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A new magnetic expanded graphite for removal of oil leakage

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ABSTRACT

Magnetic expanded graphite (MEG) was prepared using the blended calcination method under a nitrogen atmosphere. MEG was characterized by scanning electron microscope (SEM), X-ray powder diffraction (XRD), Raman spectroscopy, and vibrating sample magnetization (VSM). Results show that the cobalt ferrite nanoparticles were uniformly and efficiently deposited on expanded graphite (EG). The saturation magnetization reached 55.05 emu g^{-1}, and the adsorption capacity of MEG under the optimal condition was 35.72 g g^{-1} for crude oil.

1. Introduction

Oil boosts economic development, but oil leakage causes environmental pollution. Oil is present in wastewater as a floating film, either in dispersed or emulsified form. Conventional methods, such as adsorption, dissolved air flotation, flocculation, and coagulation, are used to eliminate oil leakage (Lim and Huang, 2007). Adsorption is the most common method to solve the oil pollution issue. Various adsorbing materials, such as carbon and carbon fiber materials (Lim and Huang, 2007; Sobgaida et al., 2008; Suni et al., 2004), rubber (Wu and Zhou, 2009), and polyurethane foams (Oh et al., 2000; Li et al., 2012), are widely used for this process. However, the adsorption capacities of most of these materials are low, and they can adsorb both heavy oils and water (Masahiro and Michio, 2000).

Expanded graphite (EG) has a developed pore structure, high surface activity, low density, and a large specific surface area. EG is used to adsorb oil, with a maximum adsorption capacity that reaches 80 g g^{-1} (Savos'kin et al., 2003; Masahiro and Inagaki, 2003). EG can float on the surface of the water after adsorption. However, its small particle size and high dispersion limit its recyclability in a large-scale water environment (Wang et al., 2010). Magnetic expanded graphite (MEG) was synthesized by adding magnetic particles to EG to simplify its operation and thus improve its application. The adsorption capacity of MEG, which was prepared using the citric acid sol–gel method, is above 40 g g^{-1} (Wang et al., 2010). However, its saturation magnetization (only 17.95 emu g^{-1}) requires further improvement. MEG was prepared using the blended calcination method under a nitrogen atmosphere. The structure of MEG was analyzed, and its adsorption capacity was studied for crude oil.

2. Experimental

2.1. Preparation of MEG composite

Cobalt ferrite nanoparticles were prepared using the precipitation method (Li et al., 2011). MEG composite was prepared using the blended calcination method. EG, glycerol, sulfuric acid, polyvinyl alcohol (PVA), polyvinylpyrrolidone (PVP), and cobalt ferrite nanoparticles were uniformly mixed according to a certain mass ratio and polymerized at room temperature. The samples were then placed inside a tube furnace and heated at 10 K min^{-1}, starting from room temperature and increasing to 973, 1073, 1173, and 1273 K. The samples were kept constant for 10 min in N_2. The EG control sample was obtained by calcining at 1173 K.

2.2. Adsorption capacity and regeneration rate of MEG

Crude oil was used to measure the adsorption capacity of MEG. One gram of MEG and excess oil were placed into a beaker. MEG was then collected using a magnet after saturated adsorption at 303 K. Adsorption capacity was calculated by weighing the remanent crude oil in the beaker. Oil recovery rate was obtained by desorption under vacuum. The regeneration rate of MEG was

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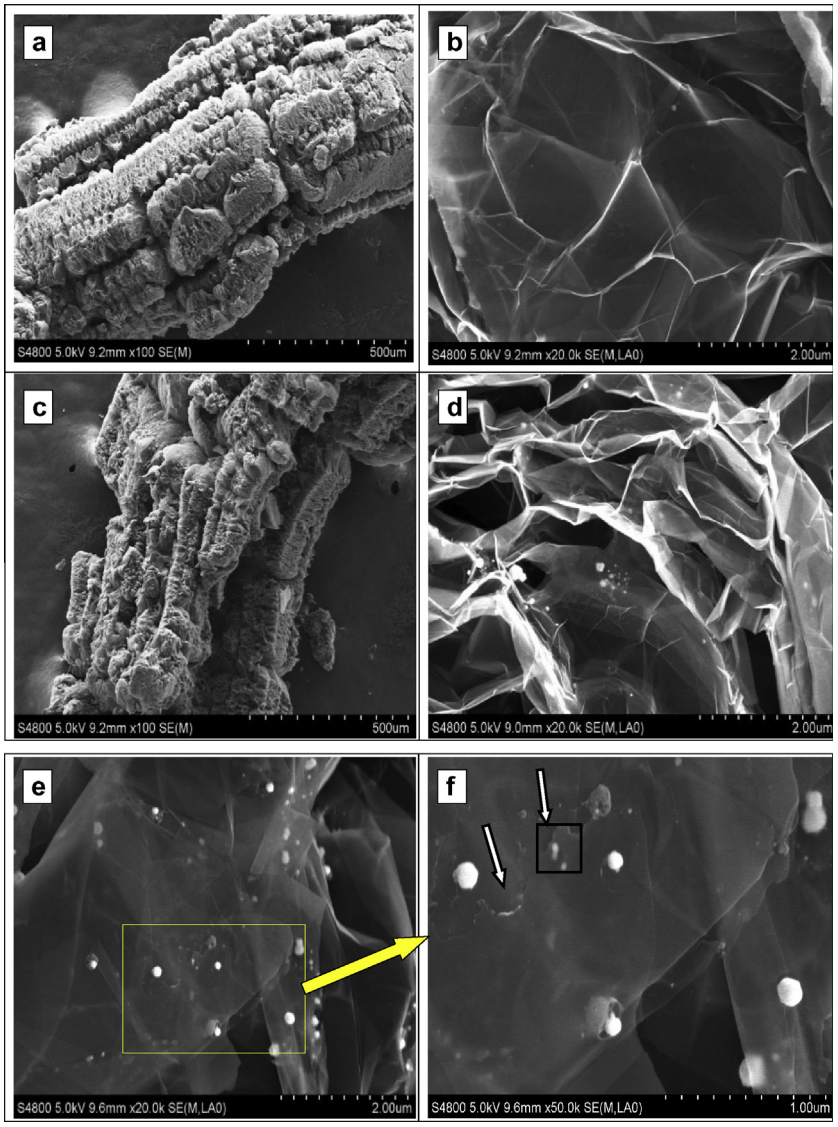

Fig. 1. SEM images of EG and MEG. (a) EG, (b) detail view of EG, (c) MEG, (d) layered structure of MEG, (e) and (f) detail view of MEG.

calculated as the difference between the oil adsorption quantity changes before and after the regeneration of MEG.

2.3. Structure of MEG

The morphologies were characterized by field emission scanning electron microscope (SEM, Hitachi S4800). Phase composition was analyzed using X-ray powder diffraction (XRD, X'PertPRO) at a continuous scan rate using Cu Kα_1 radiation (λ = 1.5406 Å). Raman spectroscopy was measured using a Renishaw INVIA. The vibrating sample magnetization (VSM) curve was obtained using a vibrating

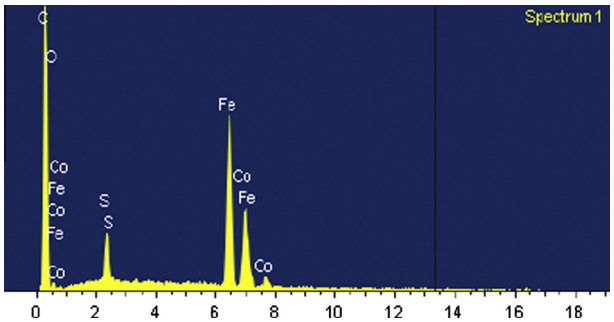

Fig. 2. EDS images of MEG.

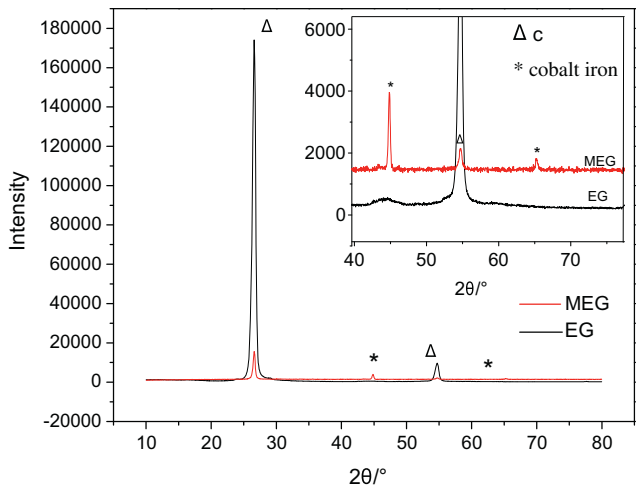

Fig. 3. XRD pattern of MEG and EG.