Quick Ignited and Smokeless Carbon Shapes From Household Garbage Agriculture Waste

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Abstract:* This study shows a method to prepare carbon shapes with quick ignition at low temperature from household agriculture garbage wastes. The products are mechanically stable and smokeless. The method involves partial drying, grinding of the waste resources, thermal charring at low temperature, mixing of the bio-char with alkali nitrate salts, blending with molasses or starch gel as a binding material, briquetting or shaping and roasting the green shapes at 600°C. Results revealed that the waste material contains paper, plastics, agriculture food residue, and other organic wastes. Analysis showed that the total carbon in the garbage amounts to 58% by weight. The weight of char left after the charring process decreases in the order agriculture waste > paper > plastic. Proper requirement of the binding material is in the vice order. Mechanical strength of the shaped products increases with the increase of the binding content approaching an optimum value of 140 kg/cm^2 .Apparent density decreases with increase in charring and roasting temperature, decrease in the binder content and shaping pressure. The average yield of the product from the waste amounts to 52% by weight equivalent to about 90% of the char portion. A model exploring the mechanism of carbonization and structure formation has been postulated. The cost of the method is rather effective and simple

***Key Words:* Alternative fuel, agricultural waste,, bio-char, smokeless carbon.**

I. INTRODUCTION

No house on the earth is not generating an agriculture waste as a result of the daily activities for cooking food or other similar works. Also, no house can live without energy supply to accomplish the requirements of personal needs pf heat and power. For these reasons, this study is seen necessary to provide a method to make use of agriculture waste to prepare solid carbon shapes with quick ignition and smokeless properties.

II. SYSTEM MODEL

this work was in the following.

- Household garbage is a recurring waste containing valuable materials to prepare shaped charcoal
- Paper, metals (Beverage cans) ,glass and wastes other than agriculture waste were separated for recycling
- A simple method was applied to prepare quick igniting charcoal from this agriculture waste
- alkali nitrate was used to enhance ignition of the shaped carbon
- the method has an added value very promising to investors

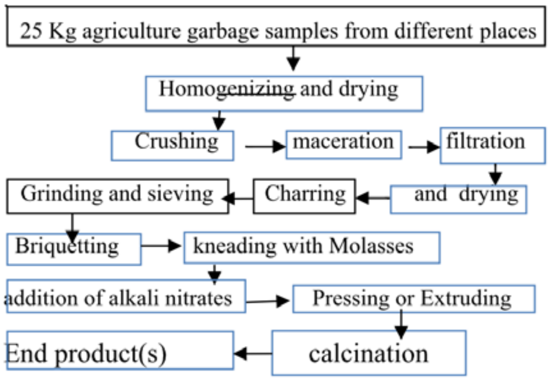

Fig.1A conceptual process flow sheet of the method applied

III. PREVIOUS WORK

Charcoal is an energy dense fuel that can easily be transported from rural to urban environments. Carbon (charcoal) formed by charring household garbage is a light, black residue, consisting of carbon and any remaining ash whereas sugar charcoal is one of the purest forms of carbon readily available.Charcoal is obtained by thermal decomposition in a slow pyrolysis process that involves removing of water and other volatile constituents by heating in the absence of oxygen. The product is usually an impure form of carbon that contains ash. It is soft, brittle, lightweight, black and porous material [1] Charcoal is traditionally found in different types; lump, hexagonal sawdust briquette, extruded charcoal and Japanese charcoal. The charcoal of Japan is classified into three kinds; a-very hard white charcoal (Binchōtan) has a metallic sound, b-black charcoalandc- ogatan charcoal which is made from hardened sawdust [2] Some methods to produce charcoal used a sealed metal container although this method sacrifices part of the material for generating process heat. It's yield is low. Modern methods employ retorting technology, in which generated heat is recovered from, and provided by, the combustion of gas released during carbonization. Yields of retorting are comparatively higher than those of furnaces, and can reach 35% to 40%. A currently invented technology is the Condensing Retort invented by Clean Fuels. Solid fuel refers to a range of solid material that produce energy and provide heating, that are generatedfrom process ofcombustion. Solid fuels include woodcharcoal, peat, coal, Hexamine fuel tablets, and pellets made from wood corn, wheat, rye and other grains are examples of solid fuel. Rocket technology also uses solid fuel [3].

Chlorinated hydrocarbons inhibit the formation of methane from hydrogen-carbon dioxide gas mixtures [4] and from sewage sludge. A similar effect might be expected for methanogenic bacteria feeding on other wastes, if such chlorinated hydrocarbons are to be found in municipal solid wastes. Importantly, the effect of small amounts of inorganic chloride and phosphorous on these bacteria is unknown [5,6]. Paper provides more than half of the carbon and also major fractions of the nitrogen, sulfur, phosphorous and chlorine. The latter elements may be from food wastes contaminating paper. Textiles are the largest single source of nitrogen (presumably from wool, acrylonitrile based synthetic fibers, and amnioblast resins used for textile finishing).

Zannikos et al. [7] reported that the geometry of the briquettes has no influence on the smoke emissions. When the briquettes had a small amount of polyethylene terephthalate (PET), the behaviour in the combustion was more steady because of the increase of oxygen supply. The smoke grade waslevelled among the 3rd and 4th marks (of the burn number scale). Flaming of the plastic in the combination with biomass increases the carbon monoxide (CO) emissions from 10%-30% as compared to CO emission from sawdust biomass emissions. Combustion fuel composed of solid biomass and recovered fuels include solid materials (e.g. wood logs or pieces) [8-11], processed materials (wood chip, pellets) [12], waste products (recycled wood, agricultural by-products) [13,14], gasified materials (methanization of solid fuels) [15], and liquefied esterification products [16]. High density, low levels of ash and high lignin content are effective as indices of wood quality for charcoal production [17,18]. Different materials were reported suitable to enhance combustion of char. Some organic compounds such as nitrocellulose [19], inorganic salts such as sodium nitrate [19] were reported

Regarding quality of charcoal, better chemical properties of charcoal such as higher levels of fixed carbon and lower ash and volatiles are indicative with high levels of lignin and low levels of holocelluloses and other extractives in wood [20]. The authors claimed that wood HHV has no any relationship with the properties of charcoal

The aim of this study is to prepare quick igniting and smokeless solid carbon shapes from household agriculture garbage. The effect of the preparation conditions, use of some adhesive materials and blending with some alkali nitrate on the ignition temperature and the mechanical hardness properties of the end products have been studied.

IV. PROPOSED METHODOLOGY

IV_1- Materials and Methods

IV.1-.1 Household garbage sample weighing about 25 kg was obtained from 25 houses in different places. These were located at different sites having different civilization standard. Cairo and Giza representing developed localities and El-Minia in Upper Egypt and El-Beheera governorates as places of lower level of civilization

IV.1-.2 The chemicals used were of pure grade.

IV.2- Bi-distilled water was used for chemical analysis whereas tap water as used for other purposes

IV.3 Method of preparation of carbon forms

Fig. 1 shows a conceptual process flow sheet of the method applied in this study to prepare quick ignited carbon forms from household agriculture garbage

Only the agriculture and cook residue in the household garbage sample was taken and divided into 25 small subsamples weighing 1 kg each. Each small sample was semidried and macerated in an open ambient conditions for one week with 1 l tap water. After maceration, the sample freed from excess water and dried. It was briquetted into wet blocks wrapped by cotton thread. Briquettes were charred in oxygen-free atmosphere at temperatures up 600°C applying different heating rate up to 10°C/,min. The obtained char was ground to pass 45 um, blended with the alkali nitrate salt and kneaded on cold with molasses or starch gel. The mass was shaped by pressing or extrusion to green shapes like cylinders 10 mm in diameter and 40-50 mm in length. The green carbon shapes were calcined at temperatures up to 600°C before use.

IV.4- Measurement of the physic-chemical properties

IV.4-.1 Total porosity was determined from the relation

$$(\delta r - \delta a) / \delta r \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where δr and δa are the real (2.25 g/cm^3) and apparent density values respectively

IV.4-.2 Ignition temperature was determined according to ASTM D3466 - 06(2011)

Standard Test Method for Ignition Temperature of Granular Activated Carbon Book of Standards Volume: 15.01

IV.4-.3 \ Compressive strength was determined according to ASTM C695 - 91(2010)

Standard Test Method for Compressive Strength of Carbon and Graphite Book of Standards Volume: 05.05

C-.4 Carbon content was determined according to the method given by Sukhnevich [21].

V. EXPERIMENTAL RESULTS

Close to item IV.4, Table 1 shows the results. It is seen that agriculture residue, paper and plastic constitute the major part (50%) of the garbage; 33, 18 and 12 % respectively. The total carbon in the dry agriculture garbage amounts to 67% by weight. The material was taken to carry out this study.

Table 1 Composition of the household garbage

Material	Weight, kg	C,%	Carbon, kg
Paper	0.18	58	0.31
Plastic	0.12	42	0.05
Glass	0.05	-	-
Beverage cans	0.12	-	-
Wood	0.08	72	0.057
Metal	0.04	-	-
Agriculture residue	0.33	67	0.25
Cloth rags	0.01	32	0.0032
Dust	0.07	-	=
Total, 1 kg	1.00		0.6702

Fig.2 shows the weight loss of the household agriculture garbage (HAG) taking place upon heating at temperatures up to 300°C at different heating rate.

It is seen that non-significant weight loss is traced up to 60°C. The extent of weight loss becomes pronounced at >150°C and up to 300°C. Partial charring is seen at ≥240°C

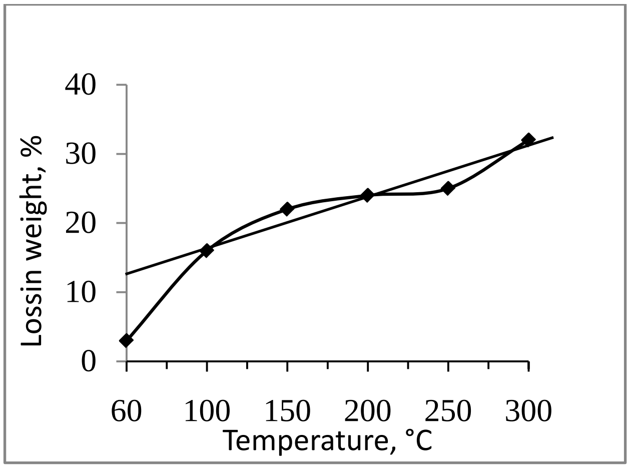

Fig.2 Fig. 2 The effect of heating temperature on the weight in loss of household garbage

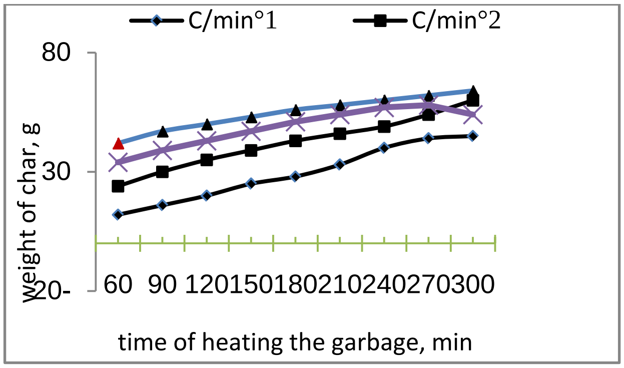

Fig. 3Fig. 3 Effect of heating time on the weight of char formedat different heating rate

Fig, 3 shows the residual weight after heating of the household agriculture garbage as a function of the heating temperature up to 300°C. It can be seen that the weight of the solid residue increases with increase of temperature increase up to 300°C. The weight loss taking place at 150°C amounts to 22% and 25% at 250°C. Pronounced weight loss amounting to 32% takes place by heating at 300°C.

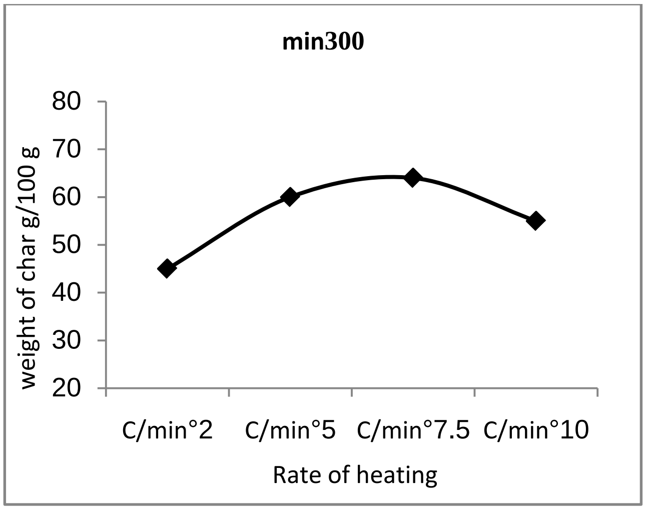

Fig. 4The weight of char as a function of rge rate of temperature increase

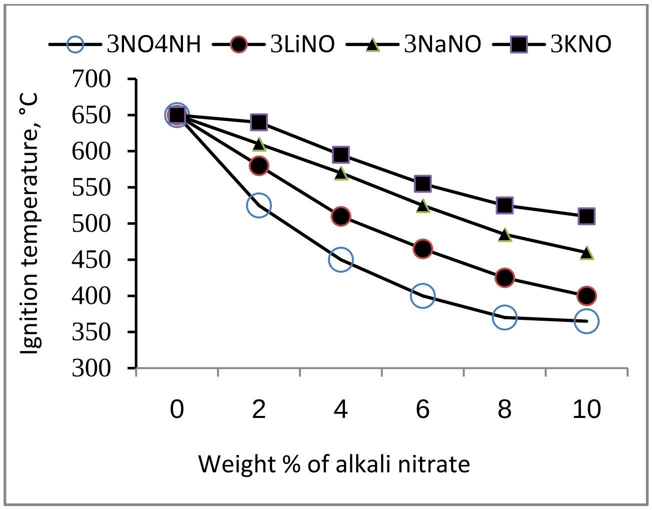

Figure 5 shows the ignition temperature of the char as affected by the weight of alkali nitrate

Fig.4 shows the effect of the rate of heating on the weight of char left after heating the household agriculture garbage. The maximum temperature is kept constant to be 600°C throughout the whole experiments. It can be seen that the weight of the produced char amounts to about 45% with the heating rate of 1°/min. By increasing the rate of heating to 3°C/min, causes an increase of the weight of the formed char to 64%. Further increase of heating rate to 4°C/min decreases the weight of the formed char to 55%.

Figure 5 shows the ignition temperature (IT) of the product(s) as affected by the weight of alkali nitrate salts blended with the char powder before shaping. Molasses is used as a binding agent in 8% by weight. Firing of the green shapes takes place at 700°C in inert atmosphere. It can be seen that the ignition temperature (IT) gradually decreases with increase of the alkali nitrate content up to 8%. It is also worthy to note that the IT of the prepared doped char increases in the order ammonium (370°C), lithium, sodium and potassium nitrate (510°C) for one and the same concentration.

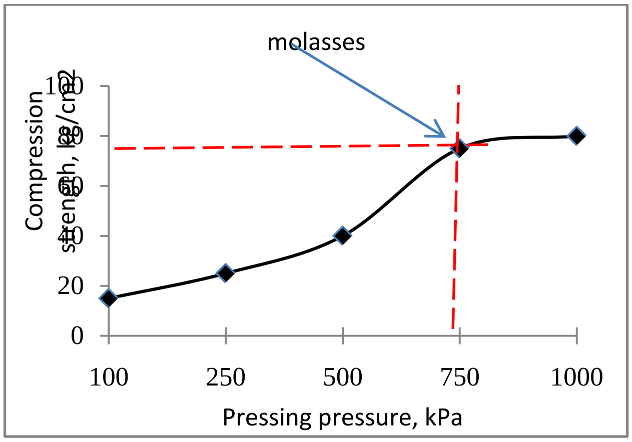

Fig. 6a The compression strength of the finished Carbon shapes as a function of pressing pressure

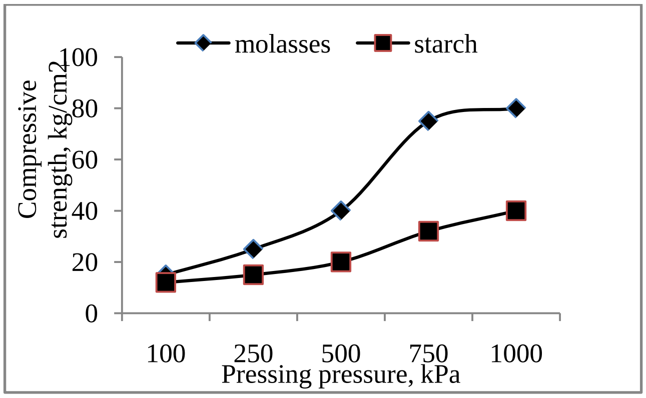

Fig. 6b The compression strength of the finished carbon shapes as a function of pressing pressure using molasses and starch.

Figs.6a and 6b show the compressive strength of the finished char as a function of the pressing pressure in kPa using molasses and starch binding materials respectively. It is seen that carbon shapes are mechanically weak (15 kg/cm^2) if pressed under low pressing pressure (100 kPa). The mechanical strength of the prepared shapes increases gradually with the increase of pressing pressure to attain an acceptable strength (75 kg/cm^2) with pressing pressure of 750 kPa. Pressing at higher pressure (1000 kPa) causes only further slight increase in the mechanical strength (80 kg/cm^2). Carbon shapes made with molasses are mechanically more strong as compared to those made of starch.

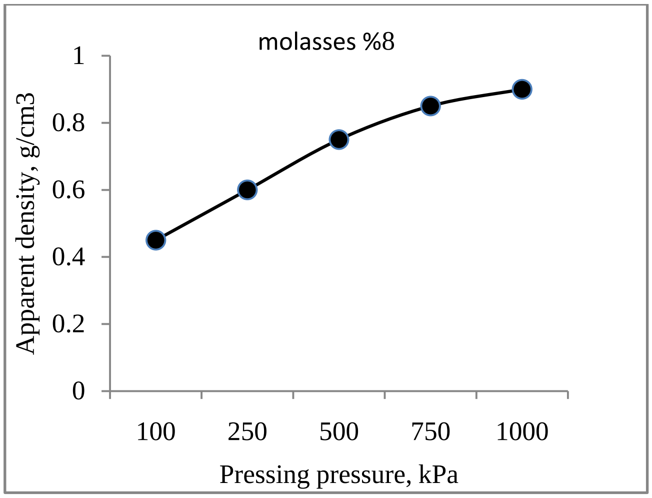

Fig.7 Fig. 7 Effect of pressing pressure on the apparent density of the prepared carbon shapes.

Fig. 7 shows the apparent density of the prepared carbon shapes meeting the acceptable mechanical strength as affected by the pressing pressure. It is seen that the density value is directly related to the pressing pressure up to 750 kPa. Applying more pressure imparts slight effect on the density value.

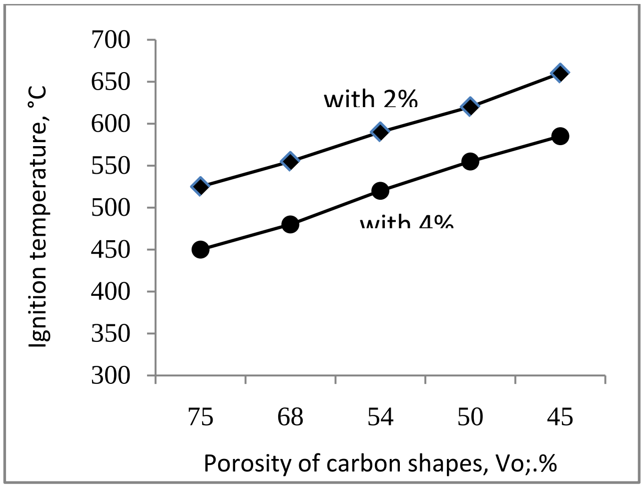

Fig. 8 The ignition temperature of the carbon shapes with different porosity Values as affected by the content of ammonium nitrate

Fig. 8 shows the ignition temperature of the carbon shapes with different porosity values containing 2 and 4 % of ammonium nitrate salt. It can be seen that the ignition temperature decreases with the corresponding increase in porosity value and the nitrate content. The lowest ignition temperature amounts to about 450°C with carbon samples having 75 % porosity (equivalent to 0.55 apparent density) and containing 4% ammonium nitrate.

Figs 9 through 11 show the Arrhenius Plots of the combustion of carbon shapes containing ammonium, lithium, sodium and potassium nitrate respectively

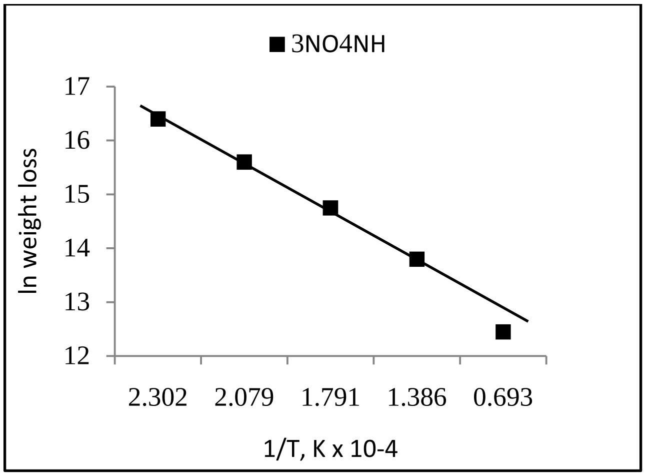

Fig. 9 The Arrhenius Plot of NH_4NO_3 doped carbon ΔE = 72.084 KJ.mol

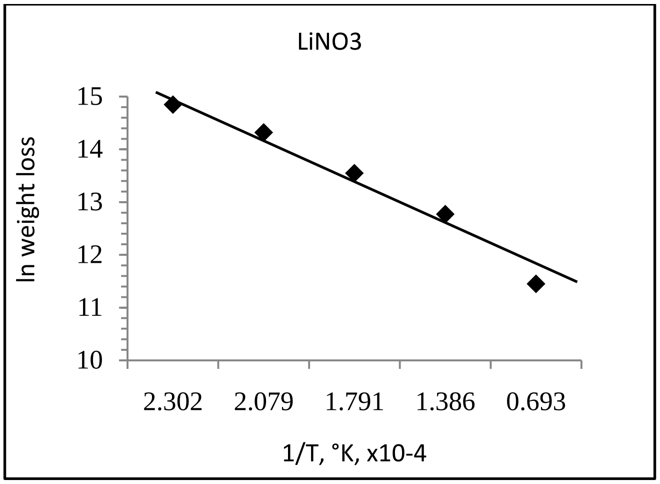

Fig. 10 The Arrhenius Plot of $LiNO_3$ doped carbon E = 50.552 KJ.mol

Fig. 12 shows the activation energy values of the char obtained as affected by addition of different alkali salts. It is seen that the ignition temperature is inversely proportional to the total porosity of the carbon, It is also seen that carbon with 4% by weight ammonium nitrate ignites more readily as compared to carbon with 2% of the same salt, Carbon without nitrate salt ignites at 680°C.

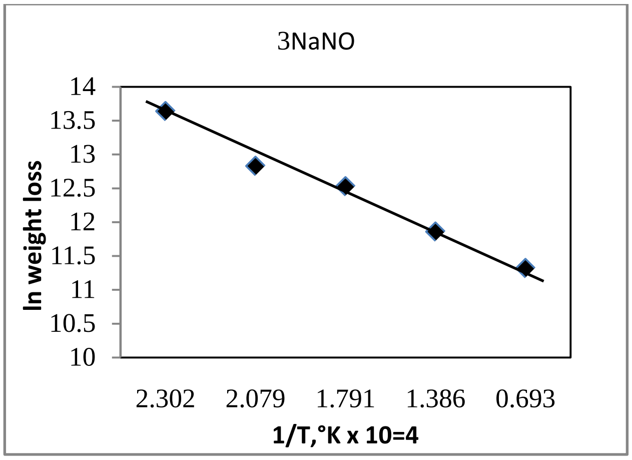

Fig. 11 The Arrhenius Plot of $NaNO_3$ doped carbon E= 24.108

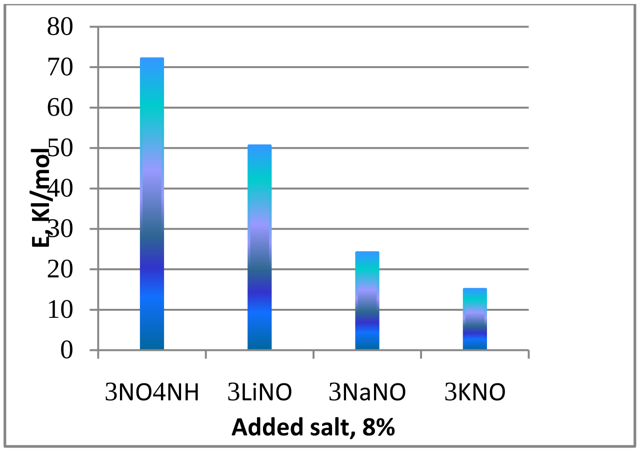

Fig. 12 The Activation energy values of carbon shapes as affected by the type of the sed alkali nitrate salt

VI. DISCUSSION

The subject of charcoal preparation from organic natural materials such as wood is a very ancient process. However, traditional charcoal has different qualities with variable market price. The household agriculture garbage is a renewable source of waste that can be studied to produce charcoal with considerable quality. The average composition of the household garbage is given in Table 1. The major constituent of this garbage is the agriculture residue and cook waste and the rejected parts in the kitchen (33%). In this study, only agriculture household garbage is taken as the waste source. Paper, rags and other similar waste materials were preferably directed to recycling technologies. The foremost theoretical bound dropping the exhaust products found are, as per the rules of thermodynamics, a portion of the chemical power can go into rotation of the drain molecules, anywhere it is not accessible for producing drive.

Helium gas has three degrees of autonomy, equivalent to the three scope of space, {*x*,*y*,*z*}, A diatomic molecule like H_2 be able to turn about either of the two axes perpendicular to the one union the two atoms. The equipartition rule of numerical mechanics load that the accessible thermal energy be separated equally between the degrees of liberty. It follows that such gas in thermal balance 3/5 of the power can go into uni-directional movement, and 2/5 into revolving

A triatomic molecule like water has six degrees of freedom, so the energy is divided equally among rotational and translational degrees of freedom. For most chemical reactions the latter situation is the case. This matter is conventionally described in conditions of the ratio, gamma, of the exact heat of the gas at steady quantity to that at stable pressure. The turning energy loss is mainly improved in exercise if the growth nozzle is large sufficient to allow the gases to expand and chill adequately, the purpose of the nozzle being to exchange the arbitrary thermal motions of the molecules in the burning compartment into the uni-directional exchange that produces drive. As long as the exhaust gas residue in balance as it expands, the early turning energy will be mostly returned to translation in the nozzle.

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