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BRIEF COMMUNICATIONS

Study of Physical and Mechanical Properties and Combustibility of Filled Acrylate Compositions

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Abstract—Compositions based on cross-linked acrylate copolymers and bentonites were obtained. Physical-mechanical and absorption characteristics of bentonite-polymeric composite materials were studied. The effect of a filling agent on the final product properties was demonstrated. The possibility of using these compositions for creating materials with reduced combustibility was shown.

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Bentonites represent clay-like materials which are mainly used for the preparation of drilling fluid, in agriculture, in industry as a basis of hydraulic insulating materials and adsorbents for refining waste and process waters, in household chemistry, in refining petroleum derivatives, etc. [1–3]. Bentonites are natural moisture absorbents, i.e. materials capable to absorb and keep an amount of water 14–16 times greater that the weight of the sample itself. It is known that when a free swelling space is limited, a strong gel hindering the further moisture infiltration is formed. Thus, the use of bentonite as a filling agent in the composition of a polymeric matrix should promote strengthening the polymeric matrix and also reducing combustibility of materials based on it.

The aim of this work was to create polymeric compositions with improved physical and mechanical characteristics and reduced combustibility on the basis of cross-linked acrylate copolymers and bentonite.

EXPERIMENTAL

In this work we obtained composites with acrylic hydrogel used as a polymeric matrix and Na–Ca bentonite (**I**) of various concentrations as a filling agent. The acrylic copolymer was obtained on the basis of acrylic acid (**II**) and acrylamide (**III**) in the weight ratio (**II**) : (**III**) = 70 : 30. The compositions were synthesized by the radical polymerization in an aqueous medium at 50°C. We used the system ammonium persulfate–tetramethylethylenediamine as the initiator and *N, N*'-methylenebisacrylamide as the cross-linking agent. The degree of neutralizing **III** was $\alpha = 0.9$. The polymerization was carried out at the initial concentration of monomers 30, of the cross-linking agent 0.3 wt %. The time of the synthesis of the compositions in the aqueous medium was 0.5–5 h.

The physical-mechanical and absorption characteristics were studied according to the standard procedures [4].

The equilibrium swelling degree of polymeric compositions was measured by a standard gravimetrical method and calculated by the equation:

$$Q = (m_s - m_d)/m_d.$$

Here m_s is the mass of the swollen sample (g), and m_d, the mass of the dried up sample (g).

In calculations the results of measuring swelling of five analogous samples were averaged.

Combustibility was investigated on a KT instrument consisting of a ceramic hot-fire camera.[a] Prepared composite samples were subjected to conditioning according to GOST 12423-66. By means of a rotameter

[a] The experiments were carried out at St. Petersburg University of State Fire Engineering Service, Ministry of Emergency Situations of Russia.

Results of studying combustibility of filled polymers

Filler content, wt %%	Moisture content, %	Composition weight, g		Weight variation		Area S_i, cm^2	K_{av}
		initial	after combustion	g	%		
50	0.67	120	83	30.83	37	565	0.1
20	0.68	92	55	40.21	37	570	0.11
10	0.65	112	88	21.42	24	577	0.13
5	0.67	88	63	28.40	25	550	0.07
0	0.67	78	27.58	64.64	50.42	565	0.1

such fuel consumption in the burner was set, that provided the temperature of 200 ± 5°C monitored within 2–3 min for the gaseous combustion products in the center of the upper connecting pipe of the chamber umbrella. Then a sample of bentonite-polymer composite material was loaded into the chamber to determine a time of ignition. As the time of ignition passed, feeding gas in the burner was stopped and the sample under study was left in the hot-fire chamber for cooling within 20 min, beginning from the moment of loading the sample inside the chamber. In the course of the test the temperature of gaseous products of combustion was recorded on a potentiometer chart strip. The areas under resulting temperature curves S_i for the calibration and main tests were used to calculate the combustibility index K:

$$K = \frac{S_i}{S_i^T} - 1.$$

The average arithmetical value of combustibility indexes found in tests of three samples was accepted as a combustibility index K_{av} of a sample under study.

As the acrylic hydrogels filled with disperse filling agent (**I**) are typical heterogeneous systems with highly-developed phase boundary, one of our main tasks was the study of the effect of filling material characteristics on its physical and mechanical properties. The dependence of tensile strength of polymeric films modified by bentonite is shown in Fig. 1. An increase in the filling agent concentration in a polymeric matrix gives rise to an increase in the strength of polymeric films due to reinforcing properties of the filling agent resulted from the interaction of polymer macromolecules with the surface of the agent filling the polymer network and from the formation of a continuous reinforcing frame as a result of the interaction of filling agent particles with each other [5]. The experiment was carried out at a constant moisture content in the samples. The tensile strength of bentonite-polymeric films containing 50–60 wt % of the filling agent is 3-3.5 times greater than that for unfilled films. The dependence of a relative elongation of modified polymeric films on the concentration of (**I**) in the matrix is given in Fig. 1b, which shows that the relative elongation regularly decreases as the filling agent content in a mixture increases.

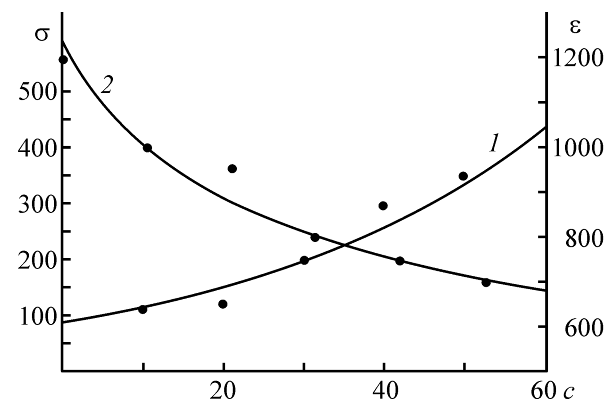

Fig. 1. Dependence of (*1*) tensile strength σ (kPa) and (*2*) relative elongation ε (%) of filled polymer films on bentonite concentration *c* (wt %).

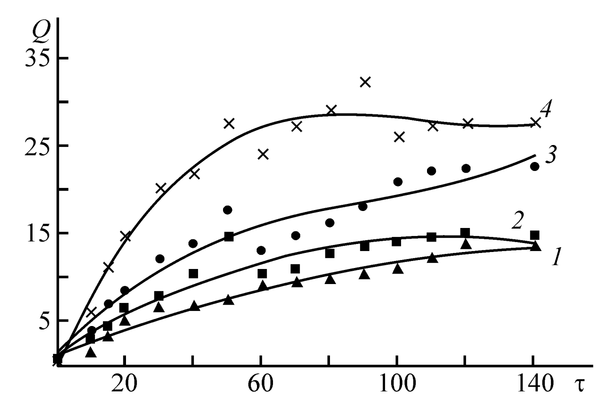

Fig. 2. Kinetic curves of swelling Q (g g^{-1}) bentonite polymeric films. τ is time (min). Concentration of **I** (wt %): (*1*) 0, (*2*) 30, (*3*) 50, (*4*) 60.

Kinetic curves of swelling bentonite-polymeric compositions are presented in Fig. 2. It is seen from Fig. 2 that an increase in a filling agent content in the polymeric matrix composition results in an increase in the absorbing capacity of the material as a result of the reduction in the effective cross-link density. The flame-resistance characteristic of the obtained composite materials based on bentonite and acrylic hydrogel is presented in the table.

It is seen from the table that the polymeric composite material under study is classified as not easily combustible ($K_{av} \leq 1$) according to its combustibility index.

CONCLUSIONS

1. The modified acrylic polymeric compositions have a reduced combustibility and are classified as not easily combustible. They can be used for making products with a reduced combustibility.

2. It has been shown that loading the filler improves deformation-strength and absorptive characteristics of the filled material.

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