through optimization of the model generated with the measured masses. Here, C *is* a dependent variable or predicted response known as conductivity in ms/cm; *X1, X2 and X3* are independent variables; representing coconut shell in grams, potassium carbonate in grams and water in grams respectively. The matrix for the three variables were chosen and varied at 3 levels (100 125 150ms/cm) for conductivity response prediction. This is done with operational temperature references of 800℃, 900℃ and 1000℃ respectively.

Table 1.0: Samples, Masses of Materials and Carbonization Temperature

S/N	Samples	Mass of Coconut Shell (g)	Mass of $KHCO_3$ (g)	Mass of Water (g)	Temperature (^{0}C)
1	Sample A	600	123	1.32	800
2	Sample B	450	100	1.50	900
3	Sample C	800	200	2.50	1000

Table 2.0: Samples and their Conductivity Values

S/N	Samples	Conductivity (ms/cm)
1	Sample A	126.42
2	Sample B	109.36
3	Sample C	145.86

III. RESULTS

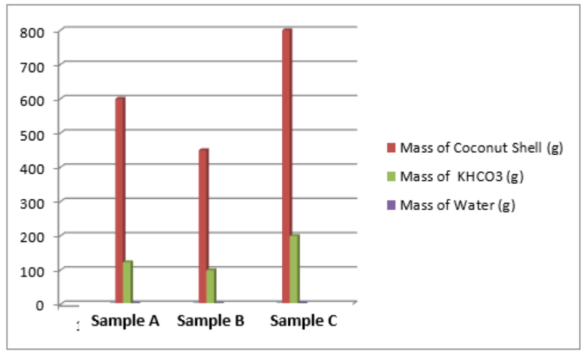

Fig 1.0: Bar Graph of Masses of Sample Materials

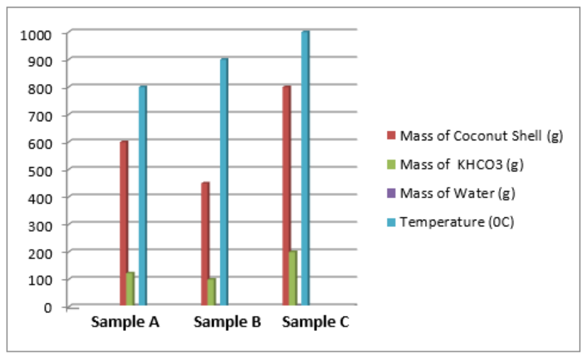

Fig 2.0: Bar Graph of Masses of Sample Material and Carbonization Temperature

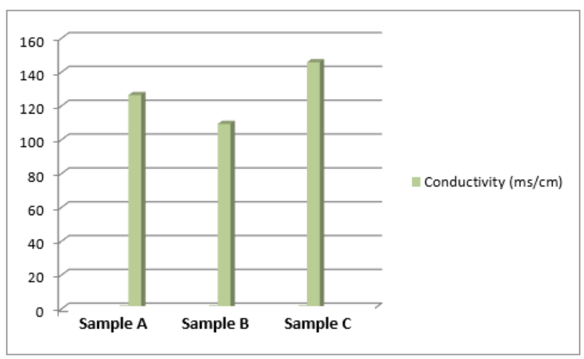

Fig 3.0: Bar Graph of Sample Material and their Conductivity

OPTIMAL VALUE OF COCONUT SHELL, POTASSIUM CARBONATE, AND WATER IS MODELED BELOW

```
>> % C = dependent response, conductivity in ms/cm;
>> % X1 = independent variable, coconut shell in grams;
>> % X2 = independent variable, potassium carbonate in grams;
>> % X3 = independent variable, water in grams;
>> C = [100 125 150];
>> A = [600 123 1.32];
>> B = [450 100 1.50];
>> C = [800 200 2.50];
>> mdl = fitlm(A,C)

mdl =
Linear regression model:
   y ~ 1 + x1
Estimated Coefficients:
```

$$(\text{Intercept}) \frac{\text{Estimate}}{17.602} \frac{\text{SE}}{21.613} \frac{\text{tStat}}{0.81439} \frac{\text{pValue}}{0.5649}$$

```
x1          1.3112     0.061121     21.452    0.029655
Number of observations: 3, Error degrees of freedom: 1
Root Mean Squared Error: 27.4
R-squared: 0.998, Adjusted R-Squared 0.996
F-statistic vs. constant model: 460, p-value = 0.0297
>> tbl = anova(mdl)
```

$$\text{tbl} = \frac{\text{SumSq}}{3.4426e+05} \frac{\text{DF}}{1} \frac{\text{MeanSq}}{3.4426e+05} \frac{\text{F}}{460.18} \frac{\text{pValue}}{0.029655}$$

```
x1 Error       748.09    1        748.09

>> mdl = fitlm(B,C)
mdl =
Linear regression model:
   y ~ 1 + x1
Estimated Coefficients:
```

$$(\text{Intercept}) \frac{\text{Estimate}}{10.384} \frac{\text{SE}}{13.863} \frac{\text{tStat}}{0.74901} \frac{\text{pValue}}{0.59074}$$

```
x1          1.7613     0.052088     33.814    0.018822
Number of observations: 3, Error degrees of freedom: 1

Root Mean Squared Error: 17.4
R-squared: 0.999, Adjusted R-Squared 0.998
F-statistic vs. constant model: 1.14e+03, p-value = 0.0188
>> F = [100 125 150];
>> mdl = fitlm(D,F)
mdl =
Linear regression model:
   y ~ 1 + x1
Estimated Coefficients:
```

$$(\text{Intercept}) \frac{\text{Estimate}}{144.31} \frac{\text{SE}}{8.0171} \frac{\text{tStat}}{18} \frac{\text{pValue}}{0.035331}$$

```
x1          -0.057789    0.016839    -3.4318     0.18051
Number of observations: 3, Error degrees of freedom: 1
Root Mean Squared Error: 9.89
R-squared: 0.922, Adjusted R-Squared 0.843
F-statistic vs. constant model: 11.8, p-value = 0.181
>>End
```

The response linear regression model for the three materials required for production of activated carbon composite is shown below.

$C = 1.3112X_1 + 17.602 + 1.7613X_2 + 10.384 - 0.057789X_3 + 144.31$ ms/cm.. (4.0)

Where;

C = dependent response, conductivity in ms/cm;

X1 = independent variable, coconut shell in grams;

X2 = independent variable, potassium carbonate in grams;

X3 = independent variable, water in grams.

```
>> G = [1.3112 17.602 1.7613 10.384 -0.057789 144.31];
>> sqrt (G)
ans =
  Columns 1 through 4
   1.1451 + 0.0000i    4.1955 + 0.0000i    1.3271 + 0.0000i   3.2224 + 0.0000i
  Columns 5 through 6
   0.0000 + 0.2404i   12.0129 + 0.0000i
```

The best maximum real root of the polynomial is 12.0129ms/cm and this represents the optimal conductivity standard solution for the material mixture.

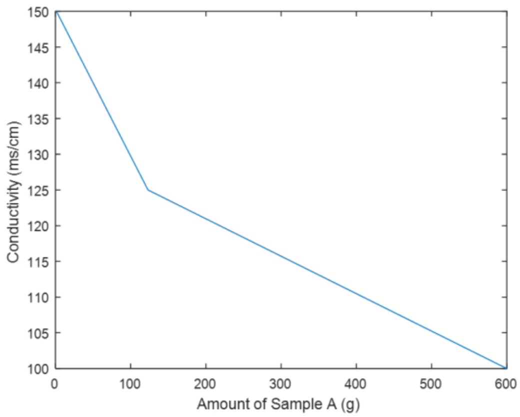

Fig 4.0: Graph of Amount of Sample A and Conductivity

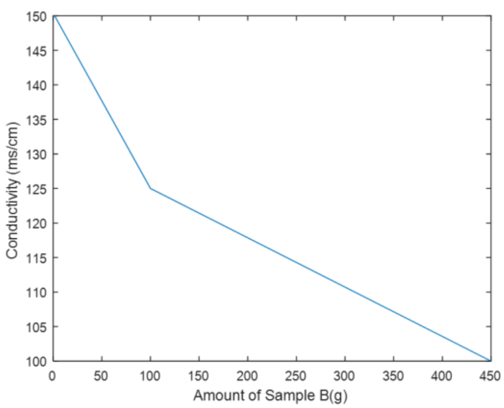

Fig 5.0: Graph of Amount of Sample B and Conductivity

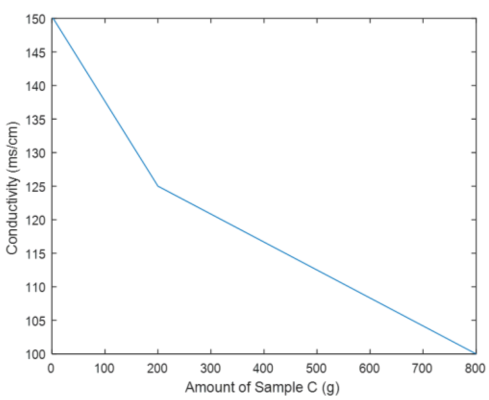

Fig 6.0: Graph of Amount of Sample C and Conductivity

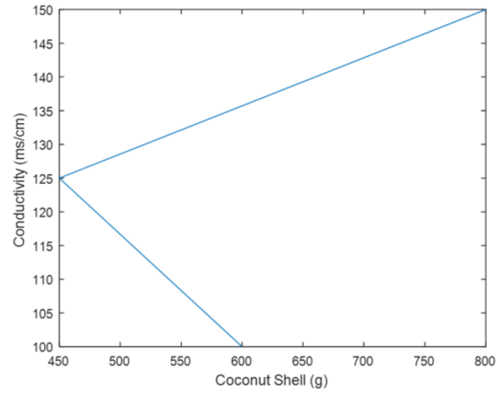

Fig 7.0: Graph of Amount of Coconut Shell and Expected Conductivity

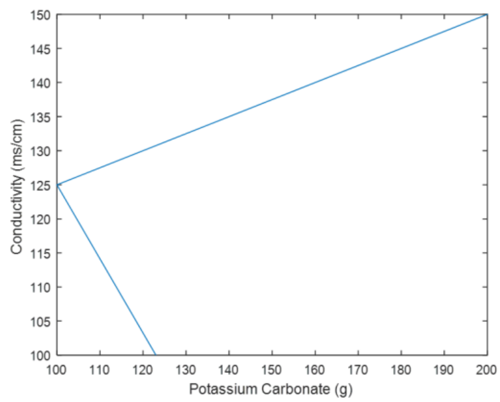

Fig 8.0: Graph of Amount of Potassium Carbonate and Expected Conductivity

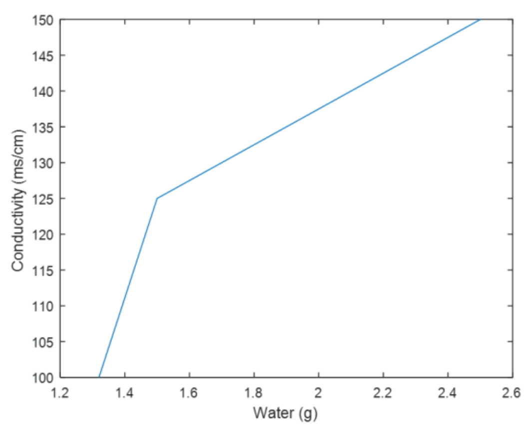

Fig 9.0: Graph of Amount of Water and Expected Conductivity

Findings suggested that the best maximum real root of the polynomial was 12.0129ms/cm and this represented the optimal standard conductivity for the material mixture under the stated condition. According to fig 1.0 to fig 9.0, the optimization of the created model for the three materials required for production of activated carbon composite revealed that the optimal values for material mixture ratio was 43.25g of coconut shell, 43.25g of potassium carbonate and 0.144g of water respectively. This data suggested that balancing the amount of coconut shell with that of potassium carbonate, in an activated carbon composite might give best quality conductivity. Hence, optimal sample as per the study was sample C, containing 800g of coconut shell, 200g of potassium carbonate and 2.5g of water activated at temperature of 1000℃, according to Fig 4.0 to Fig 6.0 and table 1.0 to table 2.0.

CONCLUSION

The findings showed that the optimal materials mixture ratio was of 43.25g of coconut shell, 43.25g of potassium carbonate and 0.144g of purified water respectively with 12.0129ms/cm as the optimal standard conductivity for the material mixture under the stated condition. In addition, optimal sample as per the study was sample C, containing 800g of coconut shell, 200g of potassium carbonate and 2.5g of water activated at temperature of 1000℃ with conductivity of 125ms/cm. The following recommendations were suggested based on the study; optimal material mixture ratio should be used in the application areas of activated carbon composite to achieve best quality conductivity, this research could also be done in future using different levels of matrix input ratio of coconut shell, potassium carbonate and water with other advanced software for generalization.

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