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BOND FORMATION IN MINERAL FIBROUS HIGH STRENGTH COMPOSITES

[1]H. J. Ismoilova, [2]Ch.H. Bobilova
Karshi Engineering and Economic Institute

ANNOTATION

Using plant fibers, it is necessary to obtain high-strength heat-resistant mineral-fiber composites. The use of various types of fibrous binders complicates the bonding mechanism and requires a special study, the results of which should form the basis for the technology of composites of increased strength based on mineral fibers.

Key words: composite, heat-resistant, durable, spectrum, mill, Cotton fibers, binders, technology, mineral fibers.

In the case of obtaining mineral fiber composites of increased strength, it is advisable to use plant fibers of various types. In this case, the heat resistance of the obtained materials decreases, but in some cases composites are required with higher strength and lower heat resistance. The use of plant fibers for this purpose is expedient, since this process can be carried out within the framework of a bridge-resistant single technological cycle, creating a composition of fibers and carrying out their formation on a paper machine without additional processing. The economic component is of great importance, since plant fibers are obviously cheaper than both mineral and polymer binders.

It is of interest for hardening purposes to use polymer thermoplastic fibers capable of forming additional interfiber bonds in composites.

The use of various types of fibrous binders complicates the bonding mechanism and requires a special study, the results of which should form the basis for the technology of composites of increased strength based on mineral fibers.

Infrared spectroscopy with the decomposition of spectra into Gaussian contours and determination of the energy characteristics of bond formation was proposed as the main research method.

The measurement of the transmission spectra of mineral fibers, as well as mineral fibers with the addition of aluminum sulfate and cotton fiber, ground in a CRA mill up to 70 ° SR, was carried out using a Specord IR spectrometer in the frequency range 2700 ... 3800 cm^{-1}, characteristic of the vibrational frequencies of hydroxyl groups, covered by a hydrogen bond. Analysis of the shape of the absorption band by hydroxyl groups was used to estimate the characteristic lengths of hydrogen bonds in mineral fibers. The analysis is based on the previously used [6] ratio of the hydrogen bond length d to the absorption frequency ν by the hydroxyl group covered by the hydrogen bond. In this work, this approach is used to study the effect of hydrogen bonding on the formation of micro-composites based on mineral fibers and hydroxyl-containing components.

The shape of the hydroxyl absorption band is analyzed using the empirical ratio of the vibration frequency of the proton ν in the hydroxyl group and the distance d (Å) to the nearest oxygen atom:

$$\nu = A - B\exp(-d / C), (1)$$

where A, B and C are numerical coefficients determined based on analysis of literature data [1]: A = 3590 cm^{-1};

B = 3.04.1011 cm-1; C = 0.13 Å.

In fig. 1 shows the fragments of IR transmission spectra for glass fiber in the range of 2800 ... 3600 cm-1 with characteristic absorption bands; fiberglass with aluminum sulfate binder; cotton fiber; a composite based on fiberglass with the addition of 30% aluminum sulfate and 10% cotton fiber.

It is seen that the introduction of 30% Al_2O_3 into the glass fiber induces a broad asymmetric absorption band. In order to analyze the shape of the absorption band, it was decomposed into Gaussian contours, an example of which for two contours is shown in Fig. 2. Such decomposition quite satisfactorily describes the experimental absorption band for basalt fiber. The contour with a maximum at a frequency of 2950 cm-1 corresponds to a stronger (shorter distance to the nearest oxygen atom d = 2.65 A), a contour with a maximum at a frequency of 3320 cm-1 corresponds to a weaker (d = 2.77 A) hydrogen bond. The accuracy of the expansion over the contour area is about 1%. In the investigated frequency range, a dependence of the shape of the absorption band on the composition of mineral fibers and the percentage of introduced Al_2O_3 was observed, which is interpreted as a change in the strength of the hydrogen bond. To estimate the strengths of the strong and weak hydrogen bonds, the ratios of the areas of the corresponding Gaussian contours are determined. The dependence of the hydrogen bond strength on the percentage of Al_2O_3 in mineral fibers is illustrated by the diagram (Fig. 3), from which it can be seen that the strongest hydrogen bond is manifested in kaolinite containing 80% Al_2O_3.

Thus, the analysis of fragments of the IR spectra shows that the introduction of polyhydroxo complexes of aluminum organizes interfiber bonding between mineral fibers, which can be qualified as a hydrogen bond.

Using the above methods for measuring transmission spectra and analyzing the absorption band shapes by hydroxyl groups, which is based on the ratio of the hydrogen bond length d to the absorption frequency ν of the hydroxyl group covered by a hydrogen bond, we studied glass fiber samples with the addition of cotton cellulose, ground to 70 ° SR in a CRA mill in the presence of 30% aluminum sulfate (see Fig. 1).

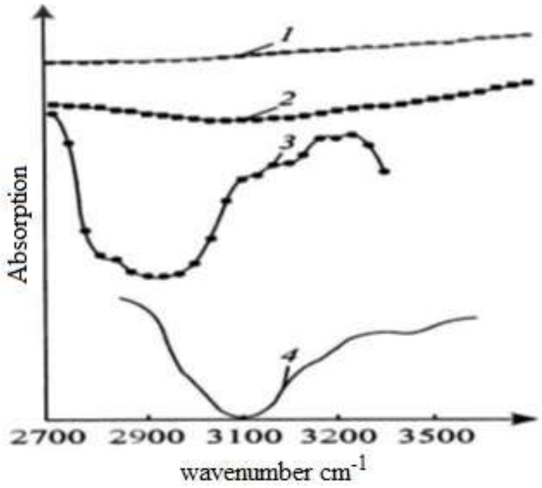

Fig. 1. Fragments of the IR spectra of the samples in the range of vibrational frequencies of hydroxide ions: 1 - glass fiber; 2 - glass fiber + 30% $Al_2(SO_4)_3$; 3 - fiberglass + 10% cotton + 30% $Al_2(SO_4)_3$; 4 - cotton

When analyzing a fragment of the IR spectrum of cotton cellulose, absorption bands are found that are most pronounced at frequencies of 3100 and 3280 cm^{-1} and are characteristic of hydroxyl groups bound by a strong hydrogen bond. It also shows a fragment of the IR spectrum of glass fiber with the addition of 30% aluminum sulfate and 10% cotton fiber, which shows a shift to the high-frequency region (3300 ... 3500 cm^{-1}), which is characteristic of weak hydrogen bonds, as well as less pronounced bands 3100 and 3250 cm^{-1} for cotton fiber.

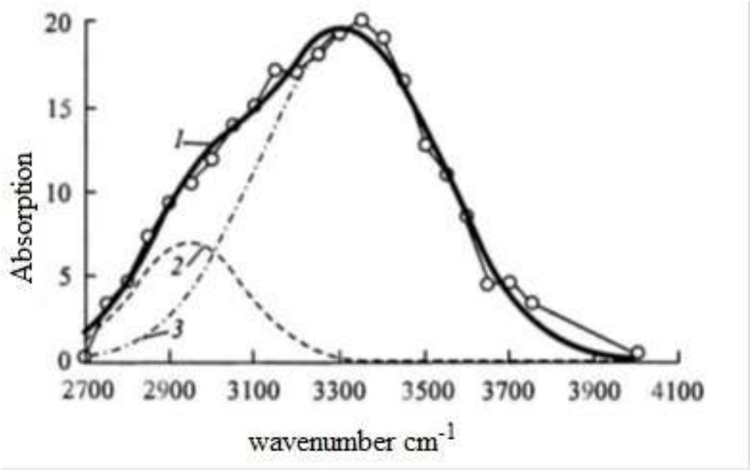

Fig. 2. Decomposition of the absorption band of basalt fiber into Gaussian contours: 1 - absorption band; 2 - Gaussian contour of strong H-bond; 3 - weak H-bond

Decomposition into Gaussian contours (Fig. 4) confirmed the distribution of bonds typical for a mixture of fibers, but the formation of new peaks was not found, which means the absence of any chemical interaction between the constituent composites.

However, when comparing the intensity of bonding in composites with a binder based on aluminum sulfate and ground cotton fiber, a significant increase in the proportion of strong hydrogen bonds due to bonds in cotton fibers was observed (peak at 2900 cm-1, corresponding to a strong hydrogen bond). The bonds formed by the interaction of mineral fibers with polyhydroxo complexes of aluminum are less energetic, since their length is higher. Well-ground cotton fibers are naturally a stronger activator of both homogeneous (between homogeneous fibers) and heterogeneous (between cotton and mineral fibers) bonds.

It should be noted that in paper-like composites based on mineral fibers in the presence of binders, as in paper materials based on plant fibers, at least the following types of bonds exist: due to friction forces and mainly depending on the nature of the fiber surface and structure density; intermolecular interactions, or van der Waals forces; hydrogen bond as a special case of coordination.

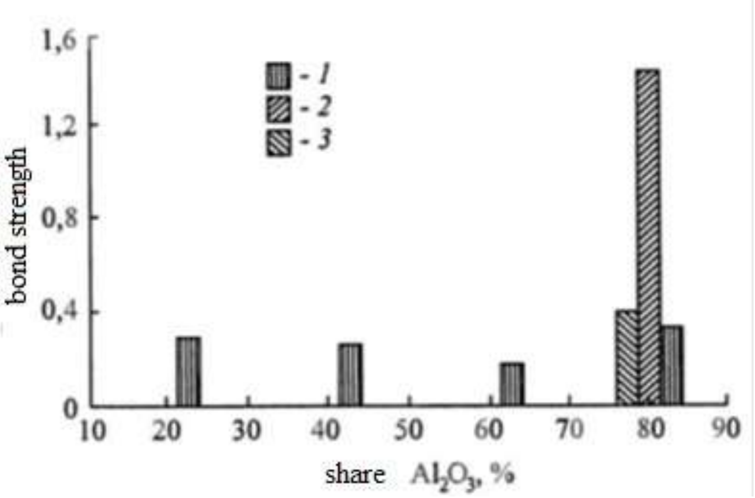

Fig. 3. Influence of the amount of binders on the strength of hydrogen bonds in the samples: 1 - glass fiber, 2 - kaolinite, 3 - basalt

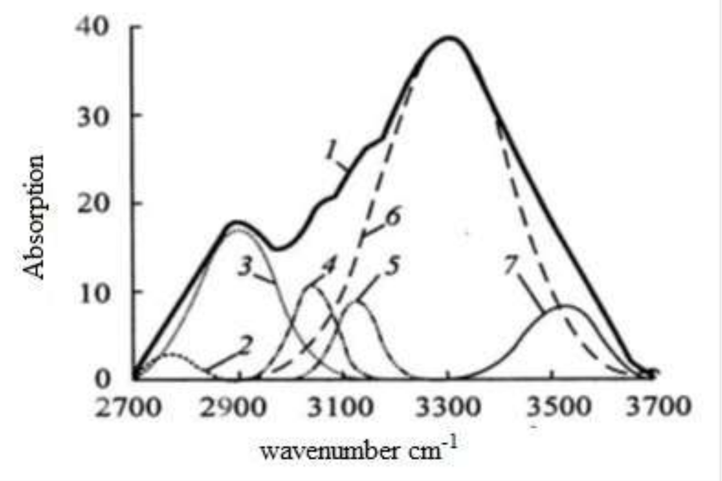

Fig. 4. Decomposition of the absorption band (1) glass fiber + 10% cotton + 30% $Al_2(SO_4)_3$ (pH 7.68) into Gaussian contours: 2 -absorption maximum at v = 2775 cm^{-1} (2%); 3 - 2990 (17%); 4 - 3042 cm^{-1} (6%); 5 - 3125 cm^{-1} (5%); 6 - 3300 cm^{-1} (62%); 7 - 3525 cm^{-1} (8%)

The essential difference in the bonds between mineral and plant fibers is as follows. In paper and paperboard made from plant fibers, frictional forces and van der Waals forces make an insignificant contribution to strength compared to hydrogen ones. S.N. Ivanov [5] rightly notes that the lower the strength of the paper (for example, from unground and weakly ground fibers), the greater part of the total strength arises due to friction and van der Waals forces. In the case of materials made of mineral fibers, the role of friction and van der Waals forces can be even greater and even exceed that for hydrogen bonds. When plant fibers are present in the structure of a composite based on mineral fibers, the predominance of stronger hydrogen bonds, which increase the strength characteristics of the material as a whole, is noted.

The absence of chemical interaction and the obvious impossibility of the formation of hydrogen bonds directly between mineral and plant fibers suggests the presence of independent structures of mineral fibers linked by poly hydroxo complexes and plant fibers linked by hydrogen bonds. Since composites are manufactured using traditional technology, i.e. From a joint fibrous suspension and at sufficiently low concentrations, which ensures a uniform distribution of fibers in the suspension, there is a high probability of mutual penetration of independent network structures, their compaction and the formation of a sufficiently strong composite.

FINDINGS:

1. Interfiber bonds in paper-like composites based on mineral fibers in the presence of cotton fibers are intensified due to better paper-forming properties.
2. Mineral and plant fibers do not directly form bonds of a physicochemical nature.
3. Strengthening of composites based on mineral fibers is associated with the formation of interpenetrating mesh structures of mineral and plant fibers.

LIST OF REFERENCES

1. Bersuker, I.B. Electronic structures and properties of coordination compounds [Text] / I.B. Bersuker. - L .: Chemistry, 1976 .-- 2nd ed. - 380 p.

2. Oak, V.K. Study of the mechanism of occurrence of moisture resistance properties in paper made of mineral fibers [Text] / V.K. Dubovy, G.I. Chizhov, V.V. Khovansky // Lesn. zhurn. - 2005. - No. 2. - P. 101–104. - (Proceedings of higher educational institutions).
3. Oak, V.K. Bondage in paper-like composites based on mineral fibers [Text] / V.K. Oak // ZhPH. - 2005. - T.78, issue 10. - S. 1733-1738.
4. Oak, V.K. Binding forces in paper from vegetable and mineral fibers [Text] / V.K. Dubovy, G.I. Chizhov // Lesn. zhurn. - 2005. - No. 4. - P.116–124. - (Proceedings of higher educational institutions).
5. Ivanov, S.N. Paper technology [Text] / S.N. Ivanov // School of paper. - 2006 .-- S. 695.
6. Formation of composites based on mineral fibers [Text] / V.K. Dubovy [et al.] // Letters ZhTF. - 2005. - T. 31, B.19. - P. 67–71.