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PRODUCTION OF ECO-SAFE, HIGHLY EFFICIENT AND CHEAP FIRE-PROTECTIVE MATERIALS OF NEW TYPE

L.Gurchumelia*, F.Bejanov, M.Tsarakhov *, Z.Khutsishvili*, L.Nadareishvili***

**TSU Rafael Agladze Institute of Inorganic Chemistry and Electrochemistry,*
11, Mindeli str., Tbilisi, 0186, Georgia
***G.Tsulukidze Mining Institute of the Ministry of Education and Sciences of Georgia*
Organization,7, Mindeli str., Tbilisi, 0186, Georgia
e-mail: l_gurchumelia@yahoo.com

The development of eco-safe, highly efficient fire-protective materials of the new type through the use of local mineral raw materials are discussed in the paper. The technology for the production of these materials differs from serial production technology. These fire-protective materials are produced exclusively through mechanical mixing of binders and fillers and need no addition of expensive flame retardants. As a result, cost prices for fire-protective materials are low as compared with imported analogues.

Keywords: *eco-safe, fire resistance, non-toxic, high efficient, fire-protective materials*

Introduction

Protection of building materials and constructions against fire effect is a matter of paramount importance, which provides for increase of their fire-resistance properties. Fire-resistance is an ability of material to withstand effect, the fire restrict the spread of fire and retain its operating characteristics at high temperatures during a fire. Protection of material against fire means a decrease of fire-hazard by a special treatment, in which surface treatment of material as well as their impregnation by fire-protective compounds is meant. Protection against fire by the use of impregnating compounds is quite costly process; it is neither universal, nor usable for materials of all types. Along with it, very often, in the course of operation process an elution of impregnating compounds takes place [1-3].

Therefore, at present surface treatment of materials is considered to be as one of the most crucial methods. Note that for surface treatment the surface protective compounds are used. It is well known that the main components of surface protective compounds are as follows: binders, flame retardants and fillers. Organic as well as inorganic compounds are used as binders. Inorganic binders are characterized by lesser operating properties. Therefore organic polymeric compounds, including polyethers, polyvinyl acetates, phenol formaldehyde, polyurethane and polycarbamide resins, are mainly used as binders. As a rule, organic compounds are qualified as easily combustible compounds and to decrease their combustibility, reactive flame retardants-chloro- and phosphoroganic monomers are added and directly involved in the processes of polymerization to form co-polymers by high fire-resistance sometimes with low operating properties. Along with this, it is well-known that chlorine and phosphorous content enhances ability for smoke formation and toxicity of polymeric material. It should also be added that the use of reactive flame retardants is fraught with quite expensive and complex processes which are not studied completely as yet [2-4]. Hence, at present one of the most important problems is the development of halogen-free, nontoxic, eco-safe, inexpensive fire-protective materials.

In considering the above stated, we suggest ways of the development of eco-safe, inexpensive, highly efficient, universal fire-protective materials of new type based on local mineral raw materials, which in composite materials are operating as efficient flame retardants. It'd be appropriate to emphasize that the technology for the production of these materials varies from the serial production technology. These fire- protective materials are manufactured only by mechanical mixing of binders and fillers and need no addition of expensive flame retardants, which, in turn, will be reflected in low price costs for fire-protective materials as compared with imported analogues.

Experimental results and discussion

Binders and fillers were selected according to their high operating properties and factors that indicate the reduction of burning processes. Polyurethane resins were selected as binders, popularity of which is due to their low prices and simplified technological process of production, including mechanical mixing of initial products; liquid isothyanate and polyol components of various viscosities by definite ratio, polymerization occurring at conventional temperatures. The surface gets hardened fully within 60-180 sec. Along with it, polyurethane resins, as compared with binders used in series are noted for some advantages: eco-safety, low combustibility, high adhesion strength practically with materials of all types (wood, metal, concrete, asphalt, etc.); high waterproof and anticorrosive properties; heat and frost resistance. Note that high-dispersed composite powders of local mineral raw materials are used as fillers. Raw materials: zeolites, clay shales and perlites were selected to comply with their high operating properties and the reduction of burning processes. It is well-known that they are mainly of silicate origin and involve hydroxides of alkaline and alkaline-earth carbonates, bicarbonates, silicates, hydroxides of Fe and Al and crystallization water [5]. Therefore, in terms of intensive heating incombustible gases, the water steam and metal oxides are separated. Released incombustible gases and water steam in flame zone are acting as phlegmatizer and cause the formation of swelled layer on surface zone. Protective film of metal oxides and enhanced coke layer hinder the transfer of heat to combustive material and thus exclude any direct contacts of combustive material with air. This attests to the fact that they are characterized by high inhibition properties. As a result, it may be suggested that such composite powders in fire-protective materials might be used as efficient flame retardants. It has to be kept in mind that obtained powders being identical to inert flame retardants are not involved in the process of polymer preparation, so their mechanical mixing with polymeric binders is possible in the course of processing, but, in contrast, it is characterized by high operating properties, for instance, they have low caking capacity, are eco-safe, practically insoluble, and no elution and migration of surfaces of the material is observed.

Not only fire-protective materials are designed to effectively protect materials against fire, but they also should retain their properties, the variation of which reduces cover efficiency. This parameter is determined not only by their inhibition properties and fire-resistance ability, but their operating properties as well. The most important ones among them are adhesion strength, impact strength, hygroscopisity, heat- and frost-resistance and artificial ageing.

Experimental studies were carried out for wood materials to produce fire-protective materials through the mechanical mixing of binders - polyurethane resins and fillers – highly dispersed composite powders: zeolites, clay shales and perlites. Operating properties of fire-protective materials were examined by standard laboratory methods [6,7]. Results of experimental researches are shown in Table 1.

Table 1. Operating properties of fire-protective materials

	Fire-protective materials	Hygro-scopisity, %	Adhesion strength, MPa	Impact strength, Sm	Artificial ageing
1	Composite powders – 40% Polyurethane resins - 60%	0.1	1.4	75	resistant against atmospheric
2	Composite powders - 50% Polyurethane resins - 50%	0.11	1.35	73	resistant against atmospheric
3	Composite powders - 60% Polyurethane resins - 40%	0.12	1.25	72	resistant against atmospheric

Estimation of fire-resistance of fire-protective materials is performed by the complex of fire-technical characteristics (combustibility, ignition, flame proportion, smoke formation and toxicity) which are selected in accordance with materials functions and scope of application. Fire-technical characteristics can be determined by various standard methods of fire testing.

Main characteristics of combustibility – time for independent combustion - t_{cr} (sec); degree of material failure (mass loss) - S_m(%) which is calculated by formula as follows:

$$S_m = \frac{m_1 - m_2}{m_1} \cdot 100$$

where m_1 is sample mass before testing, gr ; m_2 - mass after testing, gr.Degree of failure lengthwise - $S_L\%$, which is calculated by formula as follows:

$$S_L = \frac{S_1 - S_2}{S_1} \cdot 100$$

Where S_1 is sample length before testing, cm; S_2 - length of damage sample, cm.

In the course of studying combustibility of materials in an initial stage it is established combustible group bythe method of "fire tube", which is exploited for building materials for establishing of combustibility group. Classifying of materials by combustibility is carried by the following manner: incombustible material - mass loss < 9%; hardly combustible material - mass loss 9 - 20%: combustible material - mass loss > 20%. [8]. Results of experimental studies are shown in Table 2.

Table 2. Fire-resistance of fire-protective materials

	Fire-protective materials	Mass loss S_m(%),	Degree of failure lengthwise $S_L\%$	Time of indepen dent combustion t_{cr} (sec);	Combustible group
1	Composite powders –40% Polyurethane resins –60%	12.5	≤ 60	>30	hardly combustible
2	Composite powders -50% Polyurethane resins 50%	10.8	≤50	<20	hardly combustible
3	Composite powders -60% Polyurethane resins –50%	9/4	≤25	<10	hardly combustible

Experimental results demonstrate that fire-protective materials of our making are characterized by higher operating properties and fire-resistance, so they might be qualified as hardly combustible materials. Hence, we can surmise that these fire-protective materials with their operating properties and heightened fire-resistance are in line with requirements as set forth in normative documentation attached to the materials used in building processes. Thus, they can be used to secure building materials and constructions against possible hazards. Moreover we have established, that by increase of filler content in polyurethane resins fire-resistance sharply enhances and operating properties vary slightly. From this it follows that the selection optimal amount of mentioned fillers for polyurethane resins is possible and in case of its addition, fire-protective materials with high operating properties and high fire-resistance might be obtained.

Conclusions

- We developed fire-protective materials which are of new type, eco-safe, very effective and universal. They can be used to protect building materials and constructions of any type from fire.
- Fire-protective materials obtained are-manufactured through mechanical mixing of binders -polyurethane resins and fillers - high-dispersed composite powders of mineral raw materials, which operate in composite materials as efficient inert flame retardants. It should be noted that these fire-protective materials are far cheaper than imported analogues.
- Note that the technology for production of these fire-protective materials is simple and different from serial production technology.

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ПОЛУЧЕНИЕ НОВЫХ, ЭКОЛОГИЧЕСКИ БЕЗОПАСНЫХ, ВЫСОКОЭФФЕКТИВНЫХ И ДЕШЕВЫХ ОГНЕЗАЩИТНЫХ МАТЕРИАЛОВ

Л.Гурчумелия,[*] Ф.Бежанов,**, М.Царахов [*], З.Хуцишвили*, Л.Надареишвили[*]

[*]ТГУ Институт неорганической химии и электрохимии им. Р.Агладзе
ул. Миндели 11, Тбилиси, 0186, Грузия
********Горный Институт им. Г.Цулукидзе Министерства просвещения и науки Грузии*
ул. Миндели 7, Тбилиси, 0186, Грузия
l_gurchumelia@yahoo.com

В статье рассматриваются экологически безопасные, высокоэффективные огнезащитные материалы нового типа. Технология их производства существенно отличается от технологии серийного производства огнезащитных материалов. Указанные материалы получены только механическим перемешиванием связующего материала и наполнителя и нет необходимости добавлять дорогие антипирены, поэтому они намного дешевле по сравнению с импортными аналогами.

Ключевые слова: *экологически безопасные, огнестойкие, нетоксичные, высокоэффективные, огнезащитные материалы.*

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