THE DEVELOPMENT OF FOAMING AGENTS USING SLES & DH-109EX

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ABSTRACT

Experiments were conducted to develop foaming agents by using SLES and DH-109EX as raw material. PG (Propylene glycol) and BC (Butyl cellusolve) were adopted as subsidiary material. The undiluted foam solution was produced with these materials. This solution determined the expansion ratio, viscosity, drainage time and extinguishing ability of the final product. The results indicate that the expansion ratio is over 16 and drainage time is over one minute. The extinguishing ability for SLES system was succeeded in the unit of B-0.5.

INTRODUCTION

Foams as fire extinguisher are divided basically into two types-low expansion type, medium and high expansion type.[1] Early development of fire fighting foams mainly involved the low expansion type. Only until recently, innovation was made in development of medium and high expansion foams. In this experiment, it was focused by a new type of extinguishing agent with low and medium expansion type capable of manufacturing easily.

The types of foam are classified as chemical foam, protein foams, AFFF (aqueous film forming foams)[2], fluoroprotein foams, alcohol resisting foams, medium and high expansion foams.[3] Researchers have already presented the system of FM-200™ gas-filled AFFF fire extinguisher[4] during the development of the extinguishment system for automatic fire suppression.[5,6] In the system, the AFFF as foam agent was adopted and the releasing device specially designed was employed. In this research, to develop the new foaming agent, it was performed by adopting SLES (Sodium Laurylether Sulfate) and DH-109EX (Sodium Fatty Alcohol Sulfate) as the substitute for AFFF and used the releasing device mentioned above.

EXPERIMENT

In this research, SLES and DH-109EX were adopted as the raw material of new foaming agent. Table.1 shows the properties of these two kinds of detergents. The subsidiary materials include BC, PG. These materials and water were mixed at the certain proportion to form the undiluted foam solution.

The proportion of different materials in this solution range from:

SLES and DH-109EX: 20-50 vol-%

BC: 1-5 vol-%

PG: 20-30 vol-%

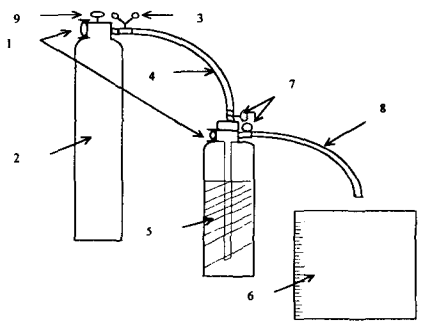
Table 1. The properties of detergents

Properties	SLES	DH-109EX
Color (at 25°C)	Yellowish	Yellowish
PH (10%)	6.0-8.0	7.5-8.5
Solubility	Soluble in water	Easy soluble in water
Ion	Anionic	Anionic
Application	Dispersion Agent Emulsifier	Foaming agent for plaster board

The undiluted solution was poured into water with the proportion ranging from 3% to 12%. In this way, the water solution of the foaming agent was obtained. Then the experiments for expansion ratio were performed. Fig. 1 shows the schematic diagram of releasing device used in this experiment. Expansion ratio is calculated as following equation. This equation assumes the density of the foam concentrate is 1g/cc.

xp = {Volume of Container (cc) × 1(g/cc)} / {Weight of Foam within Container (g)} [7]

To review the characteristic of foam after expansion, the viscosity of the foam generated was measured by using viscometer and the drainage time was recorded. In order to determine extinguishing ability of foam, we performed the test on extinguishing ability for B units of Class B fire.



1. Pressure gauge
2. Nitrogen cylinder
3. Pressure regulator
4. Charge tube
5. Aqueous foaming agent
6. Measuring vessel for volume of foam generated
7. Discharge valve
8. Releasing valve
9. Main valve

Fig. 1 Sketch of the manufacture of foaming agent

RESULT AND DISCUSSION

SELS system foaming agent

To determine the optimum proportion of varies material in undiluted solution, the following procedure was performed in the experiment. First of all, we managed to find the maximum expansion ratio of foaming agent by varying the concentration of SLES in undiluted solution with the other material maintained constant.

Fig.2 shows the result of expansion ratio of foaming agent depending on SLES concentration. With the increment of concentration of the water solution, the foaming agent appeared an increasingly expansion ratio. Especially when the undiluted solution concentration is 50% and the water solution concentration is 9%, the maximum expansion was observed. And then the expansion ratio decreased. Through this result, the optimum concentration of SLES in the undiluted solution was obtained, that is the value at which expansion ratios reach the maximum point. In the experiment followed, the concentration of SLES is fixed on this value. Second, the experiment was performed to find the maximum point of expansion ratio as the concentration of PG varied. Then, like the first step, the PG concentration was fixed on the value that expansion ratios reach the maximum point in the experiment followed.

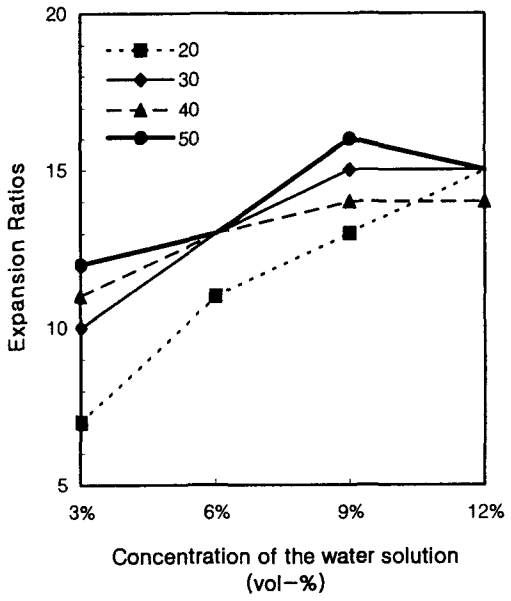


Fig. 2 Expansion ratios of the SLES foaming agent depending on the concentration of SLES raw material

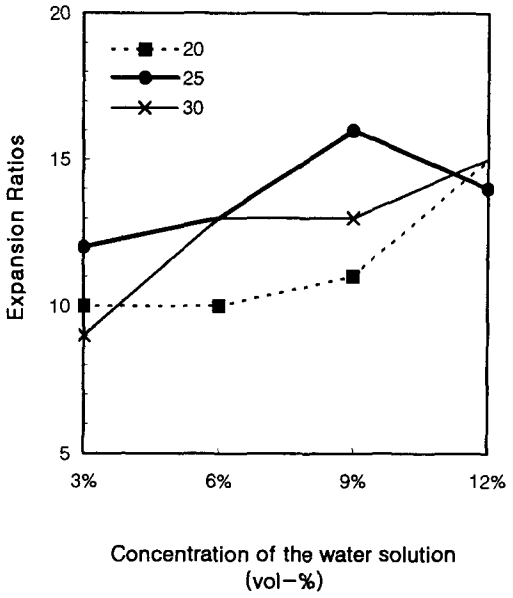


Fig. 3 Expansion ratios of the SLES foaming agent depending on the concentration of PG

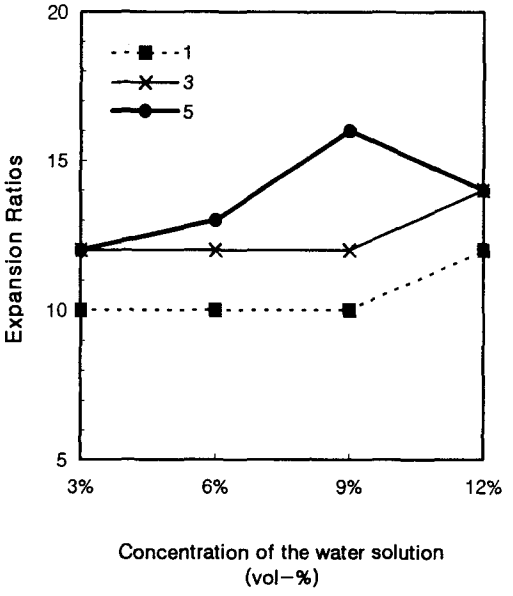


Fig. 4 Experiment ratios of the SLES foaming agent depending on the concentration of BC

Fig.3 shows the result of expansion ratio of foaming agent by varying the concentration of PG with the concentration of SLES fixed on 50% and BC maintained constant. With the increment of water solution concentration, the foaming agent appeared an increasingly expansion ratio and reached to the maximum value when the concentration of PG is 25%. Third, the experiment was performed to find the maximum point of expansion ration as the concentration of BC varied.

Fig. 4 shows the result of expansion ratio of foaming agent by varying the concentration of BC with the concentration of SLES fixed on 50% and PG fixed on 25%. At the water solution concentration of 9% and the BC concentration of 5%, the foaming agent appeared the maximum expansion ratio. Therefore, the optimum BC concentration in undiluted solution is 5%.

DH-109EX system foaming agent

In the experiment of this agent, the same procedures as mentioned above were adopted to obtain the optimum concentration of different synthetic surfactant.

Fig. 5 shows the result of expansion ratio of foaming agent depending on DH-109EX concentration. With the increment of DH-109EX undiluted solution concentration, the foaming agent appeared the same results as SLES system. When the undiluted solution concentration is 50% and the water solution concentration is 12%, the maximum expansion was observed.

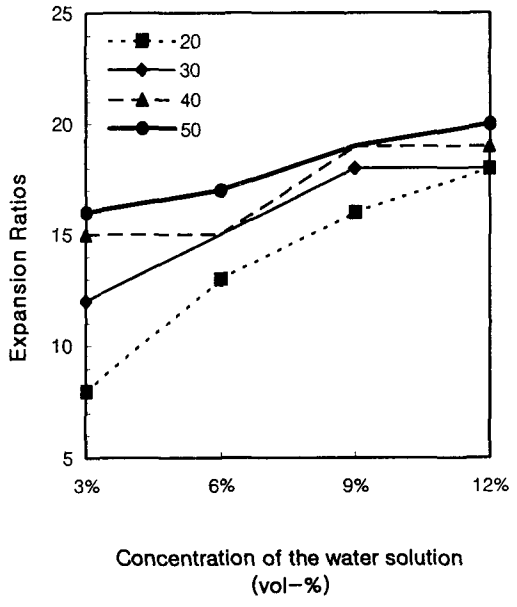


Fig. 5 Expansion ratios of the DH-109EX foaming agent depending on the concentration of DH-109EX raw material

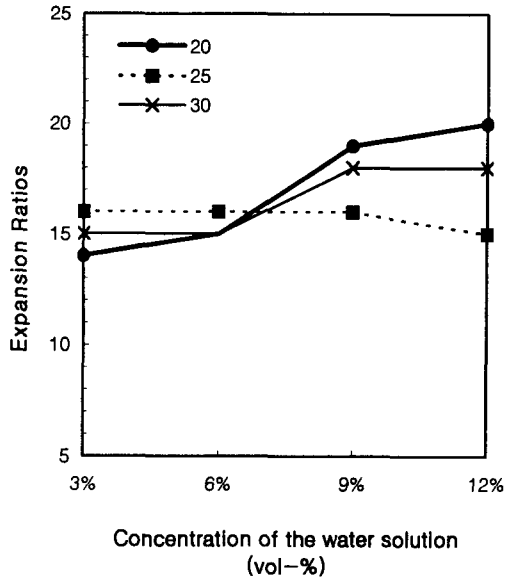


Fig. 6 Expansion ratios of the DH-109EX foaming agent depending on the concentration of PG

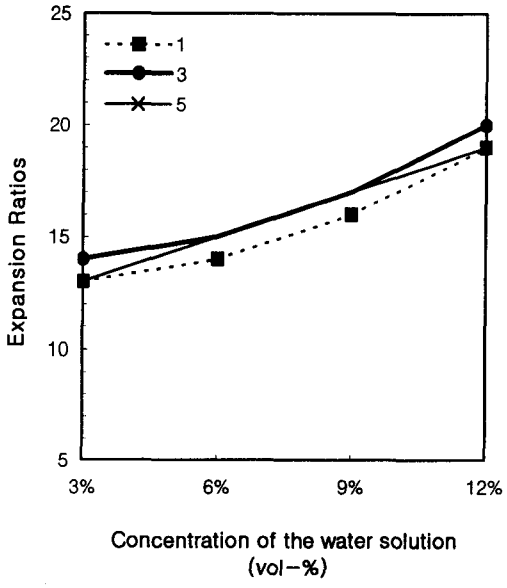


Fig. 7 Expansion ratio of the SLES foaming agent depending on the concentration of BC

Fig.6 shows the result of expansion ratio of foaming agent by varying the concentration of PG with the concentration of DH-109EX fixed on 50% and BC maintained constant. When the concentration of PG was 20% and the water solution concentration was 12%, the expansion ratio of foaming agent reached to the maximum value. Fig. 7 shows the result of expansion ratio of foaming agent by varying the concentration of BC with the concentration of DH-109EX fixed on 50% and PG fixed on 20%. The foaming agent appeared the maximum expansion ratio at the BC concentration of 9%

Optimized condition of SLES and DH-109EX system

Table 2. The optimum concentrations of foaming agent

	SLES system	DH-109EX system
Detergent (vol-%)	50	50
PG (vol-%)	25	20
BC (vol-%)	5	3
Max. water solution concentration (vol-%)	9	12
Expansion Ratio	16	20

Table. 2 shows the optimized condition of two kinds of foaming agent (SLES and DH-109EX) according to the experiment results mentioned above.

The stability and extinguishing capacity test of these two foaming agents

Table 3. Stability test of foaming agent

	SLES system		DH-109EX system	
Viscosity (c.p)	3%	288	3%	256
	12%	288	12%	304
Drainage time(sec)	3%	116	3%	80
	12%	245	12%	101

Table 3 shows the viscosity and drainage time of two kinds of foaming agent (SLES and DH-109EX) when the agents meet the requirement of varies indexes proposed in Table 2. It is seen in Table 3 that the viscosity of these two kinds of agent ranges within 250-300c.p. The duration of the drainage time meets the requirement of foam extinguishing agent. The result of stability test states that these two foam agents are qualified as the foam-extinguishing agents.

Table 4. The experiment for extinguishing ability by using foaming agent (Amount of foaming agent : 1 ℓ)

Unit	SLES system	DH-109EX system
B-0.5	○	×
B-1	×	×

To verify the extinguishing ability, the agents were used to extinguish the gasoline pool fires, the area of that are variable. Table. 4 shows the result of test. Only did SLES system extinguish the pool fire with boundary of B-0.5. In other experiments, the agents failed to extinguish the burning gasoline and Ring fire phenomenon appeared in boundary of B-0.5 and B-1 unit of Class B fire. The reason was that the foaming agents did not form a complete film on the surface of gasoline. Some parts of gasoline pool could not be isolated from air. According to this test, new method will be performed in further experiment to avoid the appearance of this phenomenon.

REFERENCES

1. Willoson, M., "Foam Systems – the Induction Options", Fire & Rescue, Issue 19, July, 1996, pp. 35-36
2. Michael Clarke, Fire Fighting Foams, Fire Surveyor, 12, 1992
3. Ki-Chang Jung, "The Development of the FM-200TM Gas-Filled AFFF Fire Extinguisher for Automatic Fire Suppression Systems in the Engine Compartment of Automobiles", M.S. Thesis, November, 1996
4. Report, "A Study on the Development of Detection System for the Hazardous Condition of Automobile", G-7 Project, September, 1997, Korea
5. J. Brittain, "Environmental Concerns Prod used By Foam Usage Fire", 10, 1994
6. Kida, "Test of Automatic Extinguisher for New Type Diesel Car", Quarterly Report of the Railway Technical Research Institute, Vol.18, No.2, pp. 95-96, 1977
7. C.F. Boyd, M.di Marzo, "Fire Protection Foam Behavior in a Radiative Environment", NIST-GCR-96-702, pp. 13-14