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Short Communication

# Further study on biomass ash characteristics at elevated ashing temperatures: The evolution of K, Cl, S and the ash fusion characteristics

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## HIGHLIGHTS

- Inorganic S is released in the form of $SO_2$ by the silicate of $K_2SO_4$ above 1000 °C.
- K is mainly reduced by the evaporation of KCl and $K_2SO_4$ aerosols.
- Cl disappears at 815 °C in the form of HCl due to the aluminosilicate of sylvite.
- Biomass AFC is mainly dependent on the high-temperature molten material.
- High-temperature molten material is built up by $SiO_2$, $K_3FeO_2$ and silicates.

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## ABSTRACT

Based on the ash-related problems during biomass combustion, the evolution of element S, Cl, K and chemical components and ash fusion characteristics of capsicum stalks, cotton stalks and wheat stalks ashed at 1000, 1200 and 1400 °C are further studied by XRF and XRD. Cl disappears at 815 °C in the form of HCl due to the aluminosilicate of sylvite. Above 1000 °C, inorganic S is released in the form of $SO_2$ by the silicate of $K_2SO_4$, which is the main reason that ashing ratio decreases at high temperature. Except of the evaporation of KCl and $K_2SO_4$ aerosol which cause the release of K, Cl and S, K may be also reduced by the organic decomposition and the releases of metal K and KOH. The ash fusion characteristics of biomass are mainly dependent on the high-temperature molten material built up by quartz, potassium iron oxide and silicates.

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## 1. Introduction

In 2007, 'Medium and long-term development plan for renewable energy in China' was published by the NDRC (National Development and Reform Commission). It declares that the installed capacity of biomass power will reach 30GW by 2020, accounting for 3% of the total installed capacity of China. And in USA and Europe, it is estimated that approximate 15% of electric power will be generated by biomass by 2020. But ash-related problems, such as slagging, agglomeration, corrosion and erosion, can result in frequent unscheduled plant shutdowns, decreasing the equipment utilization and increasing the costs of power generation (Niu et al., 2010a; Thy et al., 2006). That is closely related to the concentrations of K, Cl and S in biomass (Fryda et al., 2010; Johansen et al., 2011; Niu et al., 2010a,b,c). Therefore, detailed studies of ash characteristics, especially the evolution of element S, Cl, K and corresponding chemical components as well as fusion characteristics, are essential to resolve aforementioned problems.

An extensive and intensive research background of ash characteristics has been reviewed in previous paper (Niu et al., 2010b), respecting to ashing temperature and influence of slagging etc., only the newest research progresses are therefore introduced here. Li et al. (2012) study the ash fusion temperature using nine biomass and 27 simulated biomass ashes, and report that $Al_2O_3$ is more efficient that $SiO_2$ in reducing the slagging tendency. Johansen et al. (2011) report that the releases of K and Cl are closely related. K is significantly released in the temperature range of 700–800 °C in the form of KCl, and only 5–10% of mass loss below 700 °C; Cl is fully released at 800 °C, and Cl excess to K is release in the form of HCl; organic S is released below 500 °C, and inorganic S is released above 900 °C in the form of $K_2SO_4$ aerosol and $SO_2$ by the decomposition of $K_2SO_4$. While Wang et al. (2010) report that the largest $SO_2$ emission during the pyrolysis of straw is lied in the temperature range of 1200–1450 °C due to the decomposition of $K_2SO_4$, but the decomposition mechanisms are not declared.

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