UREA AS PCDD/F INHIBITOR IN INCINERATION OF RDF

Niina Yli-Keturi, Päivi Ruokojärvi*, Arja Asikainen*, Juhani Ruuskanen*, Ismo Halonen** and Kari Hänninen

Dept. of Biological and Environmental Sciences, University of Jyväskylä, P.O.B. 35, FIN-40351 Jyväskylä, Finland
* Dept. of Environmental Sciences, University of Kuopio, P.O.B. 1627, FIN-70211 Kuopio, Finland
**Finnish Standards Association SFS, Department of Ecolabelling, P.O.B. 116, FIN-00240 Helsinki, Finland

Introduction

Waste incineration is one of the main sources of polychlorinated dibenzo-p-dioxins and dibenzofurans. The emissions due to those toxic compounds can be reduced by preventing their formation already in the combustion chamber. Various parameters in the combustion process have effects on PCDD/F formation. Those parameters can be e.g. temperature, turbulence, residence time and the content of different flue gas parameters, such as O_2, CO, Cl_2, HCl and metal catalysts. Fuel composition and a good combustion practice are also some additional parameters which have an influence on PCDD/F formation. Some chemical additives have been proven to inhibit PCDD/F formation [1]. Especially nitrogen and sulphur compounds are potential PCDD/F inhibitors, because they can form stable complexes with metals which act as catalysts in PCDD/F formation processes [2, 3]. In inhibitor tests of urea high reduction of PCDD/Fs in the laboratory [4] and also in the pilot scale [3] have been reached. Urea is a non-toxic, inexpensive and easy to handle, which makes it possible to use also in full-scale waste incineration plants. On the basis of this previous information we wanted to simulate waste incineration and investigate the use of urea as PCDD/F inhibitor in a pilot scale plant. Especially the influence of the concentration of urea and the residence time on PCDD/F formation was studied.

Materials and Methods

Inhibitor tests were carried out in a 50 kW pilot plant (Fig. 1). The plant consists of a stoker burner and a furnace from which the flue gases were passed through the delay chamber to the economizer and to the stack. Three different residence times from five to ten seconds were investigated. The used fuel was pelletized refuse derived fuel (RDF). The heating value of RDF was 21.7 MJ/kg and the humidity was 2 %. The average fuel input during the tests was 12.3 kg/h. Mean temperatures of the flue gases at different locations were T1 (910°C), T2 (725°C) and T3 (170°C). Urea was dissolved in water and the injected amounts were adjusted to be 0.1, 0.5 and 1.0 percent of the total fuel input. The tests of all those three different concentration of urea injection were repeated by using the three residence times between five to ten seconds. Pure water injection tests were used as reference tests to the inhibition tests. Tests without any additive chemical injection were used as reference tests to the residence time tests.

Sampling of flue gas PCDD/Fs and chlorophenols was performed isokinetically. Details of the analysis are described elsewhere [5]. Analysis of PCDD/Fs and chlorophenols consisted of Soxhlet extraction with toluene, chlorophenol extraction with potassium carbonate, PCDD/F purification with concentrated sulphuric acid and separation by using aluminum oxide columns. The particulate and gaseous phases were analyzed separately. Chlorophenols were analyzed by a HP 5890 gas chromatograph using HP 5970 mass selective detector and PCDD/Fs by a HRGS/HRMS (VG 70 250 SE) at a resolution of 10,000.

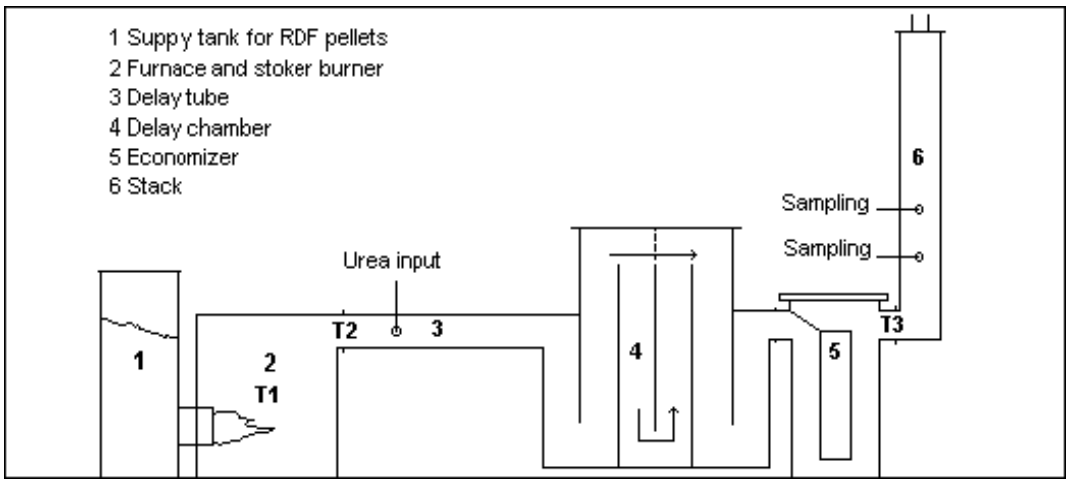

Figure 1. A schema of the pilot plant used in the inhibitor tests

Results and Discussion

Measured parameters of the flue gases and total concentrations of PCDD/Fs and chlorophenols in the longest residence time tests are presented in Table 1. Concentration of the inhibitor influenced the inhibition in the all residence times. PCDD/F concentrations were diminished by the increase of the amount of urea injected. The best reductions of PCDD/Fs were achieved with the longest residence time (Fig. 2). Pure water was also observed to inhibit the PCDD/F formation compared to the test with no water addition. This has also been noticed in previous studies [3].

Table 1. Measured flue gas parameters and concentrations of PCDD/F and chlorophenols in the longest residence time test (10 s) with urea inhibitor (mean values).

Test	O_2 (%)	CO_2 (%)	CO (ppm)	SO_2 (ppm)	NO (ppm)	PCDD/F (ng/m^3)	ClPh ($\mu g/m^3$)
Reference	9.6	8.7	42	19	220	260	14
Urea, 0.1 %	9.3	9.2	73	25	210	100	7.0
Urea, 0.5 %	9.8	8.9	85	25	200	50	3.9
Urea, 1.0 %	8.7	9.5	30	38	240	41	3.6

In the shortest residence time tests (5 s) with urea no inhibition of PCDD/Fs was observed. Increasing the residence time affected considerably to the particle phase PCDD/F reductions, opposite to the reductions in the gas phase PCDD/Fs. In all tests the concentrations of PCDD/Fs were higher in the particle phase compared to the gas phase.

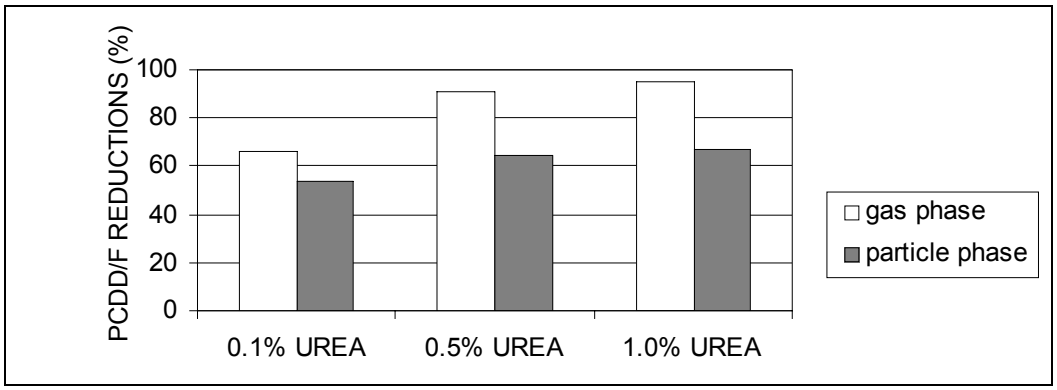

Figure 2. Influence of the concentration of urea on PCDD/F reductions in the longest residence time tests (10 s).

To conclude PCDD/F levels can be reduced in waste incineration by using urea. It is also important to adjust together both the concentration of urea injection and the residence time. Further investigations in full-scale plants and the influence of the amount of water in flue gas and fuel on PCDD/F formation are needed.

Acknowledgements

We thank the personnel of the Laboratory of Applied Thermodynamics at Helsinki University of Technology for their collaboration. TEKES Technology Development Centre is gratefully acknowledged for funding this research.

References

1. Tuppurainen, K., Halonen, I., Ruokojärvi, P., Tarhanen, J. and Ruuskanen, J. *Chemosphere* **1998**, 36, 1493
2. Ruokojärvi, P.,Halonen, I., Tuppurainen, K., Tarhanen, J. and Ruuskanen, J. *Environ. Sci. Technol*. **1998**, 32, 3099
3. Tuppurainen, K., Aatamila, M., Ruokojärvi, P., Halonen, I. and Ruuskanen, J. *Chemosphere* **1999**, 38, 2205
4. Dickson, L.C., Lenoir, D. and Hutzinger, O. *Chemosphere* **1989**, 19, 1435
5. Ruokojärvi, P., Ruuskanen, J., Ettala, M., Rahkonen, P. and Tarhanen, J. *Chemosphere* **1995**, 31, 3899