Accepted Manuscript

A flame retardant synergism of organic disulfides and phosphorous compounds

Jochen Wagner, Peter Deglmann, Sabine Fuchs, Michael Ciesielski, Christoph A. Fleckenstein, Manfred Döring

PII: S0141-3910(16)30075-1

DOI: 10.1016/j.polymdegradstab.2016.03.023

Reference: PDST 7908

To appear in: *Polymer Degradation and Stability*

Received Date: 17 December 2015

Revised Date: 3 March 2016

Accepted Date: 20 March 2016

Please cite this article as: Wagner J, Deglmann P, Fuchs S, Ciesielski M, Fleckenstein CA, Döring M, A flame retardant synergism of organic disulfides and phosphorous compounds, *Polymer Degradation and Stability* (2016), doi: 10.1016/j.polymdegradstab.2016.03.023.

A flame retardant synergism of organic disulfides and phosphorous compounds

Jochen Wagner[†], Peter Deglmann[†], Sabine Fuchs[ǂ], Michael Ciesielski[§], Christoph A. Fleckenstein[‡], Manfred Döring[§]*

† BASF SE, Advanced Materials and Systems Research, GM, 67056 Ludwigshafen, Germany.

‡ BASF SE, Petrochemicals, CP, 67056 Ludwigshafen, Germany.

ǂ Hochschule Hamm-Lippstadt, Marker Allee 76-78, 59063 Hamm, Germany.

§ Fraunhofer LBF, Schlossgartenstr. 6, 64289 Darmstadt, Germany.

***** Corresponding author. E-mail address: manfred.doering@lbf.fraunhofer.de; phone: +49 6151 7058675.

Abstract

A highly efficient halogen-free flame retardant system for polystyrene foams consisting of phosphororganic compounds and synergists of the general structure R-S-S-R is described here and mechanistic details of its mode of action are given. Compared to the corresponding individual components, the flame retarding effect is enhanced or actually imparted by the use of various combinations of those compounds. Among the disulfides investigated bis(benzothiazolyl)disulfide showed the best synergistic effect. Bis(diphenylphosphinothiolyl)disulfide as a one-component flame retardant combining phosphorous entities and a disulfide bridge in one molecule exhibits a similar flame retardant efficiency. Polystyrene samples containing these additives were analyzed by thermal desorption mass spectrometry (TD-MS), whereby the release of S_2-fragments during the thermal decomposition of the disulfides could be detected even in the case of systems for which a cleavage of S-S bonds would rather be expected. Based on these experiments and extensive quantum chemical calculations a conclusive mechanism is derived, which can help to design future flame retardant additives.

1. Introduction

Halogen free flame retardants for different polymers are of great interest to the polymer producing and processing industry [1,2]. Worldwide, the efforts in research and development of new halogen-free flame retardant formulations have significantly increased over the past years, hereby reacting to the REACH, RoHS and WEEE legislations of the European Parliament and similar legislations of other countries [3,4,5]. In the course of these decrees, some of the hitherto established flame retardants, like brominated biphenyls and diphenyl ethers, have been banned from the European markets [6]. Non halogenated substances, e.g.