ПЛОВДИВСКИ УНИВЕРСИТЕТ „ПАИСИЙ ХИЛЕНДАРСКИ“ – БЪЛГАРИЯ
НАУЧНИ ТРУДОВЕ, ТОМ 38, КН. 5, 2011 – ХИМИЯ
UNIVERSITY OF PLOVDIV „PAISII HILENDARSKI“ – BULGARIA
SCIENTIFIC PAPERS, VOL. 38, BOOK 5, 2011 – CHEMISTRY

WASTE TONERS AND CARTRIDGES – UTILIZATION OPTION

G. Patronov, D. Tonchev

Department of Chemical Technology,
Plovdiv University „Paisii Hilendarski“, Plovdiv 4000, Bulgaria
E-mail: patron@uni-plovdiv.bg

ABSTRACT

The present investigation involves determining the ash content and calorific effect of waste toners and cartridges. Non-magnetic, magnetic and mixed waste toners, waste cartridges and printer bodies were analysed.

Values obtained for the ash content varied between 1,6% and 45,5%, and values obtained for calorific effects varied between 35,44 MJ/kg and 22,33 MJ/kg for waste cartridges and magnetic toner, respectively. Results of the analysis were compared with those for conventional fossil fuels and biomass. Odours and harmful gases, emitted during combustion, reduce the possibilities for utilization of these waste products. Eventual combustion of the wastes should be carried out under appropriate conditions in convenient reactors and should be accompanied by purification of exhaust gases. The emitted heat could be used to produce process steam or electricity.

Key words: *waste toner, ash content, calorific effect, waste cartridges*

INTRODUCTION

The increasing consumption of electrical devices and electronics as a result of technological innovation and market expansion led to the

generation of significant quantities of electronic waste worldwide (mainly in Europe, USA and Australia). Their volume increased by 3–5% annually for the last few years is estimated at 20–30 mil t per year [1, 2]. A large proportion of them refer to the waste toners and cartridges. The U. S. only amount of waste toners ranges from 9 000 to 25 000 t per year [3, 4]. Complicated chemical composition, development of new technologies and pressure from environmental organizations lead to search for alternatives for processing and recycling of these waste materials with minimal environmental impact. Waste toner can be incorporated into asphalt binder for example [4]. Waste cartridges may include the following components: steels – 40%, plastics – 35%, Fe_3O_4 – 5%, Al – 12% and toner – 8% [5]. A model composition of the waste toner is presented in Figure 1 [6].

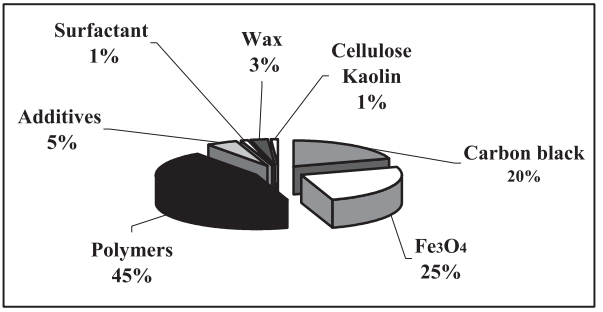


Figure 1. *A model composition of the waste toner.*

This study aims at determining the ash content and calorific effect of waste toners, waste cartridges and printer bodies with a view to eventual utilization by incineration.

EXPERIMENTAL

Samples of non-magnetic, magnetic and mixed waste toners, as well as plastic parts of the waste cartridges and printer bodies were analyzed. Samples of the waste toners were selected randomly at different times from different locations. Mixtures of non-magnetic and magnetic toners in different weight proportions are prepared and tested for better comparability of results.

Analyses were carried out under the current state standards. Lack of moisture is characteristic for these materials.

The ash content was determined by ignition at 850 ^{0}C to constant weight. Calorific effects were determined using an automated isoperibolic calorimeter KL – 10 (type Berthelot). The analysis consists of samples combustion in oxygen atmosphere in the calorimetric bomb, submerged in water and measuring the increase of the water temperature. The calorific effect Q is automatically calculated by the formula:

$$Q = \frac{K\left(\Delta t - k\right) - c}{m}, J / g \qquad (1)$$

where,

K is the heat capacity of the calorimeter, J/°C;

Δt – temperature change during the main period °C;

k – correction for heat exchange between calorimeter and environment °C;

c – corrections for additional heat effects, J;

m – mass of the sample, g.

The bombe calorimeter was calibrated against benzoic acid [7].

RESULTS AND DISCUSSION

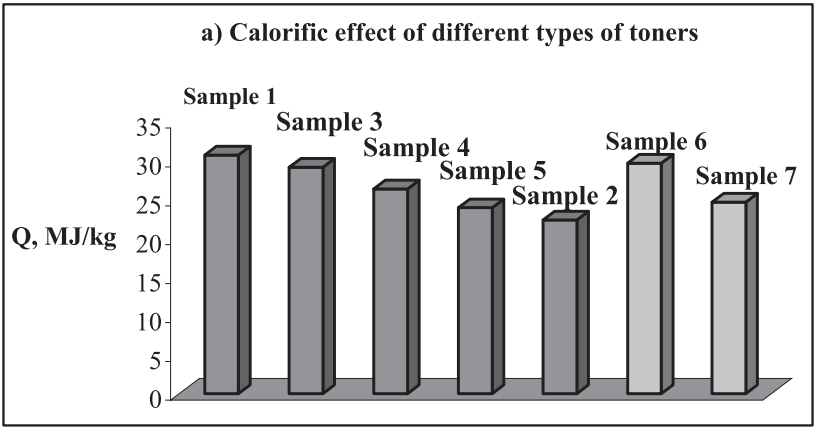
Results of the analysis (samples 1–9) are presented in Table 1 and Figures 2, 3. These results are compared with those for conventional fossil fuels (coal, briquettes) and biomass obtained from our further research (samples 10–14).

The results for samples 15 and 16 are literature data [7].

Numbers 3–5 of samples in Table 1 were artificially made by mixing non-magnetic and magnetic toners in a certain ratio to better comparability of results and more accurate analysis of the possibilities for utilization of waste toner incineration. Values obtained for ash content are ranging between 1,6% and 45,5%, and calorific effect between 35,44 MJ / kg and 22,33 MJ / kg for waste cartridge and magnetic toner respectively. As seen, the results for waste toners, cartridges and printer bodies are similar and higher than these values for conventional fossil fuels (coal, briquettes) and biomass. Odours and harmful gases emitted during combustion are limiting the possibilities for utilization of these waste products as a fuel. In addition, as shown by the results, some waste toners were characterized by high ash content.

Table 1. *Moisture content, ash and calorific effect of different samples*

№	Sample	Moisture, %	Ash, %	Calorific effect, MJ/kg
1.	*Non-magnetic toner (nm)*	-	3,4	30,70
2.	*Magnetic toner (m)*	-	45,5	22,33
3.	*Mixed toner nm:m=3:1*	-	13,6	29,13
4.	*Mixed toner nm:m=1:1*	-	25,1	26,35
5.	*Mixed toner nm:m=1:3*	-	35,1	23,92
6.	*Waste toner I*	-	12,8	29,65
7.	*Waste toner II*	-	28,4	24,65
8.	*Waste cartridge*	-	1,6	35,44
9.	*Waste printer body*	-	6,7	31,76
10.	*Coal briquette (c)*	12,3	14,6	19,78
11.	*Biomass briquette (b)*	8,9	11,1	16,60
12.	*Mixed briquette (c+b)*	12,1	14,3	17,93
13.	*Wood pellets*	7,3	0,6	19,51
14.	*Black coal*	15,9	12,7	22,96
15.	*Anthracite*			32,5 – 34,0
16.	*Coke*			28,0 – 31,0



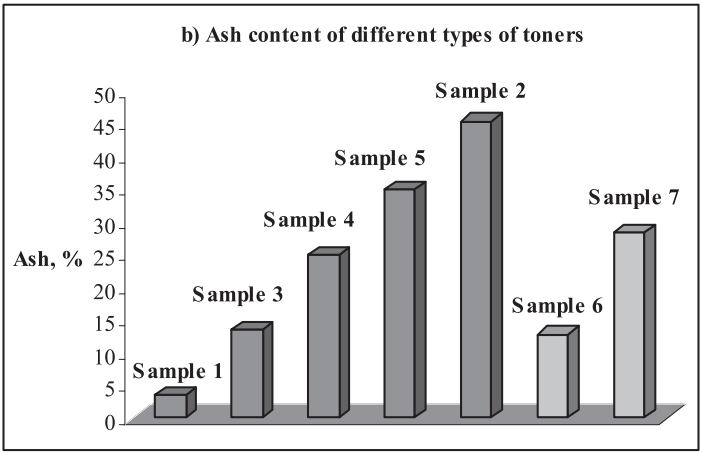


Figure 2. *Visual comparison of the results of calorific effect (a) and ash content (b) of different types of toners: sample 1 – non-magnetic toner, sample 2 – magnetic toner, sample 3 – mixed toner nm:m=3:1, sample 4 – mixed toner nm:m=1:1, sample 5 – mixed toner nm:m=1:3, sample 6 – waste toner I, sample 7 – waste toner II.*

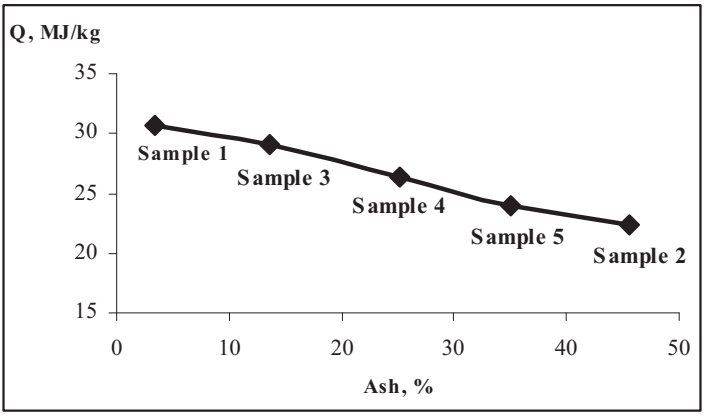


Figure 3. *Calorific effect versus the ash content of non-magnetic, magnetic and mixed toners.*

CONCLUSION

Waste toners, waste cartridges and printer bodies reveal high calorific effects. This energy is enough to be utilized as a fuel. Combustion of these wastes should be carried out under appropriate conditions in the reactors and accompanied by purification of exhaust gases. The released heat could be used to produce process steam or electricity.

REFERENCES

1. H.-Y. Kang, J. M. Schoenung, *Resources, Conservation and Recycling* 45 (2005) 368-400.
2. B. H. Robinson, *Science of the Total Environment*, 408 (2009) 183–191.
3. Ahmadi et al., *Journal of Cleaner Production*, 11 (2003) 573–582.
4. Y. Yildirim et al., *Resources, Conservation and Recycling*, 42 (2004) 295–308.
5. J. Ruan et al., *Journal of Hazardous Materials*, 185 (2011) 696–702.
6. Shaffert R. M., *Electrophotography*, Focal Press, London, 1980.
7. O. Kubaschewski and C. Alcock, *Metallurgical Thermochemistry*, Pergamon Press, Oxford – New York – Paris, fifth ed. 1979