

PREPARATION OF CARBON NANOFIBER USING CHLORINATED PVC/ISOTROPIC PITCH MIXED SOLUTIONS BY ELECTROSPINNING

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Introduction

In recent years, the demand for piping materials in developing countries such as South Asia and the Middle East is increased. Most of the piping materials are derived from the polyvinyl chloride (PVC) and chlorinated polyvinyl chloride (CPVC) due to their excellent high heat resistance and relatively low cost. An increase of such halogenated plastic derived wastes is issuing environmental problems. Incineration of PVC and CPVC emits many harmful chlorinated dioxins gases like polychlorinated dibenzodioxins. One of the effective utilization methods of the CPVC wastes is their usage-usage as a raw material to prepare useful materials, such as CPVC-derived carbon nanofibers. It has been reported that 100–300 nm sized CPVC nanofibers can be obtained using the electrospinning technique. However, the obtained electro-spun CPVC nanofiber was totally melted down during the carbonization. Yao *et al.* succeed to produce the CPVC-derived carbon nanofiber by electrospinning using Fe₃O₄ as a catalyst to maintain the nanofiber structure [1]. In this study, as an alternative method to improve-overcome the melting problem of CPVC nanofiber during the carbonization, isotropic pitch (IP) of softening point at *c.a.* 260-°C was blended with CPVC. It was-believedis expected that IP could maintain the nanofiber structure during the carbonization process and CPVC would give the-an effect of halogenation-dehalogenation to oligomerize-polymerize the pitch and CPVC with high aromaticity and molecular weight. In addition, released chlorine from CPVC during the carbonization may generate narrow micropores even without the activation step. Therefore, it is expected that CPVC/IP-derived carbon nanofiber can be utilized in many application fields as adsorbents.

Materials and Methods

CPVC (H-17 grade, the degree of polymerization (DP, JIS K 6720-2): 750±50, chloride content: 63 wt%, no-Plasticizer, Hanwha Chemical Co. Ltd., Republic of Korea) was used as a starting material. As a blending material, IP was used in this study. IP was vacuum evaporated at 270°C for 3 h with stirring. The vacuum-evaporated-IP was then thin-layer-layer-evaporated at 250–370°C for 1 h. The final softening point of thus-the prepared IP was *c.a.* 260°C. The optimum weight ratio of CPVC and IP was studied by changing the blending ratio. The mixture of CPVC and IP was placed on a hotplate and was stirred at 1000 rpm and 50°C for 3 h, and then at 500 rpm at room temperature for 21 h. The prepared polymer solution was electro-spun at 30 kV of voltage. The distance between a syringe tip and a collector, the spinneret width, and winding speed were 15 cm, 0 mm, and 100 rpm, respectively. After the collecting of CPVC/IP nanofiber, the stabilization at 260°C under in oxygen atmosphere and carbonization at a various temperature range from 400 to 800°C under nitrogen flow were conducted. The surface morphologies and fusion of fibers were analyzed by using scanning electron microscopy (SEM).

Results and Discussion

Fig. 1 (a) and (b) show morphological changes of the electro-spun nanofiber of CPVC without IP blend by the heat treatment. CPVC nanofibers fused at ~~200°C~~ 260°C, which was lower than the decomposition temperature of CPVC nanofiber.

To improve the thermal properties of CPVC-derived nanofiber, the ~~thin-layer~~ layer-evaporated IP was blended. The blending ratio of CPVC and IP was controlled from 0 to 100 wt%. The optimized CPVC/IP ratio was found to be 20:80 in weight. The optimized ratio of CPVC2/IP8 (Fig. 1 (d)) ~~showed~~ gave almost no fusion of fibers. Otherwise, as the CPVC ratio increase, the fusion of fiber ~~also~~ increase: For example, when the CPVC content was 70 wt%, a fusion of fibers ~~were~~ was observed (Fig. 1(c)) The final yield for the optimized sample was *c.a.* 58% in weight.

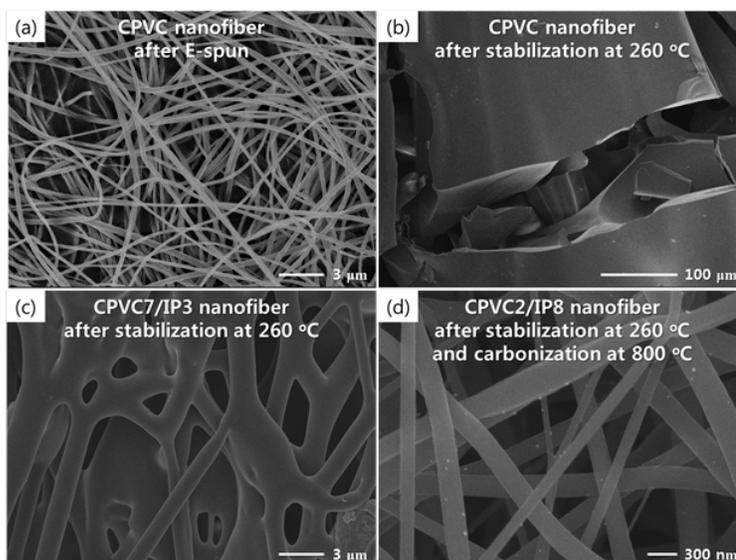


Figure 1. SEM images of CPVC-derived electro-spun nanofiber (a) before and (b) after heat-treatment at 260°C in air, (c) CPVC7/IP3 blended nanofiber after heat-treatment at 260°C in air, and (d) CPVC2/IP8 NF after heat-treatments at 260°C in air and 800°C in N₂.

After the carbonization of the stabilized CPVC/IP nanofiber at 600°C or higher ~~of the stabilized CPVC/IP nanofiber~~, the specific surface area was higher than 620 m²/g, the total pore volume was 0.2 cm³/g, and the average pore width was less than 0.7 nm. Narrow and shallow pores were considered to develop in CPVC/IP carbon nanofiber because the chlorine component was decomposed and released during the carbonization process of CPVC/IP nanofiber. After the steam activation at 800°C, the specific surface area ~~was~~ drastically increased more than *c.a.* 1700 m²/g and pore volume was doubled.

Conclusions

Using CPVC, a low-cost polymer, nano-size carbon fiber (CNF) was successfully fabricated by blending with IP. The high specific surface area was obtained even without the activation process.

Acknowledgment

Times New Roman, 10 font, justified text, single interlineal spacing

References

- [1] K. Yao, J. Gong, J. Zheng, L. Wang, H. Tan, G. Zhang, Y. Lin, H. Na, X. Chen, X. Wen, T. Tang, (2013). Catalytic carbonization of chlorinated poly(vinyl chloride) microfibers into carbon microfibers with high performance in the photodegradation of congo red, *J. Phys. Chem. C*, 117, 17016–17023.