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Preparation of activated carbon from needle coke via two-stage steam activation process

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ABSTRACT

Mesoporous activated carbon was prepared from needle coke via two-stage steam activation process under high temperature. Two-stage steam activation method involves three main steps: 1st steam activation to generate mesopores and macropores above 2 nm; coating and impregnation of substances with a low molecular weight into the pores; 2nd steam activation to expand the pore size and micropore volume. The needle coke was characterized by elemental analysis, polarized light microscopy, and thermogravimetric analysis, and the porosity structure was analyzed by the Brunauer-Emmett-Teller (BET) method, the t-plot method, the Barrett-Joyner-Halenda (BJH) method, and the scanning electron microscopy (SEM). The maximum specific surface area and mesopore volume ratio of activated carbon manufactured by two-stage steam activation method was 1134 m^2/g and 78%, respectively. The mesopore volume and average pore diameter increased as more coating and impregnation agents were added.
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1. Introduction

Recently, the demand for activated carbon has increased due to serious environmental problems, such as air pollution and water pollution and demand for electric double-layer capacitors (EDLCs) [1–3]. Activated carbon is manufactured from wood, sawdust, black liquor lignin, coconut shell, coal, petroleum heavy oil, coal and petroleum pitch, coke, etc [4–6]. The activation methods are generally divided into two methods [7,8]. One is a physical activation method [9,10] using steam, H_2O_2, CO_2, and air, and the other is a chemical activation method using KOH, NaOH, $ZnCl_2$, etc [11–13]. The chemical activation method has drawbacks of secondary contamination, complexity of the manufacturing process, and corrosion of the device, but activated carbon with exceptionally high specific surface area can be produced using this method [7]. On the other hand, the physical activation method has a disadvantage of requiring a high temperature of 700–1000 °C to expand the pore structure and increase the specific surface area [8]. Thus, it is important factor to select economical raw materials and active methods depending on the purpose of use for activated carbon.

Needle coke, as a carbon material exhibiting excellent electrical conductivity and high-density characteristics, is used as a raw material for high-performance graphite electrodes, and needle coke can be used as a high-performance carbon material for electric double-layer capacitors (EDLCs) due to its excellent electrical conductivity [14,15]. However, high-density anisotropic carbon materials, such as needle-shaped coke, are generally difficult to produce as activated carbon having a high specific surface area through physical activation with steam, H_2O_2, CO_2, and air [14,15]. Recently, an activation method to produce activated carbon having a high specific surface area using needle coke was reported through chemical activation with KOH and NaOH [13,15].

This study was designed to economically produce excellent activated carbon for use in electrode materials. Accordingly, activated carbon was developed from needle coke having excellent electrical conductivity through the steam activation method which is economical and easy to control the manufacturing process. In this study, we studied the activated carbon with a high specific surface area from needle coke by inducing a change of the surface structure via two-stage steam activation method, as shown in Fig. 1.

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