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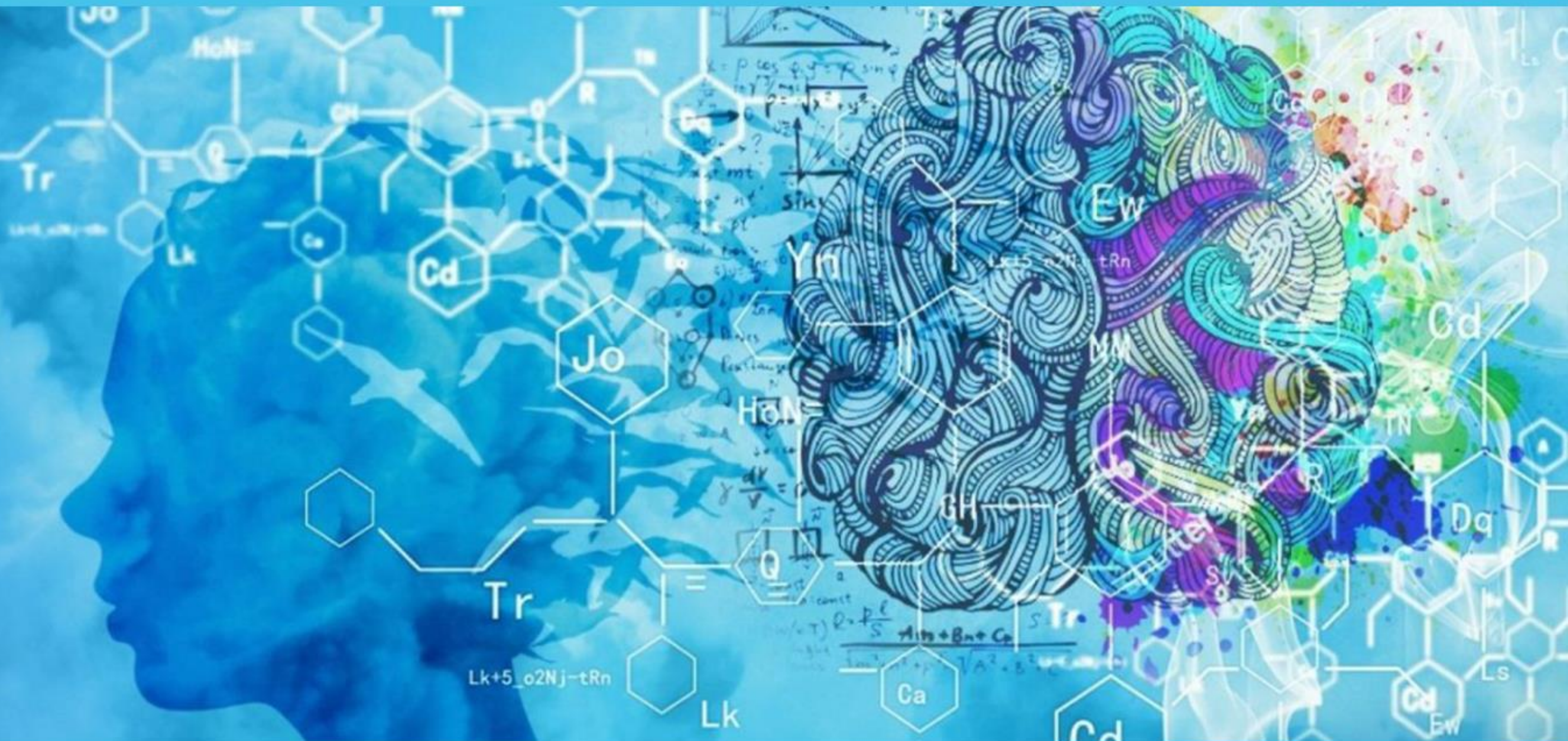

PROCEEDINGS OF II INTERNATIONAL SCIENTIFIC AND PRACTICAL CONFERENCE
SEPTEMBER 5-7, 2021

KHARKIV
2021

UDC 001.1

The 2nd International scientific and practical conference "Topical issues of modern science, society and education" (September 5-7, 2021) SPC "Sci-conf.com.ua", Kharkiv, Ukraine. 2021. 624 p.

ISBN 978-966-8219-85-6

The recommended citation for this publication is:
Ivanov I. Analysis of the phaunistic composition of Ukraine // Topical issues of modern science, society and education. Proceedings of the 2nd International scientific and practical conference. SPC "Sci-conf.com.ua". Kharkiv, Ukraine. 2021. Pp. 21-27. URL: https://sci-conf.com.ua/ii-mezhdunarodnaya-nauchno-prakticheskaya-konferentsiya-topical-issues-of-modern-science-society-and-education-5-7-sentyabrya-2021-goda-harkov-ukraina-arhiv/.

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EXTINGUISHMENT EFFICIENCY DETERMINATION OF HYDROCARBONS COMBUSTION WITH AQUEOUS SOLUTIONS OF *d*-METAL COMPLEX SALTS

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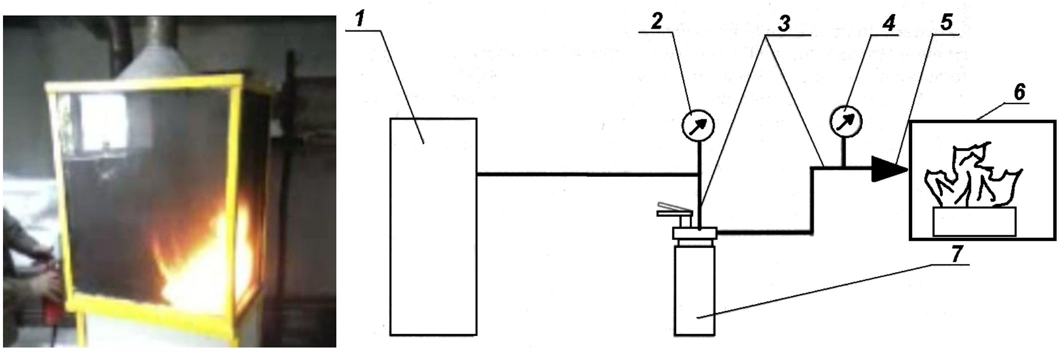
Introduction. A systematic search for new chemicals that could suppress efficiently flame and demonstrate high extinguishment performance is an important fire safety problem that must be solved immediately. To date, technologies for spraying aqueous fire extinguishing agents (AFEAs), which fully ensure the realization of both the unique physicochemical properties of water and the inhibitory function of the salts dissolved in it, are widespread in the world practice of firefighting. The salts of *s*-metals and ammonium, which are readily soluble in water, are most often used as AFEAs in extinguishing fires. In particular, some inorganic potassium salts formed the basis for the development of AFEAs based on K_2CO_3 for extinguishing class A and B fires. The development of new AFEAs based on transition metal salts is very promising. The effectiveness of extinguishing fires with aerosols of aqueous solutions of *d*-metal salts is due to the special chemical properties of *d*-metals as electron acceptors, which ultimately gives these fire extinguishing compositions a high ability to stop the spread of flame. Copper(II) salts are no less promising substances for the development of new AFEAs; in particular, a concentrated aqueous solution of $CuCl_2$ turned out to be an extremely effective means of suppressing flame when extinguishing class B fires [1].

Aim. In this work, we tried to combine the effectiveness of fire extinguishing of s- and d-metal salts and tested a 40% aqueous solution of the $K_2[CuCl_4]$ complex salt as a new extinguishing agent to suppress non-polar hydrocarbons combustion using the technologies of aerosol fire-extinguishing.

Materials and methods. To prepare AFEA and study its fire extinguishing properties, the following chemicals were used: the inhibitors of burning (base of AFEA) – copper(II) chloride dihydrate ($CuCl_2{\cdot}2H_2O$) and potassium chloride (KCl); a foaming agent (FA) (addition to AFEA) – the ammonium n-alkylsulfate ($[C_nH_{2n+1}SO_3-]NH_4^+$, where n = 12–16); a fire source (seat of fire of B_1 and B_2 classes) – "B_1": n-hexane (C_6H_{14}) and "B_2": monoethanolamine ($HOC_2H_4NH_2$).

The fire-extinguishing efficiency of the 40% aqueous solution of $K_2[CuCl_4]$ has been determined according to the all-Union State Standard 3789 using the equipment displayed in Fig. It is made up of the test chamber in the parallelepiped shape (outer size is 0.7m×0.6m×0.45 m; the net volume is 0.19m^3) in which is put a seat of fire of B class. The top of the chamber has an orifice (Ø=10 cm) connecting to a chimney. The equipment also comprises a graduated cylinder for determination of the AFEA expense, a device for the AFEA feed (the certificated Carbon Dioxide Fire-Extinguisher (CDFE-5) possessing the volume of 5 dm3 and sprinkler (Ø=1.0 mm)) and a stopwatch (precision class is ±0.2 s).



a ***b***

Fig. General view of the test chamber designed (*a*) and its schematic image (*b*)

Separately, the operating aqueous solution of the potassium tetrachlorocuprate(II) of various concentrations was prepared and the fire extinguisher BB-5 was filled these solutions. The pressure of 6 bar was set in the body of fire extinguisher, using compressed-air cylinder. Dispersion of AFEA was performed by means of centrifugal sprayer with nozzle of 1 mm in diameter. The AFEA supply productivity was 0.0045 $L \cdot s^{-1}$ (for comparison, the water supply productivity is 0.0054 $L \cdot s^{-1}$).

Results and discussion. The test results are presented in the table. The coefficient of increasing the fire extinguishing efficiency of the solution (K_1) relative to water was calculated by the formula:

$$K_1 = V_{water}/V_{AFEA},$$

where V_{water} or V_{AFEA} is the volume of water or AFEA used to extinguish the fire source.

Table

Results of fire extinguishing with aqueous solutions of $K_2[CuCl_4]$

AFEA	*n*-Hexane (B_1 class)			Ethanolamine (B_2 class)		
	V_{AFEA}, mL	$\Delta\tau_{exting.}$, s	K_1	V_{AFEA}, mL	$\Delta\tau_{exting.}$, s	K_1
40% aqueous solution $K_2[CuCl_4]$	9	7	3.2	6	5	4.2
20% aqueous solution $K_2[CuCl_4]$	11	9	2.7	10	8	2.4
10% aqueous solution $K_2[CuCl_4]$	21	12	1.4	16	11	1.6
Water	29	17	1	25	15	1

The test results showed that the time for extinguishing a fire source (B class) with a 40% aqueous solution of $K_2[CuCl_4]$ is 5 s. The fire extinguishing efficiency of a 40% aqueous solution of $K_2[CuCl_4]$ in comparison with water increased 4.2 times (for B_2 class) and 3.2 times (for B_1 class), taking into account the extinguishing time and consumption of AFEA. Thus, the tests carried out demonstrate a high efficiency of extinguishing a hydrocarbon flame with a 40% aqueous solution of $K_2[CuCl_4]$. The minimum consumption of AFEA has been found to be 1.8 $L \cdot m^2$ (B_1 class) and 1.1 $L \cdot m^2$ (B_2 class).

References

[1] Mykhalichko B., Lavrenyuk H., Mykhalichko O. New water-based fire extinguishant: Elaboration, bench-scale tests, and flame extinguishment efficiency determination by cupric chloride aqueous solutions // Fire Safety Journal. – 2019. – Vol.105. – P. 188-195