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Investigation of chemical components on uranium occurrence and mobility in coal ash and synthetic ash

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Uranium in coal ash has been receiving a significant attention as a supplementary nuclear resource as well as its potential environmental risk. During coal combustion, uranium turns to integrate with alkaline minerals and subsequently be encapsulated in other fractions including the Si-Al glass, eutectic and Fe-enriched compound. In this study, the four coals supplied from Mengwang, Daizhai and Zhangtuo coal deposits and synthetic ashes (SA, uranium content is 1000 μg/g) were employed to investigate the uranium occurrence after combustion based on Tessier sequential extraction. It was clearly found that the content of residual uranium suddenly increased once the temperature was 900 $^\circ$ due to the generation of encapsulation minerals. On this basis, the uranium contents of different occurrences in SA were projected into ternary phase diagrams (Al_2O_3-CaO-Fe_2O_3) with the fixed content of SiO_2 (30%, 50%, and 70%) and Na_2O (2%). The uranium occurrence was governed by complicated interactions between uranium and other bulk minerals. Overall, the uranium mobility is higher at a higher proportion of SiO_2, which can prohibit the generation of some eutectics. The ash problems including sintering and slagging prefer to occur if a proper amount of alkaline element is provided. Hence, uranium tends to be encapsulated especially in some compact Si-Al compounds with SiO_2 content decreasing, leading to a lower mobility. Once the SiO_2 content decreased to 30%, the proportion of uranium occurrence was dominated by carbonates and Fe-Mn oxides. We also noticed that the encapsulation of Fe_2O_3 on uranium was significantly influenced by its content as well as Si and other minerals. Simultaneously, the activation of molten CaO could destroy stubborn structures of Si-Al as well as Si-Fe compounds, resulting in a progressive susceptibility to acid attack.