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Inhibition of fine particles fugitive emission from the open-pit lignite mines by polymer aqueous solutions

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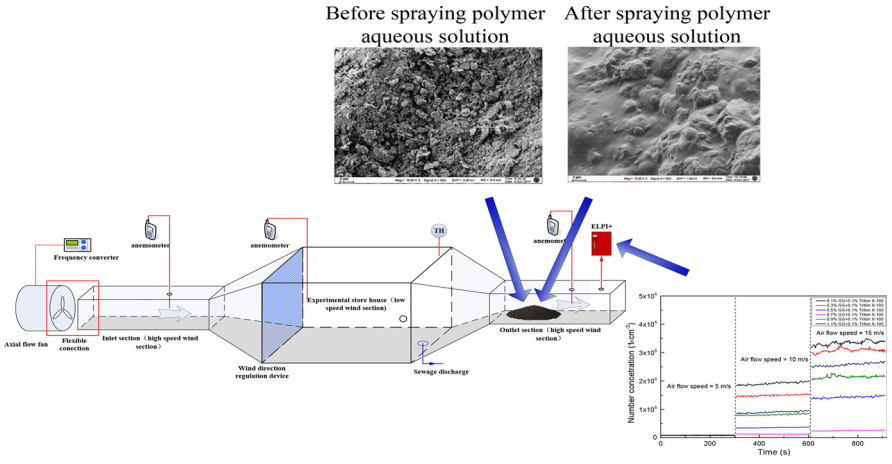
GRAPHICAL ABSTRACT



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ABSTRACT

To reduce the fugitive emission of fine particles from the open-pit lignite mines, a dust suppressant was proposed by applying a blend of 0.7% water-soluble polymer (guar gum) and 0.1% nonionic surfactant (Triton X-100) in this paper. The characteristics of the polymer protection film formed on the lignite sample's surface, as well as the wetting performances of surfactants on lignite were investigated, and the simulated dust suppression experiments aimed for the inhibition of lignite fine particles were also carried out. The results showed that the polymer molecules could adhere to the lignite fine particles through the solid-bridge force to form a polymer protective film, and the solid-bridge force between the lignite particles and polymer molecules was a type of chemical force. GG solution showed excellent solidified and anti rain erosion properties. The surface tension and contact angle of GG solution were obviously reduced with adding surfactant, and Triton X-100 with a mass concentration of 0.1% was chosen as the wetting component of the lignite dust suppressant. Besides, the lignite dust suppressant showed superior removal performances on lignite fine particles, and could effectively reduced the fugitive emission of fine particles in windy weather. When the air flow speed was in the range of 5–15 m/s, the dust suppression efficiency on lignite fine particles was above 98%.

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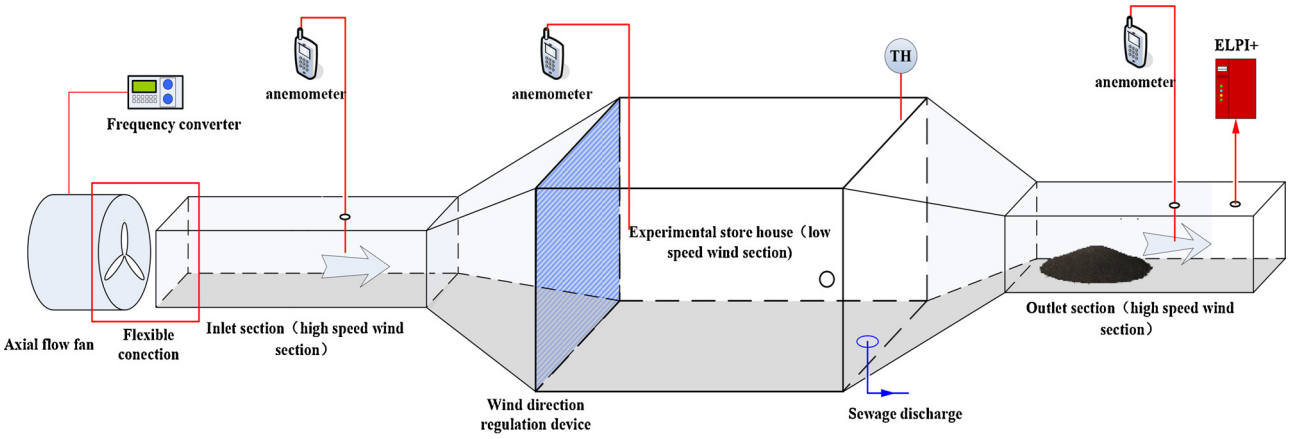
1. Introduction

Fine particles are one of the major air pollutants in China, and the air quality in haze-fog days was much worse than that in nonhaze-fog days due to the emission of fine particles [1–3]. Moreover, human also face the risk of heart and lung diseases because of fine particles, which can be easily enriched by heavy metals and toxic organic compounds [4–6]. The long-term measurement results have shown high concentration of fine particles in northern cities of China, and fugitive emission has been identified as a main source of fine particles emission [7,8]. Under the situation of ultra-low emission reformation in China, organized emissions from power plants and boilers are reduced obviously [9,10]. However, owing to fugitive emissions are difficult to govern effectively, the relative proportion of fugitive emissions are increased correspondingly [11].

On 13th June 2017, in response to the severe air pollution in China, more than twenty discharge standards of air pollutants were revised by China's Ministry of Environmental Protection [12]. The revisions improved the control requirements for fugitive emission in the transportation, uploading, loading, storage and production process of coal mines and coal-fired power plants. Currently, lignite resources are abundant in China, and it plays an important role in China's energy consumption structure [13]. According to the statistics at the end of twentieth Century, the proven lignite reserves were 130 billion tons, which accounts for about 17% of the total coal reserves in China [14]. Because of lignite's small particle size, the fine particles of lignite can be carried by the air flow in the open-pit lignite mines easily, thus, reducing fugitive fine particles of lignite has become an urgent problem to be solved in the environmental protection filed.

One of the common methods for dust suppression is water spraying, which aims to reduce the particle concentration in the air [15–17]. However, the suppression efficiency of water spraying often depends on the chemical properties of the particles surface, so that the dust suppression effect by spraying pure water on hydrophobic dust is usually unsatisfactory. The addition of surfactants can obviously reduce the surface tension of pure water to enhance the wetting performance on particles. Tang et al. reported that the respirable sintering dust was covered by a hydrophobic shell consisting of organics with n-alkyl chains and/or aromatic groups, and it could be sufficiently and efficiently wetted by Triton X-100 after moderate mixing, achieving by adsorption between their hydrophobic tails [18]. Simons et al. proposed a micro-scale study to elucidate the wetting behavior of binder solutions on paracetamol crystals in order to provide a low-cost and effective selection procedure for the optimal binder solution [19]. Ding et al. found that the contact angle of coal decreased greatly after surfactant solution was magnetized, when concentration increases from 0.02% to 0.03%; and the magnetization surfactant solution has great prospect in mine coal dust suppression [20]. However, due to the rapid evaporation



(a)

(b)

Fig. 1. The experimental facility for dust suppression. (a) Schematic of the experimental facility; (b) Photograph of the real experimental facility.