Eco-Friendly Fire-Fighting Agent for Wild land Fire

Shinji Iwamoto*[1], Yoshihiko Ohba*[1], Eiji Miki*[2]
Hidenobu Mochigase*[2], Yutaka Suzuki*[2], Hidenori Okuzaki*[3]

ABSTRACT The company has been developing and commercializing Class A foam fire-fighting agent used mainly for the buildings and also for the wood products, the textiles, the plastics and the tires. However, the international focus now is on the issue of the wild land fires. Consequently, the company has decided to develop the fire-fighting agent for the wild land fires. While various fire-fighting agents are used today, one challenge remains. Upon the aerial application of the fire-fighting water from airplanes to the fire site, it tends to diffuse and dissipate due to the airstream of the plane as well as the pneumatic resistance. This led to insufficient prevention of fire spread, since the fire-fighting agent would not adequately reach the site. In our development process, we were able to overcome this problem. At the same time, we succeeded in discovering the composition for the gel form fire-fighting agent which would not be retained by the surrounding environment when it is applied to the site.

1. INTRODUCTION

The numbers of the wild land fire and the surface damage from the wild land fire over the world are much larger than Japan. In Japan, the wild land of an average 1413 hectare(ha) per year was burned down from 2010 through 2011[1)], on the other hand, in the US, an average 1680 thousand ha per year was burned down from 2004 to 2013[2)] and it is 1200 times of burned down area in Japan.

Figure 1 shows the fire map of the world in April, 2009[3)] and the red area is the fire burned area. The fire burned area is located not only in the near equatorial region where it is subjected to a high temperature but in the tropical rain forest area or the green space area. This shows that a lot of wild land fire is occurring in the red area.

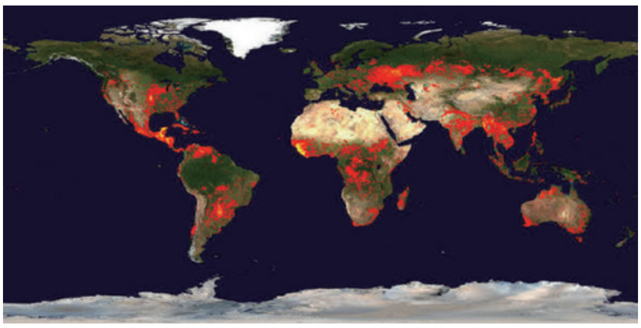


Figure 1 Global Fire Map in April, 2009 provided by NASA.

*1 Furukawa Techno Material Co., Ltd. Fire Prevention Products Div.
*2 Furukawa Electric Co., LTD R&D Div. Polymer Materials R&D Laboratories
*3 University of Yamanashi

The fire in the US is only a small part from a worldwide perspective. The fire risk is rapidly increasing because of the global warming. Recently not only the forest fire but the peat fire along Southeast Asia is focused on the big issue in the world. The peat is the soil of the accumulated dead leaves, branches and dead trees for several tens of thousands years and once ignited by the presence of the heat source, the carbon dioxide absorbed in the peat soil is released all at once. The amount of the emission comes up to 10 to 30 % of the amount of emitted carbon dioxide over the world per year.

The objects of the project are the development of the new fire-fighting agent which is effective against the wild land fire and to make an international contribution to prevent the global warming.

2. CONCEPT

Since the wild land fire covers a widespread area, the fire-fighting method is the aerial application of the fire-fighting water from the helicopter or the aircraft. (Figure 2)

Since there are some problems to get the water supply in the mountain area, the road narrowness for the fire truck to access, the limitation of the applied water flow from the helicopter, it is effective for the fire-fighting to use the fire-fighting agent at the place where the water amount is limited[4)], for example the mixed product of the mixed fire-fighting agent and water. Upon the aerial application of fire-fighting water from airplanes to the fire site, it tends to diffuse and dissipate due to the airstream of the plane as well as the pneumatic resistance. This led to insufficient prevention of fire spread, since the agent would not adequately reach the site. In order to solve the problem, the airplane has to fly low or make a slow flight which is dangerous.

Based on the back ground mentioned above, we planned to develop the fire-fighting agent composed of the viscosity improved water to prevent the fire-fighting agent from diffusing or dissipating, and which would not be retained in the surrounding environment when it is applied to the site.

Figure 2 Image of the dropping water by the aircraft. (Photo credit : ShinMaywa Industries, Ltd.)

Table 1 Comparison of the fire-fighting agent.

Item	Developed product	Marketed product A	Marketed product B
Mixture concentration	○ 0.8 ～ 3.0%	◎ 0.4 ～ 1.2%	× 1.0 ～ 3.0%
Solubility	○	◎	×
Stability in hard water	◎	×	×
Aerial application	◎ 1.28 times	× 0.56 times	— [*1]
Flame propagation prevention	◎ 2.3 times	◎ 1.6 times	◎ 1.6 times
Biodegradability	◎ Ready biodegradable[*2]	× Non-biodegradable[*2]	× Non-biodegradable[*3]
Toxicity to fish (LC_{50})	○ 32 mg/L[*4]	◎ 280 mg/L[*5]	◎ 1,400 mg/L[*5]
Metallic corrosion	◎	×	○
Effect on plastic	◎	◎	◎

(Explanation of the symbol ◎ : Great ○ : Good × : Poor)

*1 the experiment was stopped, because the viscosity of the fire-fighting agent was too high to discharge from the test apparatus.
*2 OECD 301B, CO_2 Evaluation Test
*3 OECD 301D, Closed Bottle
*4 OECD, 203, Oncorhynchus mykiss
*5 OPPTS 850.1075, Oncorhynchus mykiss

3. RESEARCH & DEVELOPMENT TEAM

The development of the fire-fighting agent was started on the basis of the collaboration between the Polymer Material R&D Laboratories of R&D Division of Furukawa Electric and the University of Yamanashi.

4. CHARACTERISTICS OF THE FIRE-FIGHTING AGENT

In our development by the team, we achieved the new fire-fighting agent based on the concept of a good flame propagation prevention performance. The composition of the agent consisted of the biodegradable polysaccharides as the thickener to solve the diffusion or dissipation of the fire-fighting water and a dispersion agent consisting of a surface-active agent and a polysaccharide to improve flame propagation prevention performance and water solubility. The evaluation of the developed product and the marketed product is shown in Table 1.

Among the important properties of the fire-fighting agent, the stability in hard water, the aerial application, the biodegradability and the metallic corrosion were better than the marketed products. The flame propagation prevention performance is equal to them. As for the property of the toxicity to fish, it is lower than the marketed products, but the result was over the criteria of the standard. The developed product is satisfactory for the important properties and the lower concentration is favorable from the cost perspective.

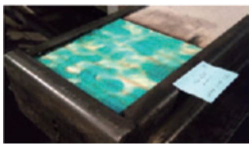
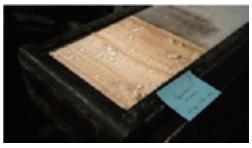
The developed product is relevant to the fire-fighting agent for the wild land fire. The flame propagation prevention performance and the aerial application are mentioned in detail.

4.1 Fire Flame Propagation Prevention Performance

The flame propagation prevention performance of the developed product and the marketed product were evaluated by the flame propagation testing equipment shown in Figure 3 in accordance with ASTM E1321. Table 2 shows the adhesion state of the water mixed with the fire-fighting agent to the ignition panel. Figure 4 shows the relationship between the firing time and the concentration of the fire-fighting agent in the water. The firing time was relative to the water, where the water was 1.

Figure 3 Flame propagation testing equipment, the heating part (Left) and the ignition panel (Right).

Table 2 Adhesion state of each fire-fighting agent to the ignition panel.

Agent	Adhesion state	
Developed product		The improved viscosity of the liquid or the gel-like material
Marketed product A		Water swelled polymer
Marketed product B		High viscosity liquid material

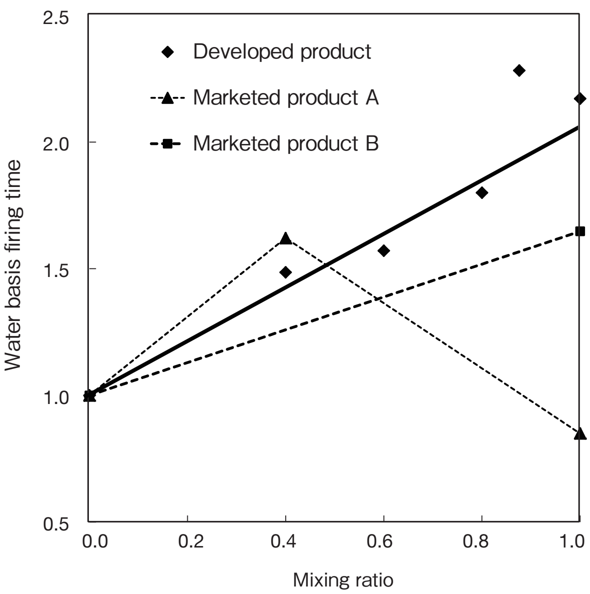


Figure 4 Flame propagation prevention performance of each fire-fighting agent.

It is preferable to use the low concentration of the fire-fighting agent in water from a cost and control perspective. The concentration of 0.5 to 1.0 % is the most preferable and the experiment and the evaluation were achieved in this range of the concentration. The result shows that the flame propagation prevention performance of the developed product equals or exceeds that of the marketed product and the performance keeps in the wide range of the concentration.

The flame propagation prevention performance of the marketed product A depended largely on the concentration of the fire-fighting agent in water. The product A consisted of the superabsorbent polymer (SAP) and the higher concentration of the SAP leads to the excessive water solubility and forms a lump which does not adhere to the physical object and loses the prevention performance. The product B shows a good performance in the condition of more than 2% of the concentration; however the expected effect was not achieved at a concentration of 0.5% to 1.0%.

The condition of the product A or the product B with the fire-fighting water depends largely on the water quality. The concentration of the fire-fighting agent has to be adjusted to the water quality for the product A or B, however it is hardly met at the fire site. Comparing with the marketed product, since the developed product keeps a good flame propagation prevention performance in the wide range of the concentration of the fire-fighting agent, it is convenient for the fire man to use the developed product.

4.2 Aerial Application

The dispersion density of 1.6〜2.4 ℓ/m^2 is relevant for aerial application from the airplane shown in Figure 5. It shows that the good flame propagation prevention performance depends on the dispersion quantity being more than 1.6 ℓ/m^2 and the larger dispersion surface area.

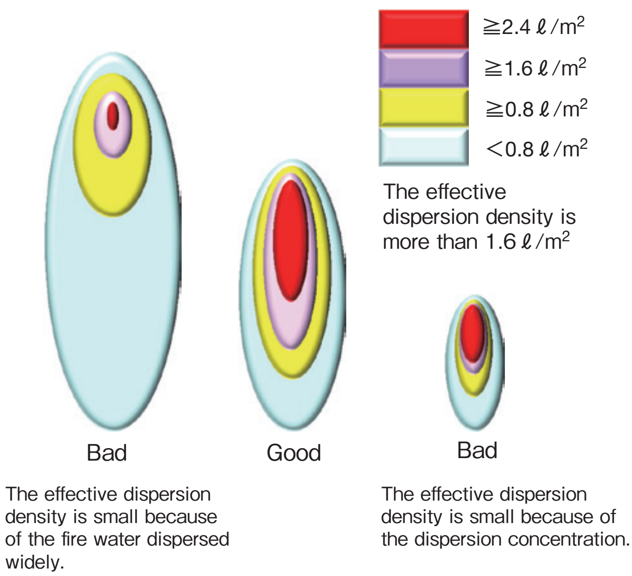


Figure 5 Example of the dispersion density.

The dispersion density of the developed product and the marketed product was evaluated on the experiment of the aerial application in the laboratory. Table 3 shows the effective fire extinguishing area for each of the fire-fighting agent. The effective area ratio for the extinguisher of the fire-fighting water with the extinguishing agent was relative to the water with the dispersion density area of more than 1.6 ℓ/m^2, where the water is 1. The effective area ratio of more than one (1) is relevant for the fire-fighting agent.

Table 3 Effective fire extinguishing area of each fire-fighting agent.

The fire-fighting agent	Concentration (W/W%)	Effective extinguishing area
none		1.00
Product A	0.500	0.56
Developed product	0.495	1.28

The effective extinguishing area of the marketed product A is smaller than the water without the fire-fighting agent because of forming of the lump. The developed product tends to diffuse and dissipate due to the airstream of the plane as well as the pneumatic resistance. However, in more than 0.5 % of the mixture concentration, the component in the fire-fighting agent makes a molecular network and the effective extinguishing area ratio becomes larger because the network prevents the diffusion.

The relevant concentration of more than 0.8 % shown in Table 1 is needed to satisfy with the request for the viscosity.

5. CONCLUSION

We succeeded in discovering the composition of the gel form fire-fighting agent which is suitable for the aerial application for the wild land fire and the composition patent was submitted to the domestic and overseas Patent Offices[5].

With respect to supply to the US market, we need to have the certification from the third party organization and be registered in the Qualified Product List (QPL) of USDA Forest service. The certified system for the wild land fire in Canada or Australia or Europe is needed to investigate, to prepare for the product to the area and to expand the extinguisher business.

REFERENCES

1) Ministry of Internal Affairs and Communications, Fire and Disaster Management Agency: Heisei 24 years Edition fire white paper (English Translated Version) http://www.fdma.go.jp/html/hakusho/h24/h24/index.html
2) NIFC (National Interagency Fire Center) HP > Fire Information > National Fire News-Current Wildfires
3) NASA , The Earth Observing System Data and Information System (EOSDIS) HP > Data > Near Real-Time Data > FIRMS > Global Fire Maps
4) Ministry of Internal Affairs and Communications, Fire and Disaster Management Agency and Ministry of Agriculture, Forestry and Fisheries: Investigation report on the solution for the wild land fires (March, 2003) (in Japanese)
5) Furukawa Techno Material, Furukawa Electric, University of Yamanashi PCT/JP2013/058316