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Influence of HDPE addition on microstructure transformation during coking of Australian coking coals

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The partial substitution of coal with waste plastics in the coking process can improve resource recycling and sustainability of cokemaking and ironmaking processes. A fundamental understanding of how plastic pyrolysis influences microstructural transformations in coke ovens remains limited, despite its significant impact on coke quality. This study addresses this knowledge gap through an interrupted plastic layer sampling technique and Synchrotron micro-CT 3D image analysis.
Representative Australian mid-rank coking coals with varying fluidity and maceral compositions were blended with recycled high-density polyethylene (HDPE) granules (3-4 mm) at a 5% ratio, a common waste plastic in Australian domestic waste streams. A lab-scale double-wall coke oven was used to prepare coke-forming layer (CFL) samples through interrupted coking tests, which included characteristic layered structures formed under practical coking conditions. Synchrotron micro-CT was utilized to scan the CFL samples to examine the impacts of HDPE addition on microstructural transitions.
Overall, the addition of 5% HDPE decreased porosity in the intermediate CFLs but increased porosity in the semi-coke and coke regions. HDPE acted as a binder, forming a HDPE-coal mixture while hindering CFL formation. Voids generated by plastic devolatilization were insufficiently filled, leading to increased porosity in the later semi-coke stage and the final coke structure. The increased coke porosity with HDPE addition appeared to be related to the coke reactivity index (CRI), likely due to the higher diffusivity of CO_2. Notably, coal with higher fluidity and vitrinite content exhibited greater increases in porosity, mean pore size, and pore wall thickness during the resolidification and semi-coke stages, while showing minimal changes in the coke quality. This can be attributed to its inherent thermoplastic properties, which extend the overall transformation and enhance its resilience to the HDPE addition effect. Consequently, coals with higher vitrinite content and fluidity may improve the carrying capacity of HDPE in cokemaking.

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