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### APPLICATION OF THE MODIFIED STYRENE COPOLYMERS FOR REINFORCEMENT OF RECYCLED PULP PAPER

The article is devoted to investigation of reinforcement efficiency of the agents received on the basis of styrene copolymers and maleic anhydride on the properties of paper made of recycled pulp. It was established that for modification of styrene copolymers it is reasonable to use  $\text{NH}_4\text{OH}$ . Preferred content of maleic anhydride is 20–22 mol. %. The molecular weight of maleic anhydride copolymers should be in the range of 5,500–6,500 c. u. The reinforcement of styrene copolymers is manifested when the content of them in fibrous slurry is 0.5% of the mass of a. d. s. Drying temperature ( $120\pm 2^\circ\text{C}$ ) increases this effect, the strength of paper samples testifies it.

**Introduction.** At present waste paper possesses more important significance as a raw material in paper manufacturing. Because of the use of recycled fiber material stable increase of volumes of paper manufacture is observed [1]. However, a characteristic feature of recycled fiber is the manifestation of much worse paper-making properties in comparison with primary semiproducts (cellulose). Besides declining of the recycled pulp quality because of the increase of its processing cycles reduces the efficiency of functioning of paper-making machine and makes it difficult to achieve the required hardening properties of the finished product. The promising way to solve this problem is the use of hardening agents in paper pulp composition the efficiency of which depends on the conditions of their manufacturing and modifying. A great variety of compounds has become widely used as such additives in paper technology, but most of them are expensive. Moreover, the absence of domestic manufacturing of hardening additives in Belarus makes paper manufacturers depend on the imported products.

As a result manufacturing and application of the domestic hardening additives is an important direction of the country's import-substituting policy. In this regard, the researchers of the Laboratory of Catalysis of the polymerization processes of SRI PhChM BSU have synthesized new additives on the basis of styrene copolymers and maleic anhydride, the efficiency of reinforcement of which was evaluated at the department of chemical processing of wood BSTU.

Synthesized additives are water soluble that is one of the conditions of their use in the composition for paper manufacturing, they have a weak anionic character (Fig. 1).

**Main part.** The aim of this work was to determine the reinforcement efficiency of the modi-

fied styrene copolymer and maleic anhydride in manufacturing paper of the recycled pulp.

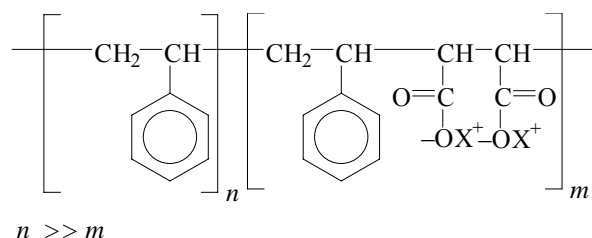


Fig. 1. Structure of styrene copolymers and maleic anhydride

As fibrous raw materials for manufacturing paper samples we used mixed waste paper MS-2A, MS-6B, MS-13B (GOST 10700-97) with grinding degree  $40^\circ\text{ShR}$ . Sizing of pulp was carried out by emulsion based on alkylketene dimer (AKD) ("Ultrasayz-200" TU 2499-004-70048729-07) in combination with cationic starch ("Hi-Cat" TU 9187-002-96457359-07). The samples of additives based on styrene copolymers and maleic anhydride, different in the type of the modifying agent ( $\text{NH}_4\text{OH}$ ,  $\text{NaOH}$ ,  $\text{KOH}$ ,  $\text{Ca}(\text{OH})_2$ ) were subjected to a comparative evaluation (Table 1).

Table 1

#### Characteristics of hardening additives of different modifying agent

Investigated sample	Modifying agent	Molecular weight, c. u.	The content of maleic anhydride, mole. %
N 1	$\text{NH}_4\text{OH}$	5,000	20.1
N 2	$\text{NaOH}$		
N 3	$\text{KOH}$		
N 4	$\text{Ca}(\text{OH})_2$		

The objects of research are paper samples with the weight of one square meter 80 g containing modified cationic starch (0.54% demand of a. d. s.), AKD sizing emulsion (0.13% demand of a. d. s.) and investigated samples of modified styrene copolymers. Dosing of chemicals was done in the given above sequence. Samples of paper were produced by the sheet-making apparatus "Rapid-Ketten" ("Ernst Haage" Company, Germany).

At the first stage of the research the influence of modifying conditions of the investigated copolymers on the efficiency of their reinforcement depending on the content of additives in the composition of the pulp was studied (Table 1). The flow varied from 0 to 2.0% of a. d. s. The received results of changing of the breaking length and absorption at one-side wetting of paper samples are shown in Fig. 2 and 3.

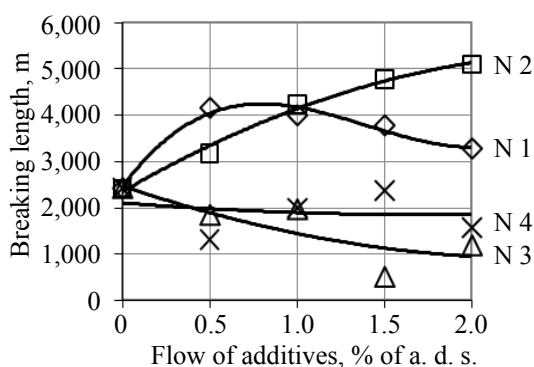


Fig. 2. The change of the breaking length of paper samples depending on the type and the flow of additives

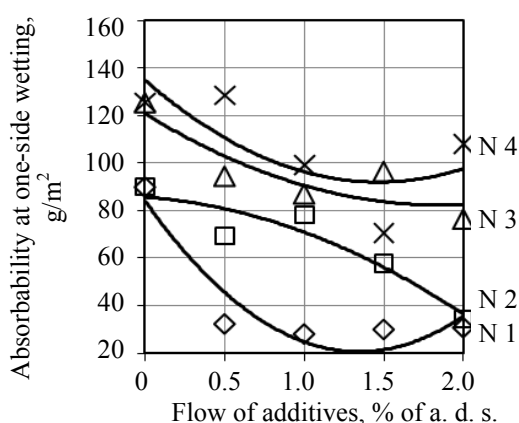


Fig. 3. The change of absorbability at one-side wetting of paper samples depending on the type and flow of additives

Comparative analysis of dependences of the change of the breaking length (Fig. 2) and absorption at one-sided wetting (Fig. 3) depending on the flow of additives indicates a high efficiency of

reinforcement of the investigated additive samples N 1 and N 2, modified NH<sub>4</sub>OH and NaOH respectively.

The largest increase of the breaking length is observed when the content of additives in paper composition is 0–1.0% of a. d. s. The increase of the flow of additives of more than 1.5–2.0% of a. d. s. is not recommended as in this case the smaller increase of breaking length of paper samples at a slight increase of absorption at one-side wetting is observed. Besides, high flow will increase the cost of the finished product. It is important to note also that the best absorption at one-side wetting (28.2–32.4 g/m<sup>2</sup>) is provided by using of styrene copolymer and maleic anhydride modified NH<sub>4</sub>OH.

This led to further investigations aimed at determining the efficacy of additives modified by aqueous ammonia (NH<sub>4</sub>OH), different in molecular mass and maleic anhydride content (Table 2). The flow (F,% of a. d. s.) of investigated additives varied from 0 to 1.5% in increments of 0.5% a. d. s.

Table 2  
Characteristic samples of strengthening additives modified by aqueous ammonia

Investigated sample	Modifying agent	Molecular weight, c. u.	The content of maleic anhydride, mole. %
N 1	NH <sub>3</sub>	5,000	20.1
N 5		6,500	22.0
N 6		5,500	15.5

The obtained results describing the effect of the above-mentioned conditions of synthesis and modification of the investigated additives on the breaking length and absorption at one-side wetting of paper samples are shown in Fig. 4 and 5.

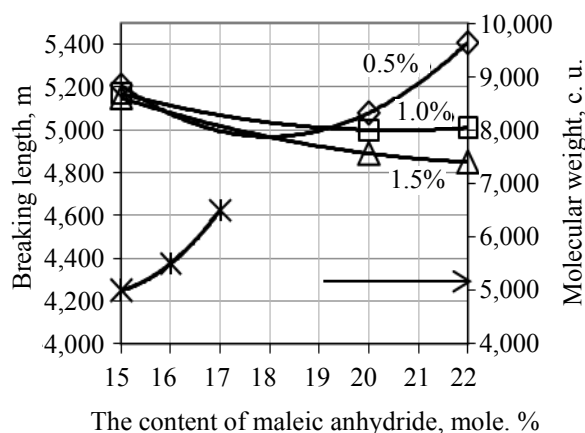


Fig. 4. The change of the breaking length of paper samples depending on the content of maleic anhydride in the composition of investigated styrene copolymers

The comparative analysis of characteristic curves (Fig. 3 and 4) showed that the best hardness and hydrophobic properties of paper samples are obtained at investigated additives flow of 0.5% of a. d. s. In addition, the range of the content of maleic anhydride units 20–22 mol. % and the molecular weight in the range 5,500–6,000 c. u. is of a practical interest.

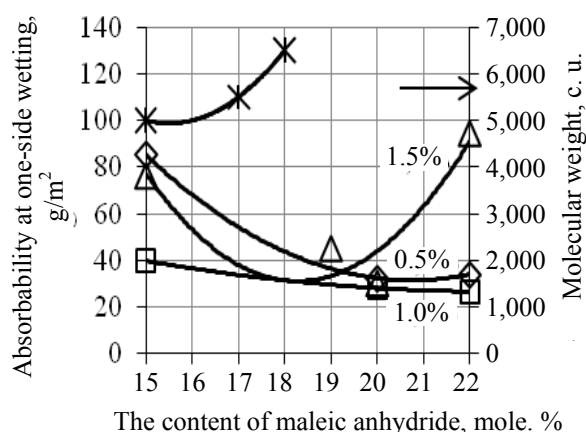


Fig. 5. The change of absorbability at one-side wetting of paper samples depending on the content of maleic anhydride in the compositions of investigated styrene copolymers

Based on the received results on the investigation of the influence of the properties of additives on the quality of paper the preferential 0.5% of a. d. s. flow of additives has been chosen.

Modified styrene copolymers content in the specified quantity in the composition of paper pulp will provide the increase of the breaking length by 20–28% in combination with the required hydrophobicity for sized types of paper in the range of 25–35 g/m<sup>2</sup>.

The important aspect of the possibility to use new chemical additive agents in paper composition is to provide the required drying mode of samples. It has caused an indispensability of the next stage of research aimed at investigation of the influence of regime parameters of drying of paper samples on their physical, mechanical and hydrophobic properties (Table 3). As an additive for comparison was used product on PAPAS basis (Melapret PAE/A).

Table 3 shows that the rise of drying temperature of paper samples increases the values of the breaking length and energy absorption at break, in this case samples of additives N 1 and N 5 give comparable results. It should be noted, however, that drying of the samples at a temperature of 130°C is not economical.

Table 3

**Quality characteristics of paper samples produced with the using of additives N 1, N 5, Melapret at different temperature of drying**

Investigated sample	Drying temperature of paper samples, °C	The values of quality parameters of paper samples				
		Braking length, m	Energy absorption at break, J/m <sup>2</sup>	Rigidity at break, kN/m	Young modulus, GPa	Absorbability at one-side wetting, g/m <sup>2</sup>
N 1	100	3540	31.1	357.6	2.21	84.7
	110	3550	28.3	370.3	2.26	30.4
	120	3590	28.7	380.8	2.41	34.0
	130	3490	31.3	361.3	2.26	48.2
N 5	100	3725	27.7	403.8	2.38	50.9
	110	3725	31.4	392.8	2.40	41.3
	120	3385	25.4	372.2	2.36	18.4
	130	3575	27.6	376.7	2.35	42.6
Melapret	110	4165	40.7	390.5	2.35	19.2
	110	3670	35.9	346.4	2.20	27.5
	120	3980	40.6	389.0	2.43	21.2
	130	4635	54.7	407.5	2.44	16.1

The comparable results for the investigated and traditional (Melapret) samples of additives were observed at 120°C, it's justified by the 380–389 kN/m rigidity at break of paper samples. The effect of increasing of rigidity of the samples indicates a rise in interfiber bonding forces in paper. The increase of rigidity is very important factor for packaging types of paper and the main direction in improving of their quality. Young modulus increase at rise of drying temperature of paper samples testifies the proper increase of paper rigidity and, therefore, is a significant parameter in estimating of reinforcement of the investigated additives.

The best hydrophobic properties are achieved at drying temperature of 120°C, the values of absorbability at one-side wetting are within 18.4–21.2 g/m<sup>2</sup>. It should be mentioned that reinforcement of the investigated samples of additives is similar to that of Melapret (imported product). As a result of researches of the influence of drying temperature while using new additives the proper temperature of drying of paper samples of 120 ± 2°C was stated, this temperature gives the opportunity to achieve high physical and mechanical properties and the required hydrophobicity of the finished product.

**Conclusion.** It is shown that the efficiency of reinforcement of the styrene copolymers and maleic anhydride depends on the terms of their modifying. It is determined that effectually to use aqueous ammonia NH<sub>4</sub>OH for modifying of copolymers. The content of maleic anhydride units should be 20–22 mol. %, molecular weight should be in the range of 5,500–6,500 c. u. Dependences of influence of the type and the flow of the investigated additives on the basic quality parameters of paper samples are stated. Recommended preferable flow of the investigated samples of the modified styrene copolymers is 0.5% of a. d. s. The expediency of drying of paper samples at 120 ± 2°C is established. The possibility of using of the modified styrene copolymers and maleic anhydride for reinforcing of recycled pulp paper instead of imported analogs is established as well .

#### References

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