Flame Retardants
Protect Life and Property against Fires

(The 7th Expert Panel Discussion on April 16th, 2015)

We feel fear for the fire which takes our lives and valuable property on the instant. A variety of flame retardants have so far been developed to prevent it. They have been extensively employed for buildings, automobiles, ships, household appliances including TVs and many other products used in a daily life. Brominated flame retardants in particular have been much employed owing to their excellent flame retardancy and handiness. On the other hand, moves are being made increasingly worldwide towards refraining from easy use of flame retardants in an effort to steer clear of influence on the environment and human health. Discussions are being needed to analyze scientifically and objectively the usefulness and risks of flame retardants and contribute to the development of products beneficial to the society. Bromine Science and Environmental Forum Japan consisting of manufacturers of flame retardants have so far hosted seven panel discussions including the last one held in April this year. It was chaired by Professor Masaru Kitano at Shukutoku University, who was also a member of a meeting at the fall of 2013 of the residual organic pollutant examination committee, and attended by four other experts. At the event conducted were lively discussions, including questions given by participants, on circumstances surrounding flame retardants and an outlook for the products.

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Kitano: Flame retardants have played an important role in preventing fires in vehicles, ships and structures. Stricter regulations have also contributed to fire prevention. I would like panelists to talk about fire preventives taken hitherto particularly for automobiles, ships and structures and risks of fire and chemical substances. Professor Kobayashi, could you please explain about your approach to prevention of vehicle fires?

Kobayashi: Statistics by the Fire Defense Agency show vehicle fires continued to increase until around 2000 along with an increase in the number of vehicles owned. Since then, however, they have been declining slowly and dropped to nearly half a peak level in 2012. A ratio of vehicle fires per 10,000 units fell sharply from 1966 through 1976 and almost plateaued after that until 2001. It then declined again and stands at some 0.7 at present.

A rapid decline after 2001 is credited partly to a fall in the number of traffic accidents but I think that it is owing greatly to the prevention of fires through enhanced flame retardancy in car seats and electrical wiring. It is considered to be triggered by the facts that a memorandum on the technical standard for the safety of land transportation vehicles was issued in 1993 by the director general of the Road Transport Bureau of the then Ministry of Transport and details of the safety standard for land transportation vehicles were announced by the authorities in 2002.

I think, however, a background of the rapid decline in the ratio of vehicle fires is not limited to the enforcement of these regulations and standards for transportation vehicles and, as a major contributory factor, private businesses have come to take seriously the product liability (PL). It seems that the number of car components which have undergone flame-retardant treatment is increasing steadily whether or not they are under regulations and I presume that improvement in the mechanical system involving engines has also contributed substantially to a decline in the said ratio.

Automobiles have been undergoing drastic changes since the turn of the century. Their weight has been lessened in tandem with commercialization of hybrid vehicles, electric vehicles and fuel-cell vehicles The share of plastics in their exterior materials and structural ones are rising and it will be necessary to enhance their flame retardancy. New problems are seemingly coming up regarding, for example, the need for ensuring flame retardancy with due consideration given to a breakout of fires resulting from natural disasters including earthquakes.

Suzuki: When it comes to fire in buildings, they are designed and maintained to prevent fire under the Building Standards Act and the Fire Defense Law. We can check through fire experiments whether they hardly catch fire and prevent fire from spreading to ensure time for evacuation. We have been well informed that it is crucial to control the spread of a fire at its initial stage in particular. Flame retardants are needed so as to prevent the building interior and furniture from catching fire and restraining fire from spreading in its initial stage. It is also important to ensure flame retardancy for an increasing number of timber buildings under construction under government policies.

The spread of a fire varies with the category of vehicles when a fire broke out in vehicles in a parking lot within a building and a fire in houses spreads to vehicles. Combustibles account for 11~16% of the vehicle weight

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and have the characteristic heat release rate and amount of total heat release: they have been confirmed through full-scale fire experiments. It is important to work out measures for ensuring flame retardancy of tunnels by looking into how fire spreads among vehicles.

A fire in structures damages structural materials such as steel. Attention should be directed to a recent increase in the use of a large amount of panels in which cellular plastics are sandwiched between metal sheets.

Fires usually take such steps as catching fire, spreading vigorously and being extinguished. Flame retardancy is required for the initial stage when a fire breaks out and is going to spread.

Yoshida: Regulations on ship and building fires have been formed by the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC); they contain measures for assessing a breakout of fires and their development. Surveys are being conducted on catching fire, spreading of fire and thermal generation caused by incineration and experiments are underway on how to meet regulations on flame retardancy. It is possible to assess the performance of flame retardants using an ISO 5660-specified cone calorimeter, which is capable of monitoring quantitatively whether flame retardants can hold down thermal generation caused by fires. Smoke and gas both generated by fires are gauged by a smoke chamber according to ISO5659_2 and ISO/CD19021. ISO provides a guideline for calculating a time for evacuation on the basis of these experimental data.

International regulations on the safety in ship fires are stipulated in the International Convention for the Safety of Life at Sea (SOLAS). The use of combustibles in accommodation spaces in the ship is restricted by SOLAS while the international fire experimental method for interior materials for the ship is stipulated in the Fire Test Procedures Code of the International Maritime Organization (IMO) and embraces a bench mark to gauge the concentration of carbon monoxide, nitrogen oxides and hydrogen halogenide.

Capitalizing on the fruit of studies hitherto conducted, I would like to say that it is reasonable to evaluate flame retardancy in terms of preventing combustion, retarding burning and curbing generation of heat by incineration. A new method has been developed to assess the gas generated when materials contained in flame retardants are incinerated and decomposed thermally and it is possible to assess the performances of such materials by means of small-scale burning tests. It is, however, difficult to assess their impact to the human body since it is influenced considerably by a volume of products incinerated, spread of burning, the extent of a space and ventilation. Taking these into account, they at ISO are striving to establish the ISO/TC92 standards for the methods to assess safety in a fire and conduct related experiments.

There is a new matter which we should think about. How should we treat furniture, though clear standards for building materials have already been established? The ongoing aging of the society is expected to heighten the possibility of a breakout of fires.

Kitano: We have heard about fires in automobiles, structures and ships, a process from catching fire to spreading fire and extinguishing fire, and relevant testing methods. It is also pointed out that flame retardants play a certain role in a step from catching fire to burning. Chemical substances including brominated flame retardants protect human life and property against fires but they involve indigenous risks. Mr. Tsunemi, could you please explain how we should think about risks and risk-return trade-off while paying attention to risks stemming from fires and chemical substances?

Tsunemi: The fire risk can be indicated by of the probability of a breakout of fires multiplied by their severity. The severity consists of a degree of f lare, as hazard, and an impact on humans, as vulnerability. The hazard is affected markedly by the performance of f lame retardants. The probability can be estimated on the basis of the data of actual fires in the past. The number of f ires depends on whether flame retardants are used. The chemical risk can be indicated by the chemical hazard multiplied by exposure. The probability of its occurrence is out of consideration because it is set at 1 at steady state, provided they are slowly emitted from household appliances and other sources. Hazard is assessed by estimating a non-observed affected effect level of chemical substances on the basis of toxicity tests on animals. Exposure is quantified through the estimate of their emission from products, human intake indoors and from foods, or intake by aquatic life and secondary predatory animals in the environment. The four index are often employed to assess the risk: the number of deaths, loss of life expectancy, quality-adjusted life years (QALYs) and willingness to pay (WTP). QALYs is to consider the quality of life as well as the state of living for a long life. WTP is ready to pay in a bid to avoid the risk, which can be translated into the value of statistical life (VSL).

Given the above, three cases of study on risk trade-off involving fires and chemical substances used in TV sets and wall paper show that the use of f lame retardants contributed to more effect on reducing fire risk than on increasing chemical risk. On the other hand, I think we need to assess risks from diverse aspects involving safety, health and the environment and give due consideration to personal risk perception regarding the influence of such risks to the economy and society. In other words, it is important increasingly to assess the risks from a viewpoint of social risk. I believe we should work out a new framework including, for example, cooperative research by the industry and research organizations.

Kitano: All the talks given by the panelists have allowed us to know the actual conditions of fires in detail. We have also known that regulations aimed at preventing an outbreak of fires produced certain results and the industry's voluntary efforts involving PL and others have also played an important role in preventing fires. It is evident that flame retardants back up such their efforts. Commercialization of new substances requires us to develop new test and assessment methods.

A concept of risk-return trade-off involving flame retardants needs to be extensively accepted by the society as the major premise. I suppose it is essential to employ an accurate method for risk assessment and provide correct information so that flame retardants can be understood clearly.