

# A ROLL OF FILLER FOR THE PREPARATION OF GLASS-LIKE CARBON

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## Introduction

Glass-like carbons are known to be typical isotropic and non-graphitizable carbons [1]. Remarkable properties of glassy carbon include its chemical inertness, thermal stability, hard, impermeability to gases and liquids, and electrical conductivity.

A wide variety of organic materials can be converted to glassy carbon, including phenol formaldehyde resins, furfuryl alcohol resins, furan resins, cellulose, polyacrylonitrile and polyvinyl chloride [2].

The ultimate performance and properties of the glass carbon will be influenced by material processing which often involves the addition of filler. Additions of filler materials are quite effective to diminish weight losses, to suppress shrinkage and also to release readily the evolved gases at the polymerization and curing stages.

In this study, small thermosetting resin was used as the filler for the composite glass-like carbon fabrication. Properties of glass-like carbon were evaluated by several methods for the verification role of filler.

## Experimental

Furan resin known commercially KC-5302 of Kangnam Chemical Co. in Korea was used as the carbon precursor. P-toluen sulfonic acid monohydrate ( $\text{CH}_3\text{C}_6\text{H}_4\text{SO}_3\text{H}\cdot\text{H}_2\text{O}$ ) of 0.5 wt. % used as the hardener mixed with furan resin to prepare the curing. The filler material was made with furan resin and 0.5 wt.% of hardener and then cured. Ethanol was added also to resin/hardener mixture and resin/hardener/filler mixture to control of viscosity. The resin mixture was stirred by mechanically for 30 min. at room temperature. The stirred resin mixture was then poured into glass molds and placed in drying oven at room

temperature for 5 days. The samples were then placed in a convection dryer for curing for 0.1 °C/min.. The sample was pyrolyzed by slowly ramping to 1000 °C in flowing nitrogen and held 1 h. The density, 3-pt bending strength and electrical resistance were characterized.

## Results and Discussion

Table 1 and 2 show the yield and shrinkage during the process. The change of yield and shrinkage remarkably decreased in carbonization, while yield and shrinkage changes decreased with increase of filler contents.

Figure 1 shows the change of density in process. Ethanol added samples (EF0, EF5 and EF10) were lower density than that of un-added samples (F0, F5 and F10). Ethanol addition became the lower viscosity and reduced the gas bubble size in the mixture. Very fine bubbles were dispersed well in the mixture. The bubbles were not suppressed during polymerization because of too fine size. And also, the bubbles change to pores in carbonization. The density was increased by addition of filler may affected the reduction of bubbles in the mixture. The interface of filler and mixture may role as the channel to escape the gas bubble during the polymerization.

Figure 2 shows the result of 3-point bending test in process. The strength was generally reduced by filler addition. The strength was abruptly reduced in carbonization with ethanol added samples. Because the strength depends on the pores which much existed in ethanol added samples.

Table 3 showed the electrical resistivity after carbonization. Ethanol added samples had higher electrical resistivity than that of un-added samples. The effect was due to the pore. Since the electrical resistivity was proportioned to the pore.

## Conclusions

In this study, ethanol addition in the mixture to make glass-like carbon became the lower viscosity and reduced the gas

bubble size in the mixture. The bubbles were not suppressed during polymerization because of too fine size. The bubbles change to pores in carbonization. The density was increased by addition of filler may affected the reduction of bubbles in the mixture. The interface of filler and mixture may role as the channel to escape the gas bubble during the polymerization. The strength and electrical resistivity were generally reduced by filler addition. The strength and electrical resistivity were abruptly reduced in carbonization with ethanol added samples. Because the strength and electrical resistivity depend on the pores which much existed in ethanol added samples.

### References

1. Johnson KK and Jones LE, "Phenol-Formaldehyde Resin Structure for the Synthesis of Glassy Carbon," Extended abstracts, 23<sup>rd</sup> biennial conf. on carbon. Penn St. (University Park. USA): American Carbon Society, 1997; Vol. II; 478-479.
2. Neenan TX, Callstrom MR, Bachman BJ, McCreery RL and Alsmeyer DC, British Polymer Journal, 23 [1&2], pp.171-177 (1990).

### Acknowledgements

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Table 1. Change of Yield during Process

Sample	Polymerization	Curing	Carbonization
F0	13.72	22.15	53.67
F5	11.87	16.88	51.21
F10	10.62	15.49	50.60
EF0	22.32	29.40	58.81
EF5	19.21	22.80	54.80
EF10	17.53	21.69	54.36

Table 2. Change of Shrinkage during Process

Sample	Curing	Carbonization
F0	2.39	21.97
F5	2.13	21.57
F10	1.94	21.80
EF0	1.89	21.88
EF5	1.82	21.78
EF10	1.74	21.76

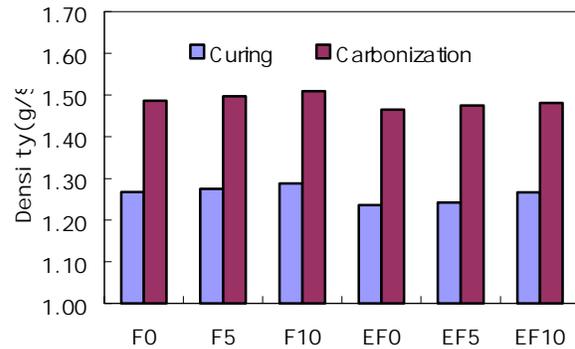


Fig. 1. Change of Density during Process

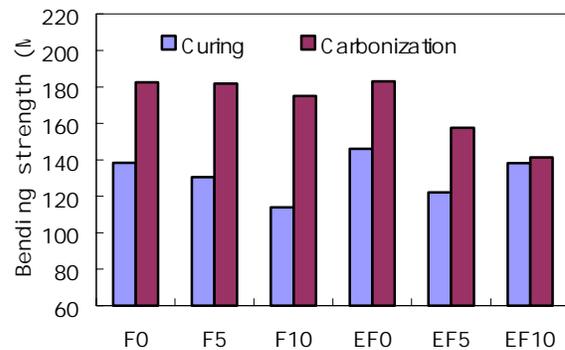


Fig. 2. Change of Results in 3-Point Bending Test

Table 3. Results of Electrical Resistivity ( $\mu\Omega m$ )

Sample	F0	F5	F10	EF0	EF5	EF10
Carbonization	73.3	68.1	69.1	74.0	77.3	97.2