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# Chemical substance risks and disaster prevention Inflammability and tradeoffs What should health damage be recognized?

After The Great East Japan Earthquake that occurred three years ago, necessity to create disaster resistant cities has been stressed. There is an urgent need for Tokyo metropolitan district where large earthquake is expected to occur to take appropriate measures for fire disasters. Though it is required to use inflammable materials for building materials, furniture, home electronic appliances and vehicles, chemical substance risks are pointed out for flame retardants. What should we consider tradeoffs between disaster prevention and health damage? (Chaired and compiled by Takahiro Soma)

— If a large earthquake such as one occurring directly beneath the Tokyo Metropolitan Area occurs, wooden houses with no seismic strengthening will fall, leading to large fire disasters.

**Kitano:** Against the background of necessity to protect human lives and their properties, BSFF (the Bromine Science and Environmental Forum) consisting of world chemical manufactures appeals the importance of fire safety. Brominated flame retardants which BSDF educates people for understanding are excellent in their non-flammability and are widely used in home electric appliances and vehicles.

**Kobayashi:** In Japan, there is much higher probability for fire disasters resulting from earthquakes to occur compared to any other regions in the world. In overseas countries, large earthquakes seldom lead to major fire disasters in which whole cities will be on fire. That is because most of the

houses are made from wood in Japan. I'm also concerned about the vehicles. In the last Great East Japan Earthquake, a quite number of large Tsunami fire in which several hectares were burned occurred and the most of the fire sources is assumed to be the cars. Though the previous cars were not so flammable, many plastic parts instead of steel plates have been applied to the recent cars in order to make them lighter in weight.

**Flame retardants reduce the fire damages.**

**Kitano:** In today's society, plastics are imperative materials because they are cheap, light, strong and durable. On the other hand, being flammable and exhausting black smoke when combusted are their weaknesses, which are overcome with addition of flame retardants. If there had been no flame retardants, I wonder how tremendous damages might have been caused by fire.

**Kobayashi:** In the past I

examined the causes of fire accidents and to what the flame spread first. The analysis showed that interior materials including walls and ceilings were less affected than I had expected. Not only flame retardants are used for the interior parts of buildings so that they will not catch fire, but they also have effects to prevent the phenomenon of flashover, that is, local fire spreading in a flash.

**Kitano:** You mean flame retardants save time to escape.

**Kobayashi:** Yes. The problem is, it is not clear how high the chemical substance risks of the flame retardants are.

In Fire Service Act, curtains and carpets that meet the disaster relief criteria are designated as "flame retardant goods" although toxicity test is not implemented. It is because it is regarded that toxicity is examined according to Law Concerning the Examination and Regulation of Manufacture, etc of Chemical Substances. Regarding to beddings and

pajamas that may contact human skins or infants may lick, oral toxicity and contact skin disease are examined.

— How chemical substance risks are managed in Law Concerning the Examination and Regulation of Manufacture, etc of Chemical Substances?

**Kitano:** Chemical substance risks are divided into two, that is, danger to take fire and explode and toxicity. Law Concerning the Examination and Regulation of Manufacture, etc of Chemical Substances is the first law in the world in which pre-examination to evaluate risks before manufacturing any chemical substance was introduced. Hazard and toxicity of a substance itself, namely how it will affect human health or environmental biology is examined in Law Concerning the Examination and Regulation of Manufacture, etc of Chemical Substances.

On the other hand, there is a

concern that curtains made from such substances will exhaust hazardous gas when combusted in case of fire. Unfortunately Law Concerning the Examination and Regulation of Manufacture, etc of Chemical Substances does not cover this far. Although hazard and toxicity of chemical substance A and B are examined, compounds made from A and B are not targets for examination.

**Causes of death by fire changed**

**Kobayashi:** Looking at the causes of death by fire, significant changes can be seen during 1969 and 1974.

As the buildings become more sealed, more incomplete combustion tends to occur. It was assumed that death from carbon monoxide poisoning would increase while death by fire would decrease as more and more buildings became sealed. Actually, the result was quite the opposite. Although more people died from carbon monoxide poisoning by that

time, the trend was reversed during that time.

The secret lies in external examinations. As death from smoke is defined as death from carbon monoxide poisoning or choke only, any other people who died from other chemical substances or who died because they were unable to move are treated as those who died from fire.

Hydrogen cyanide, carbon hydride and acrolein are said to be particularly dangerous among all the chemical substances. It is estimated that those died from these three chemicals increased from 1969 to 1974. That plastics or foamed polystyrene started to be widely used instead of natural materials around that time is regarded as the causes.

Still, the death rate from fire and the death rate from smoke have been almost the same since then and the number of per capita death from fire has recently decreased. I think that no extraordinarily hazardous gas has recently occurred in fire disasters.

**"Pre examination and after the fact control are imperative to determine whether a certain chemical substance is safe or not."**

**Mr. Masaru Kitano, Professor, College of Integrated Human and Social Welfare, Shukutoku University**

Born in Tokyo in 1942. Graduated from Engineering Department, Meiji University in 1995. Completed doctoral course of School of Engineering Chemistry, Graduate School of Engineering, Tokyo Metropolitan University in 1972. Obtained doctoral degree in analytical chemistry. After working at several institutions including Chemicals Inspection and Testing Institute (present Chemicals Evaluation and Research Institute), he took the present position in April, 2013.

**"In Japan earthquakes often cause fire disasters. It would be the best way to use flame retardants while examining their toxicity and once the risk of a certain material turns out to be high, to regulate the concerned material."**

**Kyoichi Kobayashi: Professor, Department of Fire Science and Technology, Graduate School of Tokyo University of Science**

Born in Chiba in 1948. Graduated from Engineering Department, The University of Tokyo in 1972. Entered Construction Ministry (present Ministry of Land, Infrastructure, Transport and Tourism) in 1973. Retired after working as Director of Tokyo Fire Department, Director-General of the Civil Protection and Disaster Management, Fire and Disaster Management Agency. Obtained doctoral degree by the research on performance specification of Fire Service Act in 2008 and took the present position in October in the same year.

**“It is not clear whether they will accumulate over generations or not.”**



Photo by Koichi Kitayama

**“If you make chemical substances more high molecular, the risk of their absorption in organisms can be reduced.”**

## Flame retardants save time to escape. Their safety at time of use and availability of resources need to be considered.

**— Is there any way to reduce the harmful effects caused when chemical substances are burned?**

**Kitano:** Current laws and regulations assume the cases where chemical substances are naturally exhausted to the environments and do not examine further the area where they are burned to transform. Namely, accidents are treated as exceptions.

On the other hand, flame retardants are regulated by Stockholm Convention on POPs (Persistent Organic Pollutants). The largest issue for brominated flame retardants is that they are not dissolved in the environment. Some of them are accumulative and have some toxicity.

Though Hexabromocyclododecane (HBCD) has not much harmful effects on human beings, it is regulated by Law Concerning the Examination and Regulation of Manufacture, etc. of Chemical Substances because it is detrimental to birds.

**Manufacture of extinguishing agent Halon is now prohibited.**

**Kobayashi:** It is better that flame retardants have higher performances in order to control the damage caused by fire. However, they may have harmful effects on the environments or human beings. It cannot be determined from a fire fighting perspective whether they may be accumulative and be critical to the existence of human beings after a period of time. It would therefore be desirable for us to choose to use the ones that are nonflammable as much as possible from a list of safe materials that will be indicated according to Law Concerning the Examination and Regulation of Manufacture, etc. of Chemical Substances. Though chemical substances are also used in extinguishing agents, they have larger acceptable range for toxicity compared to flame retardants. The representative extinguishing agents include Halon and CO<sub>2</sub>. While Halon has more toxicity, it is regarded safer than CO<sub>2</sub> because extinguishing with CO<sub>2</sub> may suffocate human beings.

However, manufacture of Halon is currently prohibited based on the Montreal

Protocol because Halon is damaging the Ozone layer. Though it was assumed that the substitute would be soon developed, actually it has not been so far.

**Kitano:** Halon was that good for an extinguishing agent.

**— Regarding to extinguishing agents, more emphasis was placed on environmental reservation than on fire safety.**

**Kobayashi:** Well, exceptional use is allowed for important cultural properties, submarines or fighter planes. Japan ranks the 2<sup>nd</sup> in stockpiles of Halon 1301 which is used in the buildings. “Halon bank” system to recycle the Halon 1301 already used in the buildings is implemented. Specifically, when old buildings are reconstructed, Halon 1301 is collected for reuse.

Though Halon 1301 destroys the Ozone layer, it does not need to radiate unless fire occurs. Based on the understanding that Halon 1301 is valuable to be carefully recycled, it is a concept to use Halon 1301 as little as

possible by making full use of other measures. As it also contributes to effective use of resources, it is globally evaluated from a perspective of environmental preservation.

**Kitano:** Halon bank seems a good idea. I think environmental burden should be recognized from a perspective of life-cycle as a whole while flame retardants should be evaluated for their performances. Brominated flame retardants are less used because their harmful effects on human beings are concerned though they have highly inflammable effects.

However, bromine is abundant on the earth. In that sense, it may be required to think from a broader viewpoint including safety of a product itself, its safety at time of use and exhaustibility of resources. It is important to see as a whole life cycle instead of just looking at the finished goods.

**Kobayashi:** Looking at the causes of death resulting from the fire, no extraordinary chemical substances have increased so far and I am not so worried about it. Still, it is not clear whether they will accumulate over generations or not.

**Try not to absorb chemical substances in the bodies.**

**Kitano:** Polybrominated Diphenyl Ether (PBDE), which is regulated by Stockholm Convention on Persistent Organic Pollutants, is not usually dissolved in the environments and once absorbed in organisms, it will pose a serious problem. The smaller the molecules are, the easier they are absorbed. If they accumulate in the bodies, they may have a negative consequence.

Regarding to fish, if the molecular weight of a certain chemical substance exceeds 1,000, it cannot go through gills and therefore won't be absorbed in the bodies. Accordingly, I think chemical substances will not be detrimental if we make them more high molecular in such a way as mentioned above.

If chemical substances are burned on fire, they may emit hazardous gas. However, if we can save time to escape by using flame retardants, we will not be there while the gas is emitted. I cannot imagine such hazardous gas will be emitted during the fire. We can also reduce the risk by making chemical substances more high molecular. Measures against chemical substances are being taken in such a direction as this on a global basis.

**— What should we do in order to resolve the tradeoffs between chemical substance risks and fire safety?**

**Kobayashi:** Try a variety of flame retardant materials while examining their risks and once the risk of a certain material turns out to be high, regulate the concerned material. I think such a stance toward chemical substances is appropriate.

**Kitano:** Since the Law Concerning the Examination and Regulation of Manufacture, etc. of Chemical Substances was enforced in 1973, degradability, accumulateness and toxicity on human beings as well as on environmental biology of newly produced chemical substances are examined in advance and if a certain substance does not meet the requirements, it becomes

a target for regulation. Applications and amount to be used are also regulated.

Concerning existing chemical substances which had been produced before the Law Concerning the Examination and Regulation of Manufacture, etc. of Chemical Substances was enforced, those which are used in particularly large amount are examined on national government budget. Under these circumstances, it is not expected that chemical substances with tremendous risk will be used in the future.

I think “chemical substances have double edges.” The less they are used, the better. The point is to make those with excellent performance while securing their safety. Chemical substance risks are evaluated by exposure and hazard. It is important for users to use less and for research development to make less hazardous ones.

It is imperative to perform “pre-examination” and “after the fact control” in order to determine whether a certain chemical substance is really safe or not. We should perform a combination of these two when we use chemical substances and if a certain chemical substance turns out to be hazardous, it should immediately be added to a control list.

If we try to identify every risk only with pre-examination, it will cost several hundred million yen and nip industry in the bud.

**Kobayashi:** I think everything has been well managed by the Law Concerning the Examination and Regulation of Manufacture, etc. of Chemical Substances so far. Still, it cannot be denied that new chemical substances are precarious. We need to watch them carefully and if a certain substance turns out to be really hazardous, it has to be regulated.

**Kitano:** Fire safety is extremely important. Regulating chemical substances well, to be specific, how to minimize the risk of fire disaster by using flame retardants is to be asked.

## Strengthening of both control on chemical substances and disaster prevention measures required

### Tradeoffs between chemical substance risks and fire safety

Global strengthening of chemical substances (Stockholm Convention on Persistent Organic Pollutants, RoHS Directive, Law Concerning the Examination and Regulation of Manufacture, etc. of Chemical Substances)

Learning from the Great East Japan Earthquake Mega earthquake expected to occur.

Prohibited use of hazardous substances

Expanded use of flame retardants

Chemical substance risks

Fire safety

Use of some brominated flame retardants is restricted according to Stockholm Convention on Persistent Organic Pollutants, RoHS (Restriction of Hazardous Substances) Directive and Law Concerning the Examination and Regulation of Manufacture, etc. of Chemical Substances. Against the background of mega earthquake expected to occur, flame retardants are increasingly becoming important and it is an issue how to regard them in relation to their chemical substance risks.