Design of Rheological Modifiers for Dispersion and Stability of Petroleum Coke Slurries

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ABSTRACT

Slurries made from petroleum coke (petcoke) particles in water have the potential to be a useful energy source. We studied the interactions between various additives and the petcoke and the effects on the slurry rheology. Adsorption and rheology studies with polyvinylalcohol, a partially hydrophilic polymer, showed that the polymer reduced viscosity only when adsorbed to the petcoke surface. Adding xanthan gum causes shear-thinning behavior, which increases storage stability, so the combination of these two additives may yield optimal slurry characteristics.

KEY WORDS: Petcoke, slurry, dispersion, stability, rheology.

INTRODUCTION

Petroleum coke (petcoke) is the solid byproduct of petroleum distillation. While it has some uses in specialized industries as a carbon source, it remains difficult to use petcoke as an energy source. One idea for its utilization is to grind it into small particles and produce a slurry with water that can be burned similarly to a heavy oil. The challenge lies in producing a slurry from large (1-100 µm) hydrophobic particles suspended in water while maintaining a very high solids content, low viscosity, and high stability against settling.

There has been much previous work about producing coal-water slurries (Stover, Thambimuthu, and Todd, 1990; Sugawara, Arai, and Ukigai, 1990; Thomson, 1989). In these studies, the primarily additives used were naphthalene sulfonate to induce a surface charge on the coal particles for better dispersion, and xanthan gum to create shear-thinning behavior for better stability. Only a few recent studies, however, have focused on producing slurries with petcoke (Zhou, Yang, and Qiu, 2008). In this talk, we will outline our progress in finding new strategies for optimum petcoke dispersion, through analysis of petcoke surface properties and its interactions with various surfactants and rheological modifiers.

EXPERIMENTAL

Rheological measurements were performed using Rheometric Scientific RM180. ATR-IR was used to measure adsorption isotherms via solution concentrations. A Thermo Scientific Nexus 670 FT-IR with a ZnSe ATR crystal were used for these measurements. Polyvinyl alcohol and xanthan gum were purchased from Sigma Aldrich. Petcoke was provided by SK Innovation Global Technology, and is sourced from Korea. The size distribution of the ground petcoke is shown below in Figure 1.

![Figure 1](https://example.com/image1.png)

Figure 1. The size distribution of the ground petcoke used to create slurries.

RESULTS AND DISCUSSION

We investigated the effects of polyvinyl alcohol (PVA) – a polymer with simple molecular structure and partial hydrophilicity – on the rheological properties of petcoke slurries. The PVA used for this study had $M_w=10,000$ and was 80% hydrolyzed (80% vinyl alcohol, 20% vinyl acetate). Figure 2 shows the viscosity of 57.5wt% petcoke slurries with added PVA. The PVA effectively decreases the viscosity across a wide range of shear rates (indeed, the shear stress decreased below the minimum detection limit of our rheometer at low shear rates, resulting in incomplete data sets). It is interesting to note that the slurry is shear-thinning with little or no PVA added, but becomes slightly shear-thickening when the viscosity is lowered at higher concentrations of PVA.

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