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Effect of CO_2 on the characteristics of soot derived from coal rapid pyrolysis

Qinghua Chang[1], Rui Gao[1], Hongjun Li[1], Guangsuo Yu[1], Fuchen Wang[1]

[1]Key Laboratory of Coal Gasification and Energy Chemical Engineering of Ministry of Education, Shanghai Engineering Research Center of Coal Gasification, East China University of Science andTechnology, Shanghai 200237, PR China

Email (Presenter): changqinghua123@live.com

Coal particles experience rapid pyrolysis in CO_2-rich atmospheres during oxy-fuel combustion, knowledge about soot formation in the CO_2-rich atmosphere is required to identify the possible chemical effect of high CO_2 levels on the soot characteristics. The present work aims to investigate the effects of a CO_2-rich atmosphere on the characteristics of coal-derived soot. The rapid pyrolysis of Shenfu bituminous coal was conducted in a Drop tube furnace (DTF) in N_2 and CO_2 atmospheres with a wall temperature of 1073-1473K and residence time below 700 ms. A series of techniques (elemental analysis, HRTEM, Raman, XRD, FT-IR and thermogravimetry techniques) were used to analyze the yields and microstructure characteristics of N_2-soot and CO_2-soot.

The soot formation was a rapid process and favoured T>1273 K. CO_2 enhanced the soot formation and proceeded the dehydrogenation. The sooting tendency increased in the CO_2 atmosphere compared to that in the N_2 atmosphere. The increased residence time and temperature caused the continually increased C/H and C/O atomic ratios. The higher C/H atomic ratios of CO_2-soot indicate the enhanced dehydrogenation in CO_2 atmosphere.

By analysing the Raman and XRD spectrum results, some remarkable differences of the carbon microstructures for CO_2-soot in comparison with N_2-soot were found: CO_2 improves the order of the internal carbon lattices, enhances the lateral extension of carbon nanostructures, decreases the interplanar spacing of the graphene layers and promotes the stack of polyaromatic layers. The variations of the SOLO, DUO, TRIO and QUARTO structures were also analysed, and the contribution of CO_2 was found to reduce the defects of the basic structure units (BSU).

The CO_2 atmosphere can promote the polymerization of tar and enhance the graphitization of soot. The CO_2-soot is more mature than the N_2-soot, and the gasification reactivity of CO_2-soot is relatively lower. The defects of soot are important indications of the initial gasification reactivity because there is an approximately linear correlation between r_0 and the area of the FT-IR peaks in the range of 925-700 cm^{-1}.