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Cooperative effect of polyethylene glycol and lignin on SiO_2 microsphere production from rice husks

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HIGHLIGHTS

- Preparation of dispersed SiO_2 microspheres with narrow size distribution from rice husks (RH).
- Optimum synthesis conditions of the employed method were determined.
- Plausible cooperative effect of added PEG and extracted lignin on the formation of SiO_2 microspheres.

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ABSTRACT

A simple method to the preparation of SiO_2 microspheres from rice husks (RH) was developed. The rice husks were extracted with 2 M NaOH solution to obtain a extract contained silica and lignin, and silica spheres were obtained after addition of distilled water, ethanol, 1 M H_2SO_4 and PEG (W_{silica}:W_{PEG} = 2:1) to the extract in a controllable sol–gel process and calcination at 550 °C. The optimum synthesis conditions were, adjustment of the extract to pH 3, a volume ratio of 1:1:2 of ethanol, water, and extract, respectively and a silica to polyethylene glycol weight ratio of 2:1. The SiO_2 microspheres produced under these conditions exhibited a relatively uniform particle size distribution around 500 nm as determined by LPSA, which indicated a cooperative function of added PEG and extracted lignin towards the formation of SiO_2 microspheres.

1. Introduction

With a silica content of about 20%, rice husks (RH) could be a valuable feedstock for the production of porous silica useful for such applications as separation, adsorption, catalysis and thermal insulation (Jullaphan et al., 2009; Li et al., 2011). The conversion of RH, RH char and RH ash into porous silica has already been described (Adam et al., 2008; Chareonpanich et al., 2007; Jullaphan et al., 2009; Li et al., 2011; Sanchez-Flores et al., 2007; Witoon et al., 2008, 2009), and the use of rice husks (RH) as sources of lignin and silica for the production of nano-composites by a sol–gel process has also been investigated (Qu et al., 2010).

The hydroxyl groups in lignin can form hydrogen bonds with Si–OH groups (Hayashi et al., 1997; Qu et al., 2010) moreover the three-dimensional network of lignin (Argyropoulos and Menachem, 1998) may improve the uniformity and dispersibility of silica spheres. The current research aimed at finding a simple way to make use of RH as sources of lignin and silica to prepare SiO_2 microspheres in situ using a controllable sol–gel process. The influence of preparation conditions on morphology and size of the microspheres was investigated by changing the pH, the amount of water, ethanol and PEG in the sol–gel reaction system.

2. Experimental

2.1. Materials and reagents

RH was provided by a rice mill near Dalian, China, in the autumn of 2011. RH was washed thoroughly with distilled water to remove adhering soil and dust, and 0.5 M HCl was used to remove metal impurities. After drying at 100 °C overnight, the samples were porphyrized to 60 mesh. H_2SO_4 (AR), NaOH (AR), and ethanol (AR) were provided by Tianjin Kermel Co. Ltd. Polyethylene glycol (PEG, molecular weight = 2000, AR) was provided by Aladdin Chemical Co. Ltd. Distilled water was employed in all synthesis and treatment processes.

2.2. Preparation of silica spheres

Cleaned RH powder and 2.0 M NaOH were mixed at a ratio of 1:7 (w/v) in a 200-mL three-neck round-bottom flask equipped

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