DETERMINATION OF THE OXYGEN INDEX OF FIRE-RETARDANT ENAMEL COATINGS MODIFIED WITH A THERMOSTABLE MODIFIER BASED ON ACRYLIC ACID AND SILICA SOL

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Abstract. *This study examines the flammability of fire-retardant enamel composite coatings of the TB-1 and TB-2 grades, obtained by introducing a thermostable modifier based on acrylic acid and silica sol into KO-8101 paint. Flammability was evaluated by the oxygen index method in accordance with GOST 12.1.044-2018 and GOST 21793-76 on coated poplar and pine wood samples, and the optimal modifier content in the paint composition was determined.*

Keywords: *oxygen index, flammability, fire-retardant coating, silica sol, acrylic acid, thermostable modifier, enamel paint.*

INTRODUCTION

Metal and wooden structures used today in many branches of industry and construction require reliable protection against high temperatures and fire. Wood is a combustible material, while unprotected steel structures rapidly lose their load-bearing capacity when heated. For this reason, fire-retardant composite coatings are widely used, and the oxygen index is increasingly employed as one of the key criteria for analyzing their properties[1],[2].

The oxygen index (OI) is the minimum volume concentration of oxygen in an oxygen–nitrogen mixture at which a sample still sustains flaming combustion. Since air contains about 21% oxygen, materials with an OI above this value do not sustain burning under normal atmospheric conditions[3]. Systems based on silica sol are promising in this respect: on heating, the silanol groups of colloidal silica condense to form a Si–O–Si network that acts as a heat-insulating barrier, while the acrylic acid

component ensures compatibility of the modifier with the organic binder of the paint[4],[5]. Accordingly, the aim of this work was to determine the effect of a thermostable modifier based on acrylic acid and silica sol on the oxygen index of fire-retardant enamel coatings.

RESEARCH OBJECT AND METHODS

The research objects were KO-8101 enamel paint and the fire-retardant composite coatings TB-1 and TB-2 prepared on its basis. The TB-1 composition contained 92% KO-8101 paint, 4% thermostable modifier based on acrylic acid and silica sol, and 4% solvent (isopropyl alcohol); the TB-2 composition contained 90% paint, 6% modifier, and 4% solvent (mass %). The coatings were applied to poplar and pine wood samples; samples coated with the unmodified enamel served as the control.

Samples were prepared and tested in accordance with GOST 12.1.044-2018 and GOST 21793-76. Testing began with a mixture containing 20% oxygen, and the oxygen concentration in the oxygen–nitrogen mixture was then varied within the range of 18–42% until the minimum concentration sustaining combustion was established. To assess fire resistance on metal, the selected composition was applied to metal plates measuring 140 mm × 80 mm × 1 mm in accordance with Ts 22626846-03:2016 and O‘z DSt 2313; after coating, the samples were conditioned for 14 days at 20 ± 5°C and 60 ± 10% relative humidity and then exposed to temperatures of 800–1000°C.

RESEARCH RESULTS

The results of the oxygen index measurements are given in Table 1. The control samples coated with unmodified enamel had an OI of 18.9% (poplar) and 20% (pine), i.e. below the oxygen content of air, which means that they sustain combustion under normal conditions.

Sample	KO-8101 paint, %	Modifier, %	Isopropyl alcohol, %	OI (poplar), %	OI (pine), %
Control (enamel)	100	0	–	18.9	20
TB-1	92	4	4	28	31
TB-2	90	6	4	33	38

Table 1. Effect of the TB-1 and TB-2 fire-retardant composite coatings on the oxygen index of wood samples.

The introduction of 4% modifier (TB-1) raised the oxygen index to 28% for poplar and 31% for pine, i.e. by 9.1 and 11.0 units (48.1% and 55.0%) compared with the

control. Increasing the modifier content to 6% (TB-2) raised the OI further to 33% and 38%, respectively — by 14.1 and 18.0 units (74.6% and 90.0%). For both modified compositions the OI exceeds 21%, so the coated samples do not sustain combustion in air. At every composition the pine samples showed higher OI values than the poplar samples, which is likely associated with differences in the density and structure of the wood.

The increase in the oxygen index is explained by the formation, under thermal exposure, of a dense silicon-oxygen (Si–O–Si) layer from the colloidal silica of the modifier, which limits heat transfer to the substrate and the diffusion of oxygen and combustible volatile products into the flame zone[4],[6]. Although the TB-1 composition with 4% modifier also markedly increased the oxygen index, its physical and mechanical properties fell below the required standards. Therefore, the TB-2 composition containing 6% modifier was selected as the most effective and was used for fire-resistance testing on metal plates at 800–1000°C.

CONCLUSION

The studies showed that the thermostable modifier based on acrylic acid and silica sol substantially reduces the flammability of KO-8101 enamel coatings. With 6% modifier in the composition (TB-2), the oxygen index of coated wood samples increased from 18.9% to 33% for poplar and from 20% to 38% for pine, reaching the level of materials that do not sustain combustion in air. Taking into account both the oxygen index and the physical-mechanical properties, a modifier content of 6% was found to be optimal. The developed TB-2 fire-retardant composite coating is of practical value for the fire protection of wooden and metal structures.

REFERENCES

1. GOST 12.1.044-2018. Occupational safety standards system. Fire and explosion hazard of substances and materials. Nomenclature of indices and methods of their determination. Moscow: Standartinform, 2018.

2. GOST 21793-76. Plastics. Method for determination of oxygen index. Moscow: Izdatelstvo standartov, 1976.

3. ISO 4589-2:2017. Plastics — Determination of burning behaviour by oxygen index — Part 2: Ambient-temperature test. Geneva: ISO, 2017.

4. Horrocks A.R., Price D. Fire Retardant Materials. Woodhead Publishing and CRC Press LLC, 2001.

5. Jones F.N., Nichols M.E., Pappas S.P. Organic Coatings: Science and Technology. 4th Edition. Wiley, New York, 2017.

6. Weil E.D. Fire-protective and flame-retardant coatings — a state-of-the-art review. Journal of Fire Sciences, 2011, Vol. 29, No. 3, pp. 259–296.