Synthesis, Characterization and Selective Adsorption of Ordered Mesoporous Carbon in Different Pore Size Distribution

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***Abstract*—Ordered mesoporous materials, because of its specific high surface area, a large pore size and uniform pore size distribution, reflects its more obvious advantages in the adsorption. By regulating the pore size distribution of mesoporous carbon, not only can expand the range of selective adsorption of ordered mesoporous carbon for heavy metal ions, organic molecules and functional groups, but also provide limited space for ions or molecules which loaded into the aperture of mesoporous carbon and it is conducive to diffuse in the pore canals and adsorptive separation for pollution and solvent molecules. The study describes the adsorption behavior of dyeing wastewater such as rhodamine B from aqueous solution using ordered mesoporous carbon in different pore size distribution. Ordeded mesoporous carbon was synthesized with the evaporation induced self-assembly method in different proportion of template agent (F127) and phenolic resin and employed to evaluate the effects of initial concentration, contact time, pH and temperature on the removal of rhodamine B in batch experiments. In addition, because of the fluorescent effect of rhodamine B, this study used laser scanning confocal microscopy (LSCM) to observe the pollutants' adsorption conditions under different apertures of ordered mesoporous carbon. The experimental results indicated the ordered mesoporous carbon in different pore size distribution showed significant differences in the adsorption of rhodamine B and it was provided with an excellent selective adsorption.**

Keywords-ordered mesoporous carbon; rhodamine B; pore size distribution; adsorption; laser scanning confocal microscopy

I. INTRODUCTION

Ordered mesoporous carbon (OMC) has been studied extensively in the adsorption and catalysis fields and has a mesoscale pore [1, 2]. Ordered mesoporous materials play a most important role in the adsorption because it has specific high surface area, a large pore size and uniform pore size distribution [3]. But it is still a serious problem that how to effectively regulate the pore size distribution of mesoporous materials. Zhao Yuan et al [4-6] use triblock polymer F127 as template, phenolic resin as carbon precursor and OMCs were synthesized by solvent evaporation induced self-assembly method in a non-aqueous system. Also they successfully prepared mesoporous carbons in different pore distribution through the use of homemade two block polymer as a template agent. So it is an effective way to control the pore distribution by exchanging the template agent or exchanging the proportion of template agent and carbon precursor [7, 8].

II. MATERIAL AND METHODS

OMCs were synthesized via an evaporation-induced self-assembly (EISA) method with Pluronic F127 as a template [9]. For a typical preparation procedure, 1.0–3.0 g of F127 was dissolved in 10–30g of ethanol, and then the dilution of phenolic resin (Ming Yang Bonded Materials Co., Ltd., Wuxi City, Jiangsu Province) in ethanol solution was added by stirring for 10 min to obtain a homogeneous solution. The proportion of template agent (F127) and phenolic resin was 1.5:1,1:1,0.5:1, respectively. The solution was poured into dishes to evaporate ethanol at 50℃ for 12h, followed by thermopolymerization in an oven at 105℃ for 24h. The as-made products were scraped from the dishes and crushed into powders. In order to remove the Pluronic F127 templates, the as-made samples were calcined in a tubular furnace under nitrogen atmosphere with the flowing rate of 60 cm^3/min at 700℃ for 180 min[10, 11]. Scanning electron microscopy (SEM) and laser scanning confocal microscopy (LSCM) were used to characterize the adsorbing material.

III. RESULTS AND DISCUSSIONS

Fig.1 shows the SEM images of the mesoporous carbon (F127: phenolic resin=1:1) with different magnifications. They are consistent with the well-ordered body-centered mesoporous structure. SEM images (Fig.1 a and b) show that the structures of the as-synthesized monoliths are constructed from interconnected particles. As can be seen

from Fig.1, OMCs is provided with cylindrical shaped particles and ordered structure.

A 200 mL sample of rhodamine B solution with the initial concentration 9.92mg/L, was added to 0.5g of adsorbent and the concentration of rhodamine B in the solution was monitored at different times, namely 30, 60, 90, 120, 150, 180, 240, 360, 480, and 1440 min at optimum pH, T, etc. After the reaction starts, both adsorption and desorption processes occur till equilibrium is reached. As Fig.2 shows, the adsorption capacity of mesoporous carbon increased with contact time up to 120 min. After this time, there is no considerable change in rhodamine B removal. Therefore, one can conclude that the system attains equilibrium value at 120 min; this time is used for all equilibrium studies that follow. At the same time, the figure shows that when the mass ratio of F127 and phenolic resin reached 1:1, the adsorption ability of ordered mesoporous carbon was best. Adsorption studies have indicated that pH of the solution strongly affects adsorbate removal because both density and sign of charges on the adsorbent surface varies with pH of the solution. In this work, pH of rhodamine B solution was adjusted to arrange of values from 3 to 11 with appropriate volume of buffer solutions, all other parameters was kept constant, and the results are shown in Fig.3. Adsorption of rhodamine B onto mesoporous carbon decreased from 99.546% to 84.805% when pH of the solution was increased from 3 to 11.

After adsorption equilibrium is reached, adsorbate is collected again and is evaporated at 105℃ for 24h. Then we use laser scanning confocal microscopy to detect the adsorbate with different pore size distribution compared with commercial ordered mesoporous carbon (Ji Cang nanometer, Nanjing City, Jiangsu Province), the results obtained with the adsorption equilibrium results. As the Fig.4 shown, under the same magnification, the adsorption ability of the ordered mesoporous carbon when the mass ratio of F127 and phenolic resin reached 1:1 was the best and the fluorescence of it reflects that this kind of adsorbates has more active adsorption sites compared with others. So the controlling of the mass ratio of F127 and phenolic resin is an effective way to synthesize the ordered mesoporous carbon in different pore size distribution. When the mass ratio of F127 and phenolic resin reached 1.5:1-1:1, the pore size distribution of ordered mesoporous carbon is well-organized and uniform, but in different space structure. If the mass ratio of F127 and phenolic resin declines to 0.5:1, the pore structure of ordered mesoporous carbon will be irregular and the adsorption ability will corresponding decreases at the same time.

IV. CONCLUSIONS

Results of this study demonstrate that OMCs can be used to remove rhodamine B from aqueous solutions effectively. Also the results show that the adsorption ability of OMCs is as follows: the mass ratio of F127 and phenolic resin reached 1:1> the mass ratio of F127 and phenolic resin reached 1.5:1> the mass ratio of F127 and phenolic resin reached 0.5:1. So the most optimun proportion of F127 and phenolic resin for synthetizing OMCs is 1:1 and it is an effecttive and feasible way to control or adjust the pore size distribution of OMCs by changing the mass ratio of template and carbon precursor.

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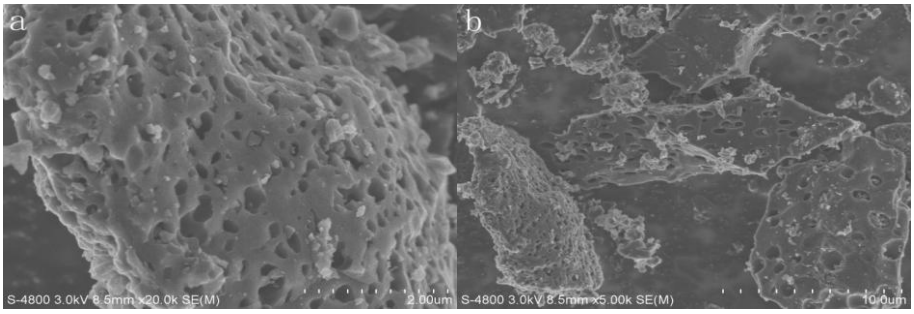

Figure 1. SEM images of ordered mesoporous carbon (F127: phenolic resin=1:1) in different magnifications

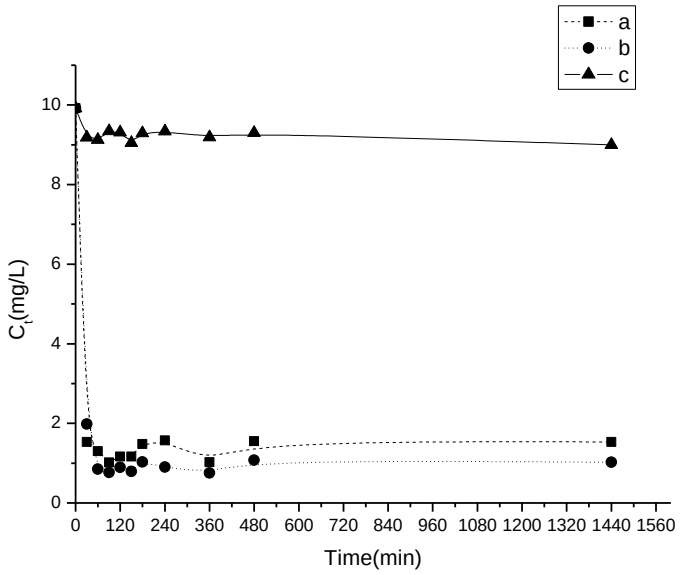

Figure 2. Effect of agitation time on the adsorption efficiency of rhodamine B on mesoporous carbon. a: the mass ratio of F127:phenolic resin=1.5:1; b: the mass ratio of F127:phenolic resin=1:1; c: the mass ratio of F127:phenolic resin=0.5:1

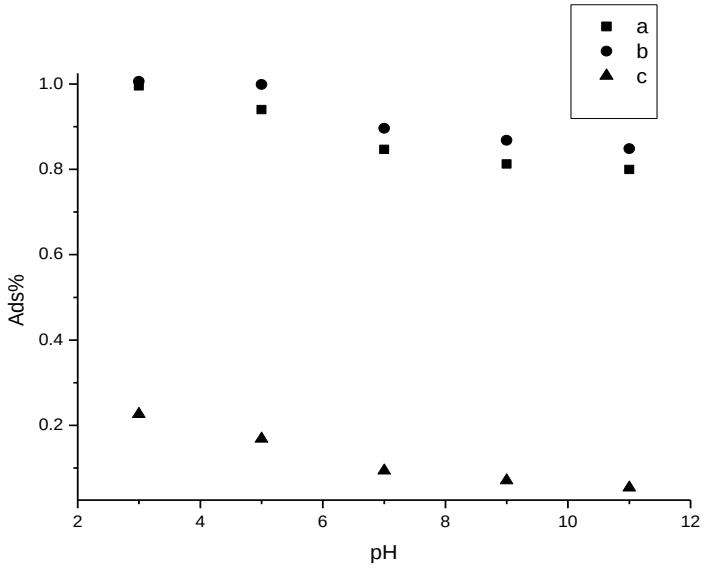

Figure 3. Effect of pH on the adsorption efficiency of rhodamine B on mesoporous carbon. a: the mass ratio of F127:phenolic resin=1.5:1; b: the mass ratio of F127:phenolic resin=1:1; c: the mass ratio of F127:phenolic resin=0.5:1

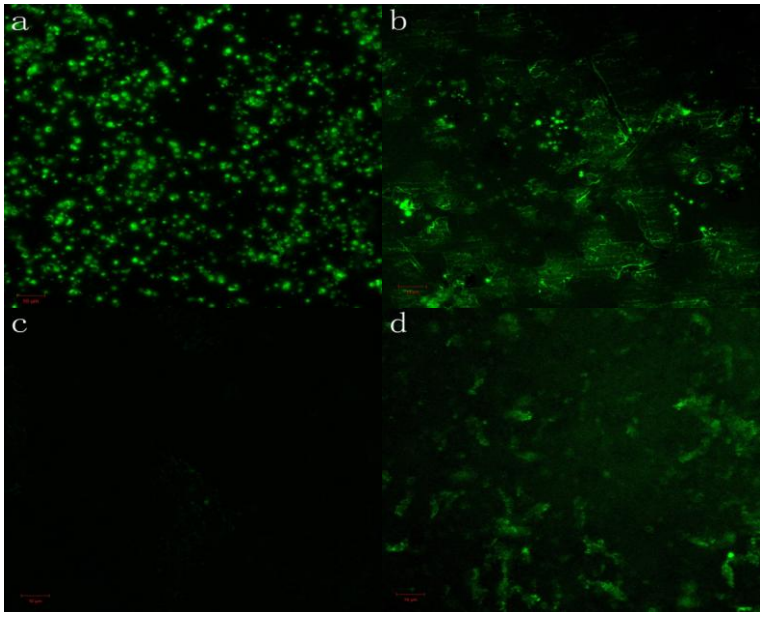

Figure 4. Laser scanning confocal microscopy (LSCM) images of the OMCs after reaching adsorption equilibrium under the same magnification. a: the mass ratio of F127:phenolic resin=1.5:1; b: the mass ratio of F127:phenolic resin=1:1; c: the mass ratio of F127:phenolic resin=0.5:1; d: commercial ordered mesoporous carbon.