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Full Length Article

Box-Behnken design approach towards optimization of activated carbon synthesized by co-pyrolysis of waste polyester textiles and $MgCl_2$

Zhihang Yuan [1], Zhihua Xu *,[1], Daofang Zhang, Weifang Chen *, Tianqi Zhang, Yuanxing Huang, Lin Gu, Haixuan Deng, Danqi Tian

516 Jungong Rd., School of Environment and Architecture, University of Shanghai for Science and Technology, Shanghai 200093, PR China

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A B S T R A C T

Pyrolysis activation of waste polyester textiles (WPT) was regarded as a sustainable technique to synthesize multi-pore activated carbons. MgO-template method of using $MgCl_2$ as the template precursor was employed, which possessed the advantages of ideal pore-forming effect and efficient preparation process. The response surface methodology coupled with Box-Behnken design (BBD) was conducted to study the interaction between different variables and optimized preparation conditions of waste polyester textiles based activated carbons. Derived from BBD design results, carbonization temperature was the most significant individual factor. And the maximum specific surface area of 1364 m^2/g, which presented a good agreement with the predicted response values(1315 m^2/g), was obtained at mixing ratio in $MgCl_2$/WPT, carbonization temperature and time of 5:1, 900 °C and 90 min, respectively. Furthermore, the physicochemical properties of the sample prepared under optimal conditions were carried on utilizing nitrogen adsorption/desorption isotherms, EA, XRD, SEM and FTIR. In addition, the pore-forming mechanism was mainly attributed to the tendency of carbon layer coating on MgO to form pore walls after elimination of MgO and the strong dehydration effect of $MgCl_2$ on WPT.

1. Introduction

As a highly effective adsorbent, activated carbon has been used in various applications such as water treatment, air purification and gas storage, due to its high surface area, diverse pore structure and wealth of surface functional groups [1–3]. At present, application of commercial activated carbons is mainly confined to economic reasons of relatively expensive raw materials. Therefore many researchers have focused on the development of alternative precursors such as agriculture and industrial waste, due to their eco-friendliness and cost-effectiveness [4–6].

Recently, more than 20 million tons of waste textiles were produced every year in China, and close to 70% of which is waste chemical fabrics [7]. It is bound to result in serious pollution if disposed improperly. In particular, waste polyester textiles (WPT), one of the common chemical fabrics is refractory in the environment if not properly treated. Most of them were burned in open air for quick disposal, leading to serious air pollution. Another way to dispose of this waste was focused on dissolution method for recycling. Oftentimes, it consumed large quantity of chemicals and required hard processing [8,9]. To solve above problems, some researchers employed waste textiles such as cotton woven [10] and acrylic textile [11] as precursor for the production of activated carbons. However, few studies focused on the WPT feasibility as precursor to prepare activated carbon. This material is quite similar to most of precursors for activated carbon preparation, thus it is reasonable to presume that WPT also could be a promising carbon precursor.

In general, activated carbons were mainly produced by pyrolysis-activation method. Recently, more studies were made to manipulate the activation pathway so as to produce activated carbons that possess high surface area and specific pore structures. One of the methods reported in recent papers is the so-called MgO-templated method, utilizing MgO as templates to prepare nanoporous carbon [12–14]. Compared to conventional activation processes such as $ZnCl_2$ [15], H_3PO_4 [16], CO_2 [17] and $H_2O(g)$ [18] activation, this method was successful in preparing activated carbon with high surface area and has advantages to obtain

* Corresponding authors.
E-mail addresses: zhihuaxu_usst@163.com (Z. Xu), chenweifang@tsinghua.org.cn (W. Chen).

[1] Both authors contributed equally to this work and should be considered co first authors.

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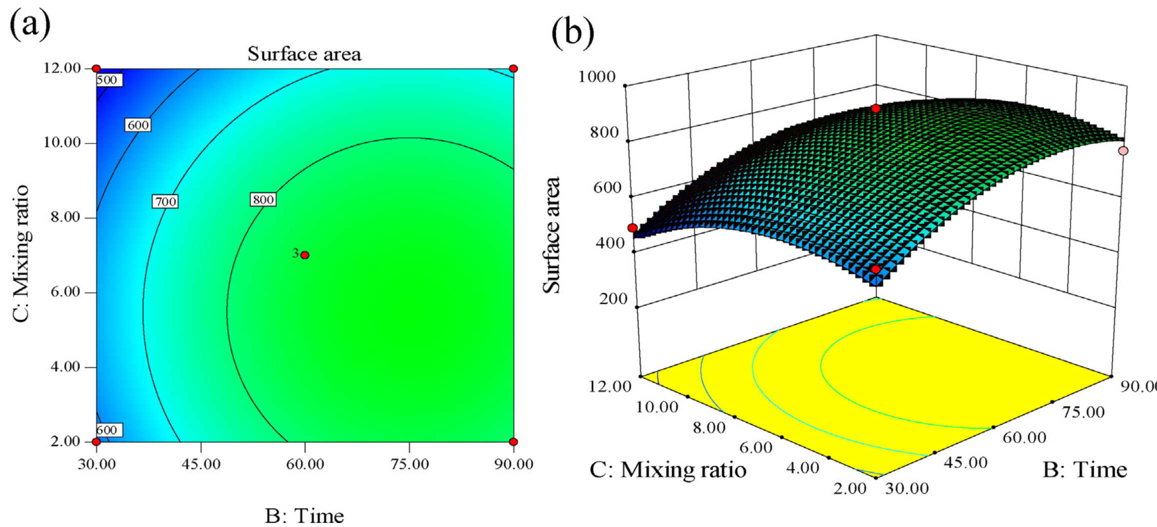

Fig. 1. Contour plot (a) and three-dimensional response surface (b) for effect of mixing ratio in $MgCl_2$/WPT and carbonization time on surface area.

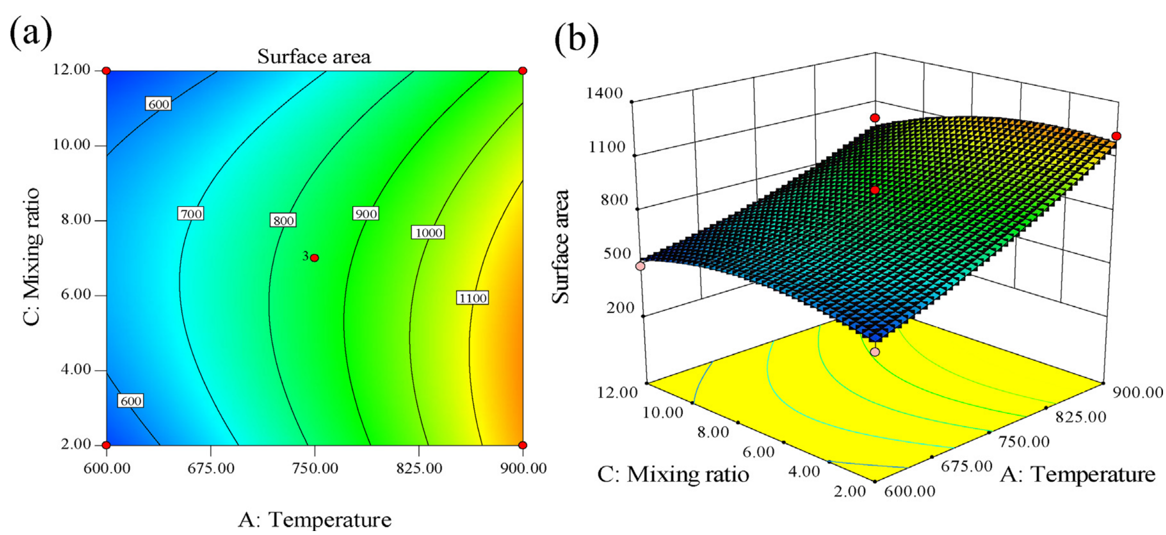

Fig. 2. Contour plot (a) and three-dimensional response surface (b) for effect of mixing ratio in $MgCl_2$/WPT and carbonization temperature on surface area.

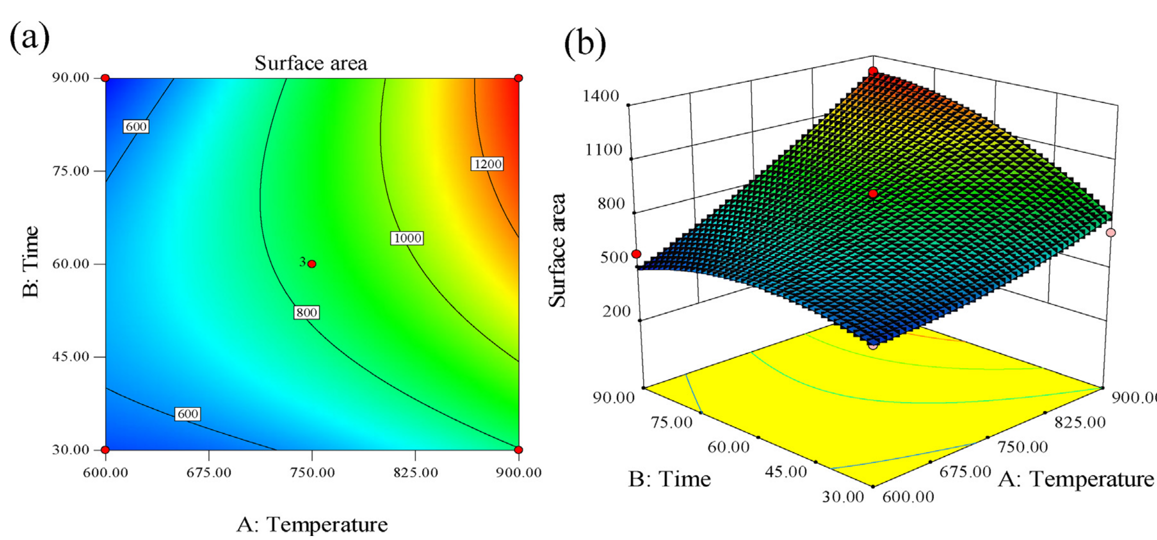

Fig. 3. Contour plot (a) and three-dimensional response surface (b) for effect of carbonization time and temperature on surface area.