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Rapid pulse carbonization to convert organic solid waste into charcoal

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ABSTRACT

This project describes a quick and efficient carbonization technology that converts solid waste into bio-carbon after a few tens of minutes of reaction time. Our work is based on adequate parameters such as temperature, pressure and catalytic heat diffuser. This work emphasized the heat and control of pressure within a packed bed of solid waste . the reaction was complete after 20 min. The solid waste will be transformed into bio-fuel with almost zero waste. The gas obtained is in majority the steam of water.

KEYWORDS

Carbonization;
Rapid;
Pulse;
Solid organic;
Waste pressure temperature;
Catalytic diffuse.

INTRODUCTION

There are various options available to treat municipal solid waste MSW. Mainly, the following types of technologies are available: (1) sanitary landfill, (2) incineration, (3) gasification, (4) anaerobic digestion, and (5) other types. Sanitary landfill is the scientific dumping of municipal solid waste due to which the maturity of the waste material is achieved faster and hence gas collection starts even during the landfill procedure. Incineration technology is the controlled combustion of waste with the recovery of heat, to produce steam that in turn produces power through steam turbines. About 75% of weight reduction and 90% of volume reduction is achieved through burning. A gasification technology involves pyrolysis under limited air in the first stage, followed by higher temperature reactions of the pyrolysis products to generate low molecular weight gases with calorific value of 1000–1200 kcal/m3. These gases could be used in internal combustion engines for direct power generation or in boilers for steam generation to produce power. In biomethanation, the digested pulp produces the combustible gas methane and inert gas carbon dioxide. The remaining digestate is a good quality soil conditioner. Other technologies are available such pyro-plasma, and flash pyrolysis. All these technologies have merits and demerits. The choice of technology has to be made based on the waste, quality, and local conditions. The best compromise would be to choose the technology, which (1) has lowest life cycle cost, (2) needs least land area, (3) causes practically no air and land pollution, (4) produces more power with less waste, and (5) causes maximum volume reduction.

The technology that we are working is based on the Hydrothermal carbonization (HTC), at high pressure and at 400 degrees. The organic solid waste should be transformed into charcoal within few ten minutes and with a low coast of energy. The advantages of our technology are summarized as follow:

1. Bio-fuel production
2. Low coast
3. Small space
4. Water vapor emission
5. No toxic gas

MATERIALS AND METHODS

Equipments

The apparatus used for the carbonization is a home made machine presented in Figure 1

The main elements of the apparatus are :

1. Cylindrical stainless steel reactor home made with the dimension H= 50cm ;D = 12 cm; thickness = 6 mm
2. Heat electric system of 2000 w
3. High pressure compressor
4. Diffuse heat catalytic

Flash EA 1112 elemental analyzer

The elemental analyzer is equipped with two combustion columns, one for the analysis of carbon, nitrogen, hydrogen and sulfur under high oxygen conditions, whilst the other column is set up for oxygen analysis in an oxygen free environment.

All of the samples are weighed into either tin or aluminium cups for CHNS analysis or into silver cups for oxygen analysis. This is done on a Mettler Toledo balance that can weigh down into the microgram range and reads directly into the computer. Several standards are available to run samples against.

Material to be treated

The raw materials to be treated are manly constituted by the municipalities organic solids, the hospital solid waste, expired drugs and others organic compounds.

RESULTS AND DISCUSSION

Carbonization of municipalities solid waste

A mixture of solid waste were collected from municipalities solid waste (MSW). the total mass of the waste was 1kg. This mass was transferred into the reactor via the top of the reactor. The top was closed with a special shutting to avoid the leak of gases during the reaction Via the bottom of the reactor an electrical heater was installed to heat the system at 400 ^{0}C and air compressor to assure the adequate pressure.

The time of the reaction was estimated by 14 to 20 minutes according to the kind of the solid waste.

A security valve was installed on the reactor to assure a pressure at 10 Bars. If by accident the pressure become over the security valve must open and then the gases were derived into sodium hydroxide aqueous solutions.

The analysis of aqueous solution before and after the treatment was monitored.

The pH of this solutions does not change after the reaction. This results can be explained by the absence of carbon dioxide during the reaction which indicates consequently that the reaction inside the reaction was not combustion.

The only explanation is the internal cracking of the organic compounds and the transformation into charcoal.

Figure 2 shows the behavior of the solid waste before andafter treatment. As can be observed the final product is a black material without any odors. The elemental analysis of this products showed 90% to 98% of carbon and it is up to the initial raw materials treated.

However the rest of the materials supposed to be minerals.

Figure 2 : A-MSW (municipalities solid waste before carbonization)

Figure 2B- Charcoal obtained after carbonization

It has been shown that the mass of solid waste was reduced to 20 to 25% of the initial mass.

The TABLE 1 summarizes the analysis of some samples obtained after carbonization of MSW.

Mechanism of the carbonization

The RPC is an extreme carbonization or cracking of the organics . Under 10 bars, 450 °C and in the presence of the catalytic heat diffuser the organics must be converted into charcoal after ejection of the humidity or the water as steam water via the safety valve installed in the reactor.

TABLE 1 : Elemental analysis of charcoal obtained after carbonization of different MSW samples

N0 of different MSW samples	%N	%C	%H	% S
1	0	98	0	0.2
2	0	98.5	0	0.1
3	0	94	0	0
4	0	97	0	0
5	0	93	0	0.07
6	0	97.5	0	0.5
7	0	99	0	0
8	0	98.8	0	0

Expired drugs carbonization

Expired drugs delivered from Benta company (Lebanon) were tested and treated in the RPC machine. Figure 3 presents the results of the carbonization.

Mechanism of the carbonization

The RPC is an extreme carbonization or cracking of the organics. Under 10 bars, 450 °C and in the presence of the catalytic heat diffuser the organics must be converted into charcoal after ejection of steam water via the safety valve installed in the reactor.

Effect of temperature on the charcoal formation

At 10 bars of air and at different temperatures, a carbonization of the same mass of expired drugs was carried out.: Flash EA 1112, "Thermo", Elemental Analyzer for each sample was used to determine the percentage of the carbon obtained. The time of the treatment was 15 minutes.

Figure 4 presents the percentage of carbon formation in function of temperature at the same pressure 10 bars. The carbonization can achieve 98% of the initial dry material when the temperature reach 450 ^{0}C.

Effect of the pressure on the carbon formation

At 450 ^{0}C the same mass of expired drugs was carbonized at several values of pressures (1 to 12 bars). Each sample was analyzed to determine the carbon formed during the reaction. The time of the reaction

Expired drugs before treatment **Expired drugs after carbonization**

Figure 3 : carbonization of expired drugs

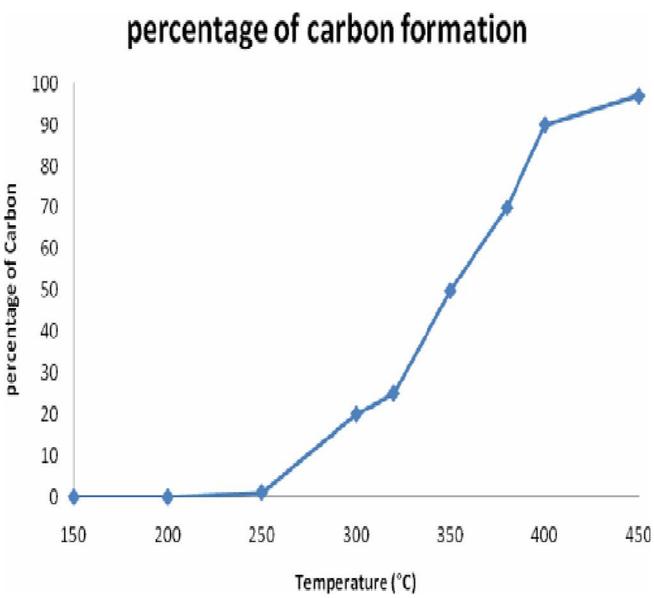

Figure 4 : Evolution of the carbonization with the temperature.

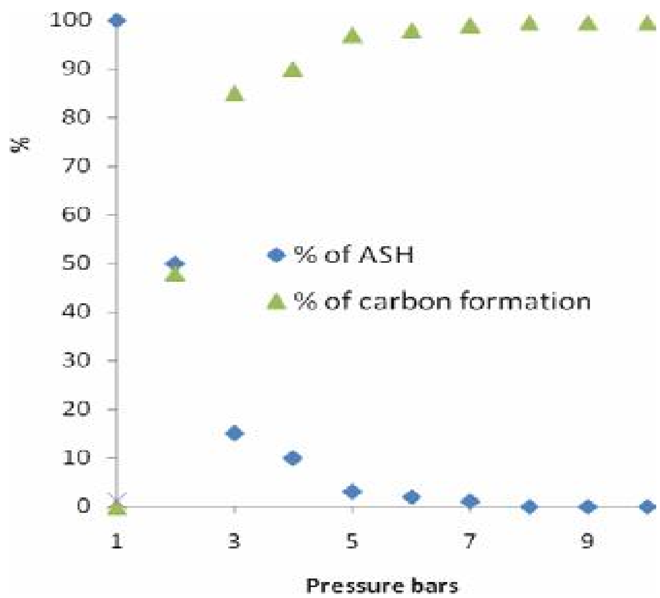

Figure 5: Evolution of carbon and ash formation in function of pressure at 450 ^{0}C.

was 15 minutes. Figure 5 shows that after 5 bars the carbonization start to become significant. At one bar the material was burned and all the mass converted to ash. However at 8 bars and more no ash formation and the organic material was converted into carbon.

CONCLUSION

The Laboratory analysis for the charcoal and for the liquid expected to trap the possible emitted gases the following:

The final product was a charcoal with 90 to 98% carbon with respect the initial mass of waste.

When the pressure become more than 5 bars no ash formation in the final product.

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