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Ethylene Gas Adsorption of Clay-Woodceramics from 3 layers-clay-woodparticleboard*1

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ABSTRACT

The woodceramics are porous amorphous carbon and glassy carbon composite materials. Woodceramics attracted a lot of attention in recent years because they are environmentally friendly and because of their unique functional characteristics such as catalysis, moisture absorption, deodorization, purification, carrier for microbial activity, specific stiffness, corrosion and friction resistance, and their electromagnetic shielding capacity. In this paper, we made new products of clay-woodceramics to investigate the industrial analysis and ethylene gas adsorption for basic data of building- and packging- materials keeping fruit fresh for a long time. Clay-woodceramics were carbonized for 3 h of heating in a special furnace under a gas flow of nitrogen(15 ml/min.) from 3 layers-clay-woodparticleboard made from pallet waste wood, phenol-formaldehyde resin(hereafter PF, Non volatile content:52%, resin content 30%), and clay(10%, 20% and 30%). Carbonization temperature was 400℃, 600℃ and 800℃. Experimental results shows that the higher the carbonization temperature, the higher the fixed carbon and the lower the volatile contents. The higher the clay content, the more the ash content. The higher the carbonization temperature, the more the ethylene gas adsorption. Carbonization temperature of 800℃ gave the best reslts as same as that of white charcoal and activated carbon.(800℃-clay-woodceramic: 5.36 ppm, white charcoal: 5.66 ppm, activated carbon: 5.79 ppm) The clay contents did not make difference of ethylene gas adsoption.

Keywords : Ethylene gas adsorption, Clay-woodceramics, Carbonization, Pallet wood waste, Phenol formaldehyde resin

1. INTRODUCTION

The population increase and high industrial development have brought us massproduction, overconsumption and enormous wastes. These are increasing the burden on the environment and natural resources. Interests for the environment demand that the resources be used with maximum efficiency along with eliminating pollution. Woodceramics, a new kind of porous carbon material can be manufactured from woody waste material, such as disused wood from the

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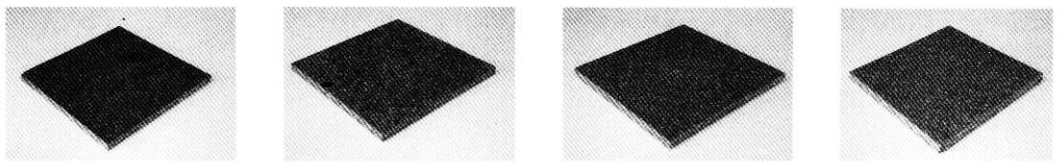
building and furniture, waste wood from pallet, waste wood from wood based panel products etc.(Fan et al. 2001) Wood ceramics are made of wood, or woody material, impregnated with phenol resin and carbonanized in vacuum atmosphere at high temperature, during carbonization the wood changes into soft, amorphous carbon and impregnated phenol resin changes into hard glassy carbon. Therefore woodceramics are porous amorphous carbon and glassy carbon composite materials. This character makes it feasible for woodceramics to have multifunctional properties and behave like advanced fiber reinforced composites.

Woodceramics attracted a lot of attention in recent years because they are environmentally friendly and because of their unique functional characteristics such as catalysis, moisture absorption, deodorization, purification, carrier for microbial activity, specific stiffness, corrosion and friction resistance, and their electromagnetic shielding capacity(Iizuka et al. 1966, Hirose et al. 2001, 2002. Fan et al. 2001). At the present time, most of the woodceramics are manufactured directly from medium density fiberboard impregnated with phenol resin. Because the homogenity and consistancy of fiberboard result in the formation of a consistent, crack-free, porous hard carbon. And a new woodceramics from MDF impregnated with liquefied wood(Hirose et al. 2001, 2002), woodceramics/ZK60A Mg alloy composite(Xie et al. 2002), electrical application of carbonized MDF(Kercher · Nagle 2002), surface area of woodceramics(Fan et al. 2001), specific heat capacity(Kano et al, 1997) humidity sensor characteristics of woodceramics(Kasai et al, 1997) are studied resently. But there has been no study on the particleboard and clay-woodceramics. Therefore, in this study, a new clay-woodceramics which are carbonized for 3 hours in a special furnace from 3 layers-clay-woodparticleboard made from pallet waste wood , phenol formaldehyde resin and clay is prepared and the industrial analysis and ethylene gas adsorption of this material is also investigated. Physical and mechanical properties of clay-woodceramics are examiened by Lee et al. 2002. Gaseous ethylene is an important plant hormone that has a profound effect on many growth and development process, as well as stress responses,(Yang and Hoffman 1984; Bardy 1987; Kende 1993; Ecker 1995) which include shelf-life, shipping potential, storage behavior, and quality of fruits and vegetables(Theologis 1992), and disease regulations.(Hoffman et al. 1999). This hormone has been extensively studied in many fruit crops because of its important role in fruit ripening and senescence. The undesirable postharvest changes which occur during the storage of fresh produce are controlled through manipulation treatment in the storage atmosphere, but there is no attempt of packaging materials to control ethylene adsorption for the fresh produce. Accordingly, in the present work, the industrial analysis and ethylene gas adsorption of this material are investigated for basic data of building- and packging materials keeping fruit fresh for a long time.

2. EXPERIMENTAL PROCEDURE

2.1. Material Preparation

Wood particle was prepared from wood pallet waste. 4 mm~15 mm(50%) and 2~4 mm(50%) particle size were used for the core layer and 0.5~1 mm(70%) and 0.25~0.5 mm(30%), for surface layers. Clay consisted of 70% of SiO_2, 20% of Al_2O_3, and 10% of other minerals. Phenol formaldehyde resin (hereafter PF) with mole ratio of 1: 1.63, which has non volitle content of 52%, pH 11.4, and viscosity of 90~130 cps, was manufactured in a laboratory.



Control Clay 10% Clay 20% Clay 30%

Fig. 1. Clay-Wood Particleboard

Con 800℃ C lay-30%(800℃)

Fig. 2. Clay-Woodceramics

2.2. Clay-wood Particleboard Manufacture

Clay-wood particleboard was made by pressing temperature of 170℃ and pressing time of 6 min, from the 3 layers-of clay-woodparticle mat made of pallet waste wood, PF(resin content 30%), and clay(clay content 10%, 20% and 30% of od weight of wood particle)(Lee 2002). There were 4 replications and press size was 200 mm×200 mm ×10 mm. Fig. 1 shows the manufactured clay-wood particleboard.

2.3. Clay-Woodceramics Manufacture

Clay-woodceramics were carbonized for 3 h of heating time in a special air-tight furnace under a gas flow of nitrogen(1.5 ml/min.) from 3 layers-clay-woodparticleboard. Carrbonization temperature was 400℃, 600℃ and 800℃. Fig. 2 shows the manufactured clay-woodceramics.

2.4. Industrial Analysis and Ethylene Gas Adsorption of Clay-woodceramics

Iindustrial analysis was carried out by JIS M 8812 and ethylene gas adsorption of clay-woodceramics was carried out by Gas chromatography(GC-14B, Shimazu,Japan).

2.5. Statistical Analysis

All statistical analysis were carried with 4 replications and all signification tests were based on Duncan's new multiple range tests at $P_{0.05}$.

3. RESULTS and DISCUSSION

3.1. Industrial Analysis of Clay-woodceramics

Table 1 shows that pH of the clay-woodceramics has a range of 9.84～10.88. The higher the clay content, the higher the pH value and the higher the ash content. In case of moisture content of range 2.5-9%, there is no distinct differences among carbonization temperatures and among clay contents. In case of volatile content, the higher the carbonization temperature is, the lower the volatile content is(CON400℃-36%, 600℃-22%, 800℃-11.5%), and the higher the clay content is, the lower the volatile content

Table 1. Industrial analysis of Clay-woodceramics.

Carbonization temperature	Treatment	Industrial analysis				
		pH	Moisture content(%)	Volatile content(%)	Ash(%)	Fixed carbon(%)
400℃	CON	9.86	6.0	36.0	8.0	50.0
	Clay-10%	9.96	4.1	34.5	18.1	43.5
	Clay-20%	9.84	5.5	26.0	24.2	44.5
	Clay-30%	10.25	2.5	20.5	42.9	34.0
600℃	CON	10.42	4.5	22.0	13.2	60.5
	Clay-10%	10.78	6.1	16.0	24.3	54.0
	Clay-20%	10.24	5.5	10.0	31.1	53.5
	Clay-30%	10.88	5.0	6.0	43.1	46.0
800℃	CON	10.54	9.1	11.5	17.3	62.5
	Clay-10%	10.51	6.5	11.0	26.2	56.5
	Clay-20%	10.23	6.0	10.5	35.1	48.5
	Clay-30%	10.36	3.5	9.5	46.0	41.0
Charcoal (*Quercus variabilis*)		9.23	9.1	5.0	2.0	83.9

is(600℃-CON:22%, Cl-10%:16%, Cl-20%:10%, Cl-30%:6%). In case of fixed carbon, the higher the carbonization temperature, the higher the fixed carbon content(CON400℃-50%, CON600℃-60.5%, CON800℃-62.5%). The higher the clay content is, the lower the fixed carbon content is(800℃-CON:62.5%, Cl-10%:56.5%, Cl-20%: 48.5%, Cl-30%:41%). Kim reported that 3.2% of moisture content, 4.18% of ash content, 8.34% of volatile content, and 84.28% of fixed carbon content in his industrial analysis of charcoal (600℃ of carbonization temperature) from particleboard. The results of this experiment derived from different raw material species, particleboard manufacture condition, and carbonization condition etc.

3.2. Ethylene Gas Adsorption of Clay-woodceramics

Gaseous ethylene is an important plant hormone that has a profound effect on many growth and development processes, as well as stress responses(Yang and Hoffman 1984, Kende 1993, Ecker 1995) which include shelf-life, shipping potential, storage behavior, and quality of fruits and vegetables(Theologis 1992). This hormone has been extensively studied in many fruit crops because of its important role in fruit ripening(Kende 1993) and postharvest fruit decay(Zheng 2000). Ethylene production and postharvest decay rating were positively significantly correated(Zheng et al. 2000).

The undesirable posthavest changes which occur during the storage of fresh produce may be controlled through many treatment, but there is no attempt to control this ability in case of packaging material to transport. Therefore to keep freshness of fruit for long time in packaging material, ethylene gas adsorption of clay-woodceramics is examined as shown in Table 2. The higher the carbonization temperature, the more the ethylene gas adsorption. Carbonization temperature of 800℃ give the

Table 2. Ethylene gas adsorption of Clay-wood ceramic (adsorption time: 48 hr)

	ethylene gas adsorption(ppm) F=35.69*					
carbonization Temp. / clay content	400℃	Duncan	600℃	Duncan	800℃	Duncan
CON	4.15±0.36	D	5.03±0.33	C	5.36±0.21	ABC
Cl-10%	2.46±0.47	E	5.68±0.31	AB	5.74±0.31	A
Cl-20%	2.46±0.41	E	5.44±0.27	ABC	5.67±0.30	AB
Cl-30%	4.12±0.44	D	5.07±0.27	BC	5.50±0.32	ABC
				Duncan		
white charcoal(oriental oak)	5.66±0.30			AB		
activated carbon(palm)	5.79±0.28			A		

* ethylene gas concentration of blank vessel: 6.07 ppm

best reslts as same as that of white charcoal and activated carbon. (800℃-clay-woodceramic: 5.36 ppm, white charcoal: 5.66 ppm, activated carbon: 5.79 ppm)

There is no difference of ethylene gas adsoption among the clay contents.

4. CONCLUSIONS

This research was carried out to examine industrial analysis and ethylene gas adsorption of clay-woodceramics which are carbonized for 3 hours of heating in a special furnace under a gas flow of nitrogen(15 ml/min.) from 3 layers-clay- woodparticleboard made from pallet waste wood, phenol formaldehyde resin(hereafter PF, Non volatile content:52%, resin content 30%) and clay(10%, 20% and 30%). Carbonization temperature was 400℃, 600℃ and 800℃. The results are summarized as follows:

1) The higher the carbonization temperature, the higher the fixed carbon and the lower the volatile contents. The higher the clay content, the more the ash content.

2) The higher the carbonization temperature, the more the ethylene gas adsorption. Carbonization temperature of 800℃ give the best reslts as same as that of white charcoal and activated carbon. (800℃-clay-woodceramic: 5.36 ppm, white charcoal: 5.66 ppm, activated carbon: 5.79 ppm)

The clay contents did not make difference of ethylene gas adsoption.

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