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Transient mass transfer modeling and simulation of polybrominated diphenyl ethers combustion in incinerators

[1]*M. Mousavi; [2]A. Taymouri; [2]V. Ghaffarian

[1]Department of Chemical Engineering, Faculty of Engineering, Ferdowsi University of Mashhad, P. O. Box 91775 1111, Mashhad, Iran

[2]Department of Chemical Engineering, Faculty of Engineering, Shahroud Islamic Azad University, Shahroud, Iran

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ABSTRACT: In this paper, modeling and simulation of combustion process for polybrominated diphenyl ethers in rotary kilns has been investigated. Proper formula is found for the solid wastes which contain polybrominated diphenyl ethers and then combustion process is simulated by considering possible reactions, appropriate dimensions and operating conditions for rotary kiln and necessary relations for reaction rates. The software of MATLAB is used for the simulation. The mass variations for solid waste, outlet gas and its components are calculated during 20 h. The results show that the reaction rate is high for the first 2 h, thus the value of solid waste and oxygen decrease quickly while value of produced gases increases. The mass increase of polychlorinated dibenzo-p-dioxins/furans and polybrominated dibenzo-p-dioxins/furans during the whole time of the process is linear with mild slope but for the other compounds, including steam, carbon dioxide, nitrogen, nitrogen oxide, sulphur dioxide, hydrogen chloride and hydrogen bromine, the slope of variations becomes mild after 3 h. The process becomes steady state almost after 9 h.

Keywords: *Combustion process; Dioxin; Furan; Mass variations; Rotary kiln; Solid waste*

INTRODUCTION

One of recent environmental problems is accumulation of wastes containing brominated flame retardants (BFRs) and especially polybrominated diphenyl ethers (PBDEs) as the most important portion of BFRs. Polybrominated diphenyl ethers are regarded as potential persistent organic pollutants (POPs) to be named under the Stockholm convention developed in 2001 in response to an urgent need for global action to protect human's health and the environment from POPs, persistent chemicals that bioconcentrate and bioaccumulate exponentially up the food chain. They are separated from aqueous media simply and absorbed by fatty tissues. Their bioaccumulation is decreased by increasing the number of bromine in their chemical structure. For example, Octa and Deca-BDE are less bioaccumulative than Penta-BDE in the environment and they convert to low brominated compounds like Penta-BDE (Alaee *et al.*, 2003). Polybrominated diphenyl ethers constitute up to 30 % of such electric and electronic products as computers, television sets, etc. On the other hand, they disorder the work of thyroid node (Paasivirta, 2000; Schettler *et al.*, 2000), result in problems in neural growth (Birnbaum and Staskal, 2004; Eriksson *et al.*, 1998), and even cause different cancers (Evans and Dellinger, 2005).

Release, accumulation, persistent and toxicity of PBDEs in the environment have been caused global concern about them which this concern has led to wide and accelerated studies around the world in this field. The combustion of PBDEs in incinerators is one of the most important parts of these studies due to production of dangerous compounds such as polybrominated dibenzo-p-dioxins/furans (PBDD/Fs) and polychlorinated dibenzo-p-dioxins/furans (PCDD/Fs). Dioxin is one of well-known toxic chemicals. A report released in 1994 by the US Environmental Protection Agency (USEPA, 1994) clearly described dioxin as a serious public health threat. The EPA report confirmed that dioxin is a cancer hazard to people, that exposure to dioxin also causes severe reproductive and developmental problems and that dioxin can cause immune system damage and interfere with regulatory hormones. Dioxins are characterized by extremely low water solubility and have tendency for being strongly

*Corresponding Author Email: mmousavi@um.ac.ir
Tel.: +98 511 881 6840; Fax: +98 511 881 6840