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Co-firing High Sulfur Coal With Refuse Derived Fuels

Technical Progress Report #10

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1. Abstract

In previous progress reports, we reported our study on the proposed mechanism for the formation of chlorinated organics during combustion, in which molecular chlorine is thought to be the key starting material. The objective of this quarter of study was to quantitatively test the inhibiting effect of SO_2 on the formation of Cl_2 during the combustion of MSW. The experiments were conducted under conditions close to those employed in the AFBC system. The principle analytical technique used for identification of the products from these experiments was GC/MS system. The results indicate that the production of Cl_2 decreases when the concentration of SO_2 in the gaseous mixture increases.

2. Introduction

In order to better manage the disposal of municipal solid waste (MSW), more attention should be focussed on incineration as a way to convert waste to energy. This method of disposal has several advantages when compared to the traditional landfilling. However, because of the possible emission of volatile organic compounds (VOCS), extra care needs to be taken in burning MSW or RDF to optimize the operating conditions of a combustor, so that combustion can take place in an environmentally acceptable manner. The following mechanism is proposed to explain the possible formation of chlorinated organics and possibly PCDD and PCDFs during the combustion of MSW:

PVC → HCl and organics (undergoes thermal decomposition) (1)

$4HCl + O_2 \rightarrow 2H_2O + 2\ Cl_2$ (Deacon Reaction) (2)

$C_6H_5OH + Cl_2 \rightarrow$ chlorophenols (3)

condensation of chlorophenols → PCDDs and PCDFs (4)

It should be noted that PVC is a major component of plastic materials in MSW and C_6H_5OH comes from the burning of newspaper.

It has been reported that when high-sulfur coal is co-fired with MSW unwanted emissions of chlorinated organics will be diminished drastically. The theory is that in the presence of a substantial amount of sulfur the production of Cl_2 and, consequently, PCDD/Fs formation is suppressed. This results from the reduction of Cl_2 to HCl according to the following reaction:

$SO_2 + Cl_2 + H_2O \rightarrow SO_3 + 2HCl$ (5)

The inhibitory effect of SO_2 on the Deacon reaction was shown in the last technical report (#9). Additional research is needed to develop optimum co-firing conditions and parameters. This report presents the results of our quantitative study of SO_2 on the formation of molecular chlorine.

3. Experimental

To closely simulate conditions in an AFBC combustor, experiments were conducted in a quartz tube mounted horizontally in an electrically heated Lindberg furnace. The flow rates of HCl (l% hydrogen chloride in nitrogen), SO_2 (4.86% sulfur dioxide in nitrogen), and air were adjusted to give the desired concentration of reactants and then introduced into the reactor. The reaction was run for 4 hours at 800°C. The evolved gases were trapped by a carefully chosen absorbent, which was prepared by dissolving 50 mg phenol (reagent grade) in 25 mL of methylene chloride (reagent grade).

4. Results and Discussion

In the quantitative study, we fixed the concentration of HCl and O_2 in the gaseous mixture, and only changed the amount of SO_2. At each condition, the results were based on three test runs. We used the rate of chlorination of phenol to measure the production of molecular chlorine during the experiments, the results of which are shown in Table 1. Phenol is an effective absorbent of Cl_2, and the amount of phenol used in each experiment was controlled to within +/-0.0001g. The production of molecular chlorine was measured by comparing the relative amounts of chlorinated phenol and phenol in the methylene chloride. Figure 1 shows that the amount of chlorinated phenol in the methylene chloride decreased as the amount of SO_2 used increased. These results indicate that the amount of Cl_2 in the gaseous reaction mixture decreased as the amount of SO_2 used was increased, as indicated by equation 5. It is now necessary to find an optimum amount of SO_2 needed to reduce the formation of Cl_2 and any possible toxic materials during the co-firing of MSW with coal.

Figure 1. Production of chlorinated phenol as a function of the sulfur dioxide concentration in the reaction mixture

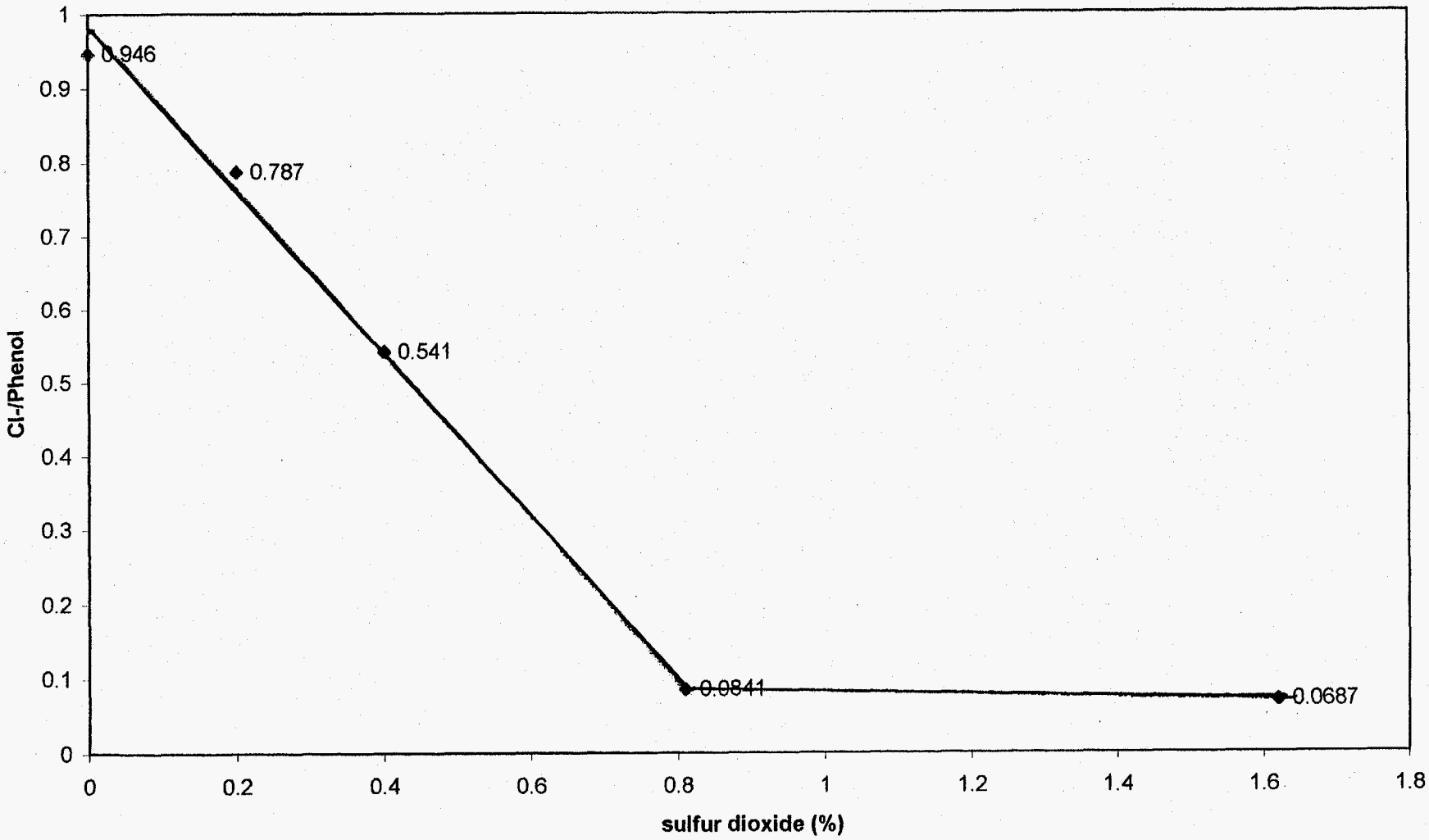

Table 1. Comparison of the Products from the Deacon Reaction as a Function of the SO_2 Concentration in the Reaction Mixture.

Reaction Ratio (%)			Product Ratio (%)
SO_2	HCl	O_2	Chlorophenol/Phenol
0.00	0.33	7.0	0.946
0.20	0.33	7.0	0.787
0.40	0.33	7.0	0.541
0.81	0.33	7.0	0.0841
1.62	0.33	7.0	0.0687

5. Further Study

In further studies the following will be emphasized:

- Perform evolved gas analysis during the combustion of WKU coal 95010, a high volatile A bituminous coal.
- Prepare fuel pellets containing PVC, newspaper and plastics to be co-fired with coal in the AFBC combustor.

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