Control of Emissions from Combustion of Cesium-Contaminated Biomass via Sorbent Injection

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In the aftermath of a wide-area radiological contamination incident, there is the potential for the generation of significant quantities of contaminated biomass waste. For example, the 2011 nuclear power plant accident at the Fukushima Daiichi plant in Japan resulted in an estimated 7.8 million cubic meters of combustible waste, most of which was biomass. These wastes are likely candidates for incineration as a means of volume reduction, due to the costs associated with disposal of low-level radioactive waste. Cesium (Cs), an alkali metal element, is a radionuclide that might possibly be used in a radiological dispersal device or may be the predominant long-term radionuclide contaminant from a nuclear power plant accident. Cs presents problematic behavior in combustion systems due to its volatility and water solubility. Although high-temperature combustion or incineration systems cannot destroy the elemental metal constituents, these environments may induce metal transformations that exacerbate difficulties in controlling the emissions of radionuclides of interest because many of the metal species, including Cs, vaporize readily within combustion environments. This saturated metal vapor will subsequently nucleate and condense downstream of the flame, forming an aerosol with a mean volume aerodynamic diameter between 100 and 200 nanometers (nm). These condensed particles, because of their small size, are difficult to collect in air pollution control systems, particularly those using an electrostatic precipitator.

A series of experiments was performed to investigate how well the use of in-furnace kaolinite sorbent injection captured Cs emissions from combustors. The experiments were performed in a rotary kiln incinerator simulator firing pelletized biomass fed into the rotating drum section of the combustor. In these experiments, the biomass material was doped with non-radioactive Cs in the form of aqueous CsCl (cesium chloride). A MOUDI spell out impactor was used as the primary sampling device, where success of capture was assessed by whether the Cs predominated in the smaller-particle-size impactor stages or whether the Cs was caught on the impactor stages corresponding to the larger sorbent particle size, an indication that the Cs was associated with the sorbent particles. The larger particle size would be more amendable to capture by a particulate matter filtration system.

Without sorbent injection, Cs was almost totally associated with the particle size fraction exhibiting an aerosol diameter less than 180 nm. With injection of the sorbent, approximately 91% of the Cs was shifted to the supermicron particle size fraction. This presentation will describe these experiments and results.