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RESEARCH PAPER

# Preparation of carbon fibers from low-molecular-weight compounds obtained from low-rank coal and biomass by solvent extraction

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**Abstract:** The practical use of carbon fibers is limited by their high price mainly due to the high price of precursors. We have examined a high temperature solvent extraction method to prepare carbon fiber precursors from low-rank coals and biomass, using a lignite from Australia and rice straw. 1-methylnaphthalene at 350 °C was used for the extraction and some of the extract in the solvent was precipated at room temperature. The soluble fractions at room temperature were obtained for use as the precursors by solvent evaporation. They were spun into fibers by a centrifuge spinning system and were then were extracted by cyclohexane to increase the softening point, stabilized by a temperature-programmed thermal treatment in air from 80 °C to 330 °C and carbonized at 1 000 °C for 1 h in $N_2$ to obtain carbon fibers. The carbon and oxygen contents of the final carbon fibers were 92 and 6.0 wt%, respectively, similar to those of commercial carbon fibers. The fiber diameter was around 4-6 μm. The soluble fractions were found to be promising low-cost precursors for carbon fibers.

**Key Words:** Carbon fiber; Degradative solvent extraction; Low-rank coal; Biomass

## 1 Introduction

Carbon fiber, as a high value-added carbon material, can be used widely for various purposes, such as a raw material for aircraft manufacture, construction, automobile, sporting goods. However, the practical utilization of carbon fiber is limited by its high price which is caused by the high cost of its feedstocks as well as manufacturing cost. Conventional precursors for carbon fiber preparation are polyacrylonitrile (PAN) and pitch. In 2012, more than 96% of global carbon fiber was made from PAN [1], which is a rather expensive precursor for carbon fiber preparation. Coal tar pitch and petroleum asphalt pitch were also widely studied to prepare carbon fiber[2-4]. However, the pretreatment, preparation and purifying procedure for these precusors is complex and the produced carbon fiber generally have poor property compared with the PAN-based carbon fiber [5]. Biomass, as a renewable material, is expected to be a promissing raw material for carbon fiber preparation. However, the real precursor is just lignin, which accounts for less than 30% of the total biomass and has to be separated from raw biomass by some methods, such as steam explosion[6, 7], organic solvent treatment or chemical method [8-12]. However, the methods used were complex and not environment-friendly. Additionally, carbon fiber preparation process generally involves spinning, stabilization and carbonization. The precursor (except PAN) is spun at the temperature over its melting point to obtain spun fiber/precursor fiber, which is then stabilized generally at about 200 – 400 °C in air by oxidization to increase their softening points [13-15]. Therefore, the melting point must be low enough for the spinning and high enough for the stabilization to be completed in short time.

We have proposed a degradative solvent extraction method to separate various types of low-rank coals and biomasses into three solid fractions under mild conditions [16-18]. The extraction was performed by using a nonpolar solvent under the temperature lower than 350 °C. The solid fractions consisted of residue (termed as residue), high molecular wieght fraction which is extracted at the extraction tempetrature but precipitates at room temperature (termed as deposit), and low molecular weight fraction which is extracted at the extraction temperature and soluble in the solvent even at room temperature (termed as soluble). The utilization of the three fractions were studied for various purposes in our previous works[19-21]. The soluble was obtained with the yield of around 23-61%, which has a carbon content of 80-85% and

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