Chemical Engineering Journal 502 (2024) 157811

Contents lists available at ScienceDirect

Chemical Engineering Journal

journal homepage: www.elsevier.com/locate/cej

Effects of supercritical CO_2 on coal microstructure in VES fracturing fluid environment: Experiments and mechanisms

Liang Wang [a,b,c,*], Weiye Chen [a,b,c,*], Minxuan Liu [a,b,c], Songwei Wu [a,b,c], Chenhao Tian [a,b,c], Kun Sang Lee [d], Chao Liu [e]

[a] Key Laboratory of Theory and Technology On Coal and Rock Dynamic Disaster Prevention and Control, National Mine Safety Administration, China University of Mining and Technology, Xuzhou 221116, China
[b] State Key Laboratory of Coal Mine Disaster Prevention and Control, China University of Mining & Technology, Xuzhou 221116, China
[c] School of Safety Engineering, China University of Mining and Technology, Xuzhou 221116, China
[d] Department. of Earth Resources and Environmental Engineering. Hanyang University, Seoul 04763, Korea
[e] School of Mechanics and Civil Engineering, China University of Mining and Technology, Xuzhou, Jiangsu 221116, China

ARTICLE INFO

Keywords:
Coalbed methane extraction
Enhanced recovery
Pore structure
Macromolecular structure

ABSTRACT

Hydraulic fracturing and CO_2 injection are two effective methods for increasing coalbed methane (CBM) extraction. Following hydraulic fracturing, permeability of coal seams increases, which facilitates CO_2 injection and further extracts CBM. The fracturing fluid residue will impact the interaction of supercritical CO_2 ($ScCO_2$) with the coal in subsequent injection of CO_2. To explore the impression of $ScCO_2$ on coal in viscoelastic surfactant (VES) fracturing fluid environment, coal samples were immersed in VES fracturing fluid and subsequently treated with $ScCO_2$. The evolution of the microstructure was analyzed through physical adsorption, Fourier transform infrared (FTIR) spectra, X-ray diffraction (XRD) and Raman spectra. The results demonstrate that VES fracturing fluid plug the coal pores and do not elicit obvious chemical interaction with coal. $ScCO_2$ is capable of extracting the VES fracturing fluid residue in coal pores, could potentially facilitate the backdrafting of VES fracturing fluids. The effect of $ScCO_2$ is attenuated in the presence of VES fracturing fluid residue. The present research offers a theoretical foundation for optimizing coalbed methane extraction.

1. Introduction

Coal possesses a cross-linked macromolecular structure that incorporates a complex network of pores [1]. A substantial proportion of coalbed methane (CBM) is absorbed within the pores of coal. Consequently, CBM extraction must undergo a series of processes, including desorption, diffusion and seepage [2,3]. The inherently low porosity and permeability of coal seams presents significant challenges to CBM extraction [4].

Hydraulic fracturing and CO_2 injection are two effective methods for increasing CBM extraction [5,6]. Hydraulic fracturing entails the injection of high-pressure fluid into a reservoir to create fractures, thereby increasing the permeability of the coal seam [7]. Fracturing fluids are of vital importance in hydraulic fracturing technology, serving to transfer pressure [8]. The earliest fracturing fluids were oil-based, however, they have been gradually replaced because of significant environmental pollution. Currently, fracturing fluids are classified into two primary types: water-based fracturing fluids and foam fracturing fluids [9]. While foam fracturing fluids offer a multitude of advantages, they have not been widely promoted due to the complexity and high cost involved [10]. The most commonly used fracturing fluids are water-based, configured with water and various chemicals [9]. Among these, viscoelastic surfactant (VES) fracturing fluid has received particular interest due to its elevated viscoelasticity and low damage to reservoirs [9,11]. The infiltration of VES fracturing fluids into coal reservoirs affects the microstructure of coal through physicochemical effects, which affects CBM recovery. Fracturing fluids can obstruct pore spaces within coal, inhibiting the desorption and diffusion of CBM. Xue et al. [12] found that various types of water-based fracturing fluid could block the coal pores at varying degrees. Huang et al. [9] observed that fracturing fluids blocked coal pores, thereby reducing the adsorption capacity and diffusion coefficient of coal. Furthermore, the chemical components of the fracturing fluid could elicit chemical interaction with the substances present in coal, affecting its chemical structure. Wang et al. [13]

* Corresponding authors.
E-mail addresses: wangliang@cumt.edu.cn (L. Wang), chenweiye@cumt.edu.cn (W. Chen).

https://doi.org/10.1016/j.cej.2024.157811
Received 29 August 2024; Received in revised form 29 October 2024; Accepted 17 November 2024
Available online 28 November 2024


CEJ
CHEMICAL
ENGINEERING
JOURNAL