STUDYING OF CARBONIZATION PROCESS FOR ADSORBENT PRODUCTION FROM NATURAL MATERIALS

O. Khandogina* and **M. Zhylina****

* Department of Environmental Engineering and Management, National Academy of Municipal Economy, Ukraine, 61002, Kharkiv, vul. Revolutsii 12 (E-mail: *khandogina_olga@mail.ru*)
** Department of Fuel and Carbon Materials Technology, National Technical University "Kharkiv Politechnical Institute", Ukraine, Kharkov, str. Frunse,21 (E-mail*: zhilina1985@rambler.ru*)

ABSTRACT
Large quantities of plant wastes and agricultural by-products, such as grape seeds, nutshells, corn waste, etc. are produced annually. Meanwhile, excellent renewable raw materials for adsorbent production can be prepared. The previous investigations have shown a potential of using walnut shell as effective adsorbent for removing oil products from sewerage water. Moreover, walnut shell can be an alternative source of production of activated carbon used as adsorbent for water treatment, medical needs, chemical processes etc. The object is to study the possibility of expanding source of raw materials via using plant wastes. Impact of carbonization principal factors on product yield, ash content and sorption activity of carbonizate obtained both from birch wood (traditional raw material) and walnut shell (alternative material) have been compared. Studies have not shown significant distinction in carbonizate yield obtained from birch wood and walnut shell. As the final temperature of carbonization increases, ash content, sorption activity and carbonizate yield of walnut are found to vary slightly. Thus, obtained results shown inexpediency of walnut shell heating to high temperatures. The relevance of further studies in the field of walnut shell carbonization for both waste utilization and adsorbent production was substantiated.

INTRODUCTION

Recently activated carbon has been using widely and its application is growing rapidly. So, activated carbon is used in water purification, food industry, oil and gas production, chemical industry, medicine, etc. With the development of nuclear technologies, activated carbon became as well a major adsorbent for radioactive gases and nuclear power plants wastewater treating.

Resources base of activated carbon is quite varied from crop waste to lignite and coal [1]. Slightly caking coals, peat, and birch are mainly used as raw materials for its production [2, 3]. The main disadvantages of activated carbon are high ash content, low sorption activity, poor mechanical strength. Reduce inventories of raw materials is another aspect to be considered and solved. Recently, this problem is particularly acute because of reducing areas of peatbogs and birch forests. Thus, the searching for new sources of raw materials for activated carbons is of big relevance nowadays.

Initial investigations have been provided recently to study sorption properties and prospective of natural sorbents using for contaminated water treatment.

In Ukraine huge quantities of vegetable wastes and agricultural industries by-products, such as fruit trees pit, grape stones, nuts, shells, grain husks, corn waste, etc are produced annually. For instance, confectionery industry gives significant amount of walnut shell (which is vegetable waste) to be disposed. The main methods of such waste treatment are landfilling or incineration, which pollute the environment, as well as exclude valuable materials from use. Meanwhile, walnut shell is considered to be excellent renewable raw material for activated carbon production. Rapid recovery

of raw materials, large resource potential and environmental safety of the sorbent caused by its vegetable origin are essential characteristics for the purpose.

One of the technological processes of activated carbon production is the carbonation process. This process is insufficiently studied [4], although output of carbonized coal and porous structure of activated carbon are substantially determined by the regimes of carbonization.

The object of the paper is to study the possibility of expanding source of raw materials via using plant wastes, to investigate influence of the major carbonization factors on the yield, ash content and the sorption activity of carbonized coal obtained from birch wood and walnut shell.

MATERIALS AND METODS

Birch wood (traditional raw material) and walnut shell (alternative material as the most promising one for activated carbon production) have been taken for investigation. Carbonization process was carried out in a tube furnace under a nitrogen atmosphere. The following parameters were fixed: the yield, ash content (according to GOST (State Standard) 12596-67) and the sorption activity on iodine (according to GOST 6217-74). The heating rate was varied from 5°C/min to 10°C/min. The heating was carried out from 300 °C to 700 °C.

RESULTS AND DISCUSSION

The investigation of dependence of studied parameters (ash content, sorption activity on iodine and yield of carbonized coal) on carbonization process regimes has provided the results presented in tables 1-3.

Table 1. Yield of carbonized coal obtained under different carbonization temperatures

Raw material	Heating rate, ^{o}C/min	Temperature, ^{o}C				
		300	400	500	600	700
Walnut shell	5	34,3	32	26,8	26,3	25,5
Walnut shell	10	31,07	28,4	25,1	24,12	23,86
Birch wood	5	34,3	27,12	26,13	24,02	22,6
Birch wood	10	31	24,37	22,75	22,09	19,4

Table 2. Ash content of carbonized coal obtained under different carbonization temperatures

Raw material	Heating rate, ^{o}C/min	Temperature, ^{o}C					ΔA
		300	400	500	600	700	
Walnut shell	5	1,17	1,29	1,35	1,61	1,88	0,71
Walnut shell	10	1,48	1,55	1,72	1,84	2,17	0,69
Birch wood	5	1,04	1,73	2,46	2,9	3,12	2,08
Birch wood	10	1,35	2,3	2,9	3,1	3,38	2,03

ΔA – difference between ash content of carbonized coal obtained under 300°C and ash content of carbonized coal obtained under 700°C (%)

Fig. 1 shows yield of carbonized coal dependence on final heating temperature. It is shown that the yield of carbonized coal derived from birch and walnut shell is practically the same, although the yield of carbonized coal obtained from the shell varies slightly with final heating temperature increase.

Table 3. Adsorption activity of carbonized coal on iodine obtained under different carbonization temperatures

Raw material	Heating rate, °C/min	Temperature, °C				
		300	400	500	600	700
Walnut shell	5	4,75	2,69	5,97	7,5	11,8
Walnut shell	10	1,27	2,1	4,49	5,55	7,85
Birch wood	5	9,64	14,6	23,48	34,51	35,17
Birch wood	10	6,11	7,52	17,61	19,6	24

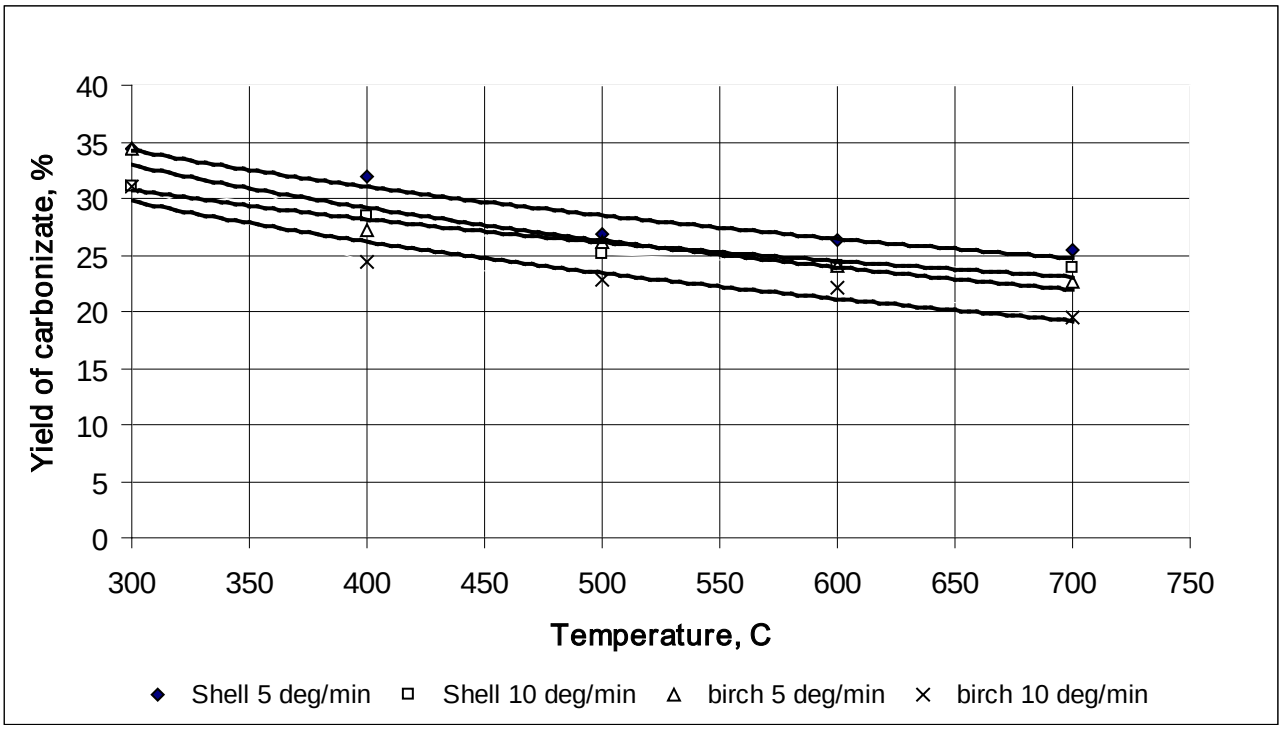

Figure 1. Dependence of the carbonized coal yield on the final heating temperature of raw materials.

Figure 2 shows alteration in ash content of carbonized coal with different heating rate during the temperature rise. So, the ash content of carbonized coal with heating rate of 5 deg/min change to 0.71%, and ash content of carbonized coal with heating rate of 10 deg/min change to 0.69% with increasing temperature from 300° C to 700 °C.

Thus, increase in ash content of carbonized coal obtained from walnut with increasing final temperature of carbonization is obviously insignificant as compared with birch samples which show 2,08 and 2,03 % of ash content increase respectively. Consequently, the final heating temperature does not affect the ash content of carbonized coal produced from plant waste (table 2).

Based on the relationships shown in Fig. 3, sorption activity on iodine of carbonized coal derived from birch wood increase simultaneously with temperature rate and the sorption activity of carbonized coal obtained from walnut shells vary insignificantly. Thus, heating the walnut shell to a high temperature is impractical because the yield of product and the sorption activity is increased insignificantly. It should be noted that the heating rate influence the formation of porous structure of carbonized coal.

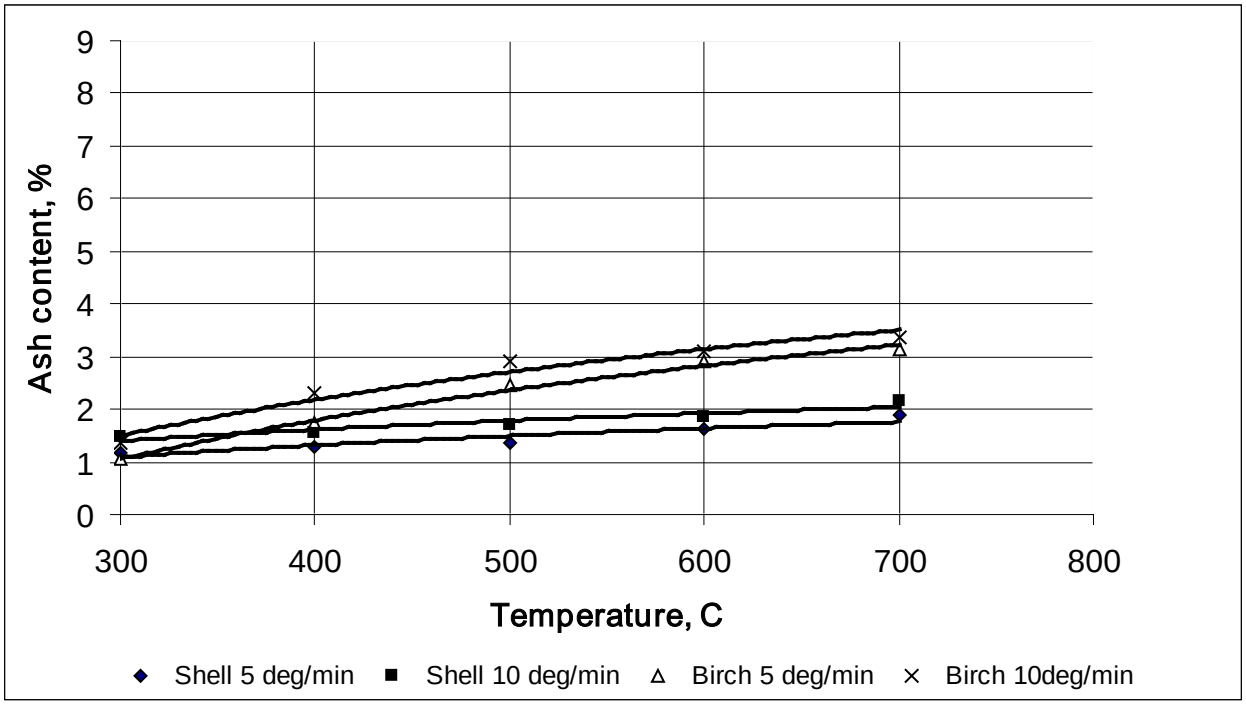

Figure 2. The dependence of the carbonized coal ash content on the final heating temperature of raw materials.

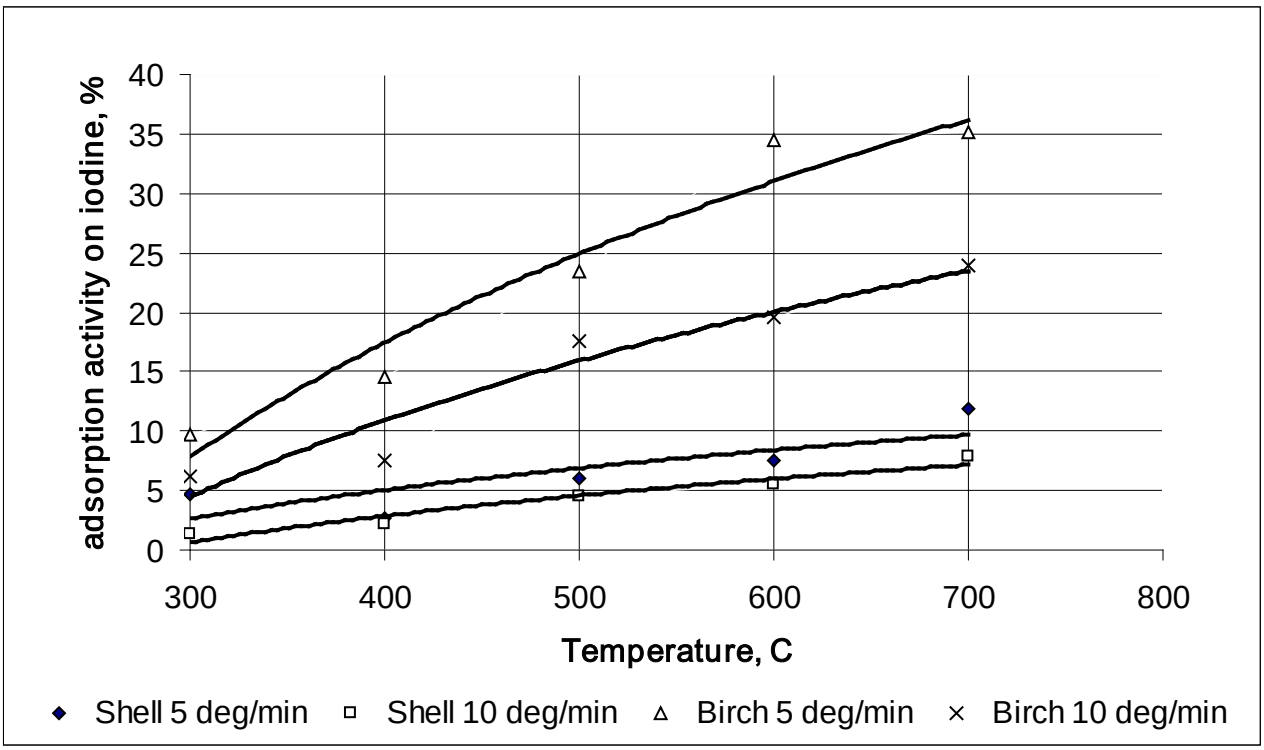

Figure 3. The dependence of the carbonized coal adsorption activity on iodine from the final heating temperature of raw materials

CONCLUSIONS

The obtained results have shown the influence of the major carbonization factors on the yield, ash content and the sorption activity of carbonized coal. Possibilities of birch and walnut shells application as raw material for activated carbon production have been studied.

Further studies are considered to investigate the carbonization process of walnut shell in order to find technological criteria to determine the optimum conditions of the carbonization process for activated carbon production. The activated carbon production can be the solution of the problem of annual shell utilization as well as provide the market with large quantity of renewable raw material and reduce the lack of sorbent.

REFERENCES

1. Дроздник И.Д. Сырьевая база и основные способы получения углеродных сорбентов (Обзор) / И.Д.Дроздник, М.Л.Улановский, А.И.Гордиенко // Кокс и химия. – 1995. – № 10. – С.13-19.
2. Бакланова О.Н. Микропористые углеродные сорбенты на основе растительного сырья / О.Н.Бакланова, Г.В.Плаксин, В.А.Дроздов // Российский химический журнал. – 2004. – Т. 18. – № 3. – С. 89-94.
3. Маслов С.Г. Торф – как растительное сырье и направление его химической переработки / С.Г.Маслов, Л.И.Инишева // Химия растительного сырья. – 1998. – № 4. – С.5–7.
4. Жилина М.В. Процесс карбонизации при получении активированного угля, сырьевая база, влияющие факторы (Обзор) / М.В. Жилина, П.В. Карножицкий // Углехимический журнал. – 2011. – № 5-6. – С. 50-55.
5. Пат. 0471 Россия, C01B31/08. Способ получения активированного угля / Жеенбаев Ж.Ж., Козьмин Г.В., Сарымсаков Ш.В.;опубл. 03.09.2001, Бюл. №8.